Pradeep Kumar Singh · Zdzislaw Polkowski · Sudeep Tanwar ·
Sunil Kumar Pandey · Gheorghe Matei · Daniela Pirvu   *Editors*

Innovations in Information and Communication Technologies (IICT-2020)

Proceedings of International Conference on ICRIHE - 2020, Delhi, India: IICT-2020

IEREK
RESEARCH & KNOWLEDGE ENRICHMENT

Springer

Advances in Science, Technology & Innovation

IEREK Interdisciplinary Series for Sustainable Development

Advances in Science, Technology & Innovation (ASTI) is a series of peer-reviewed books based on important emerging research that redefines the current disciplinary boundaries in science, technology and innovation (STI) in order to develop integrated concepts for sustainable development. It not only discusses the progress made towards securing more resources, allocating smarter solutions, and rebalancing the relationship between nature and people, but also provides in-depth insights from comprehensive research that addresses the **17 sustainable development goals (SDGs)** as set out by the UN for 2030.

The series draws on the best research papers from various IEREK and other international conferences to promote the creation and development of viable solutions for a **sustainable future and a positive societal** transformation with the help of integrated and innovative science-based approaches. Including interdisciplinary contributions, it presents innovative approaches and highlights how they can best support both economic and sustainable development, through better use of data, more effective institutions, and global, local and individual action, for the welfare of all societies.

The series particularly features conceptual and empirical contributions from various interrelated fields of science, technology and innovation, with an emphasis on digital transformation, that focus on providing practical solutions to **ensure food, water and energy security to achieve the SDGs.** It also presents new case studies offering concrete examples of how to resolve sustainable urbanization and environmental issues in different regions of the world.

The series is intended for professionals in research and teaching, consultancies and industry, and government and international organizations. Published in collaboration with IEREK, the Springer ASTI series will acquaint readers with essential new studies in STI for sustainable development.

ASTI series has now been accepted for Scopus (September 2020). All content published in this series will start appearing on the Scopus site in early 2021.

More information about this series at http://www.springer.com/series/15883

Pradeep Kumar Singh · Zdzislaw Polkowski ·
Sudeep Tanwar · Sunil Kumar Pandey ·
Gheorghe Matei · Daniela Pirvu
Editors

Innovations in Information and Communication Technologies (IICT-2020)

Proceedings of International Conference on ICRIHE - 2020, Delhi, India: IICT-2020

Springer

Editors
Pradeep Kumar Singh ⓘ
Department of Computer Science
and Engineering
ABES Engineering College
Ghaziabad, India

Sudeep Tanwar
Nirma University
Ahmedabad, Gujarat, India

Gheorghe Matei
Faculty of Economic Sciences
University of Craiova
Craiova, Romania

Zdzislaw Polkowski
Wroclaw University of Economics
Jan Wyzykowski University in Polkowice
Polkowice, Poland

Sunil Kumar Pandey
ITS Mohan Nagar
Ghaziabad, India

Daniela Pirvu
University of Pitesti
Pitesti, Romania

Preface

The First International Conference on Innovations in Information and Communication Technologies (IICT-2020) focuses on the emerging ICT trends in higher education, online learning, innovations in teaching and learning technologies using ICT and use of ICT in business management. The objective of this conference is to bring together researchers and developers from industry and academia to share new ideas, research results and development experiences on ICT for online learning, ICT in business, management and economics and ICT for sustainable smart cities and societies.

There are mainly four technical tracks of the conference: (i) digital technologies for advancements in education, management and IT, (ii) emerging ICT trends in education, management and innovations, (iii) emerging technologies for industries and education and (iv) ICT technologies for intelligent applications.

The IICT-2020 was held at Ghaziabad, Delhi-National Capital Region (NCR) region of India, on **7–8 November** 2020 in association with the Institute of Technology and Sciences (ITS), Ghaziabad; University of Pitesti, Romania; WSG University, Poland; RAISA, Romania; Fluper, Eigen Technologies and IAC education, as an academic partner and technical supporters for the event. We are highly thankful to our valuable authors for their contribution and our technical programme committee (TPC) for their immense support and motivation towards making the IICT-2020 a grand success. We are grateful to our keynote speakers: Dr. Akhilesh Sharma, Manipal University, Jaipur, India; Dr. Zdzislaw Polkowski, Jan Wyzykowski University, Polkowice, Poland; and Dr. Ioan Cosmin Mihai, Associate Professor, "Al. I. Cuza" Police Academy, the University Politehnica of Bucharest, "Carol I" National Defence University, Romania. We express our gratitude to our session chairs: Dr. Chaman Verma, Dr. Ashish Kumar Singh, Dr. Suresh Chauhan, Dr. Ashutosh Sharma, Dr. Richa Sharma, Dr. Nagesh Kumar, Dr. Shaweta Khanna, Dr. Rakesh Saini, Dr. Amit Kumar, Dr. Yugal Kumar, Prof. Hari Mohan Rai, Dr. Akhilesh Kumar Sharma, Dr. Neerendra Kumar, Prof. Pronaya Bhattacharya, Dr. Mandeep Kaur, Dr. Anupam Singh, Dr. Ashwani Kumar, Dr. Vivek Kumar Sehgal, Dr. Samayveer Singh and Dr. Deepak Gupta for their valuable feedback and suggestions during the technical sessions.

Moreover, we extend our gratitude to Dr. Nabil Khélifi, Senior Editor Springer, for his continuous help and guidance to further improve the quality of proceedings. We express our sincere gratitude to our publication partner, Springer, ASTI Series, for believing in us.

Ghaziabad, India	Pradeep Kumar Singh
Polkowice, Poland	Zdzislaw Polkowski
Ahmedabad, India	Sudeep Tanwar
Ghaziabad, India	Sunil Kumar Pandey
Craiova, Romania	Gheorghe Matei
Pitesti, Romania	Daniela Pirvu
November 2020	

Contents

ICT Technologies for Intelligent Applications

Factors Affecting Online Grocery Shopping in Indian Culture

Ashish Kumar Singh and Nishi Pathak

Abstract

Today the online grocery shopping (OGS) is helping customers by making their life convenient by offering best and comfortable deals. Scope of online grocery shopping is increasing exponentially. Therefore, this study aims at examining the influencing role played by personal innovativeness (PI), economic values (EV), design aesthetic (DA), perceived enjoyment (PEJ) and convenience (CON) attributes on development of positive attitude to use OGS by Indian customers. For testing the variables and relationship of the proposed model, a structured questionnaire was formed and dispersed among 351 Ghaziabad and Delhi residents, out of which 232 were used for analysis. The Smart PLS 3.0 programme has been used to provide partial least square structural equation modelling (PLS-SEM) method. Finding a study easy to use (PEOU), perceived usefulness (PU), PI, EV, DA and PEJ and CON have a symbolic quantitative correlation in India with the acceptance of OGS. In contrast, PEJ did not support PEOU. Therefore, the study will provide direction to all online grocery service providers to design their services according to the customer's expectation and need.

A. K. Singh · N. Pathak (✉)
Department of Management Studies, Raj Kumar Goel Institute of Technology, Ghaziabad, India
e-mail: npmba@rkgit.edu.in

A. K. Singh
e-mail: ashishs80@gmail.com

1 Introduction

The Indian e-Commerce market is predicted to grow double size from current 32.7$ (2019) to 71.9$ billion in 2022 (eMarketeers, Economictimes.com).

Online food and grocery market in India has entered into the digital age and growing with a 25–30% rate and expected CAGR by 66% during 2018–23 (Livemint Financial Express). Nevertheless, IGD suggested that the growth rate for online groceries differs according to low-, middle-, high-income countries (Johnson et al., 2018). During COVID-19 pandemic, customers preferred more online grocery shopping.

Several forms of studies have been performed on different aspects of OGS in the context of acceptance models, including the live theory of planned behavior (TPB) (Hansen et al., 2004; Hansen, 2008; Ramus & Nielsen, 2005), the theory of reasoned action (TRA) (Hansen et al., 2004) and the technology acceptance model (Childers et al., 2001; Kurnia & Chien, 2003). In various nations, demographic variables, cultures, consumer behaviours, a number of studies signifying the adoption of e-shopping have been conducted (Choi & Geistfeld, 2004; Park & Jun, 2003). A survey among American and Korean consumers has been done regarding internet buying behaviour and found that perceived risk among both countries is significantly different (Park & Jun, 2003) and Korean consumers get more influenced by subjective norms (Geistfeld, 2004). In a study of consumer perception of home shopping (online grocery shopping) in the USA, consumers showed interest in perceived risk and convenience (Park et al., 1996). Convenience and PEOU have been very efficiently verified in a further analysis of the customer advantages and disadvantages of online grocery shopping in Finland (Raijas, 2002). A study showed orientation of stores, use of information, convenience and seeking of variety as influential factors to motivate online grocery shopping in the USA (Rohm & Swaminathan, 2004). Situation-based factors can influence

continuation or discontinuation of usage of OGS, which was confirmed in a study "Effect of contextual variables on online grocery shopping in the UK". (Hand et al., 2009). PEOU and PU were strong predictors for behavioural intention, and it is influenced by education, income and age for online grocery shopping in Singapore. (Hui & Wan, 2009). The significant difference was noticed in perceived risk among frequent and infrequent online grocery shopping users in Australia (Mortimer et al., 2016). However, in some studies, online grocery shopping behaviour is similar to offline shopping behaviour (Anesbury et al., 2015).

TAM has been validated as an active method in previous studies to provide a clear picture of the subscriber's technology adoption in various contexts and cultures, including m-commerce (Bruner & Kumar, 2005), banking technology (Chau & Lai, 2003; Adamson & Shine, 2003), online games (Hsu & Lu, 2007), email, desktop video conferencing (Townsend et al., 2001), telemedicine technology (Chau & Hu, 2002) and so on.

TAM has reasons for being famous; TAM was designed for information technology and a better way to explain and predict the variety of customers' acceptance level of a broader diversity of technologies within different cultures, organisations and expertise levels. TAM has a well-established researched theory and offers a validated and trusted measurement scales. As in India, online shopping is in a very nascent stage and growing with a good pace and expected to grow in double digit with massive potential. In India, the online retail market for groceries is supposed to peak up to $10.5 billion by 2023 (Redseer, Livemint.com). Hence, a rigorous study is needed to understand customers' behaviour, expectations and factors affecting them. This study proposed and tested the modified and extended form of TAM in Indian demographics with changing social and psychological culture. So, by exploring the consumer behaviour of Indian online users, we have shortlisted and adopted five external variables, namely economic values (EV), convenience (CON), design aesthetic (DA), perceived enjoyment (PEJ) and personal innovativeness (PI).

Further, their influence on customers to perceive online shopping easy and useful and to ultimately lead the development of their attitude for using online grocery shopping. In India, consumer behaviour of youth is far different from other countries, which employs more OGS, and their behaviour is quite different from developed countries. Their living style and population are changing. Until now, no study has considered the effect of above all variables for adopting OGS by customers, especially in developing countries like India. Hence, it was believed this study is crucial, pioneer and will be helpful for understanding and planning new online retailing strategies for a dynamic environment.

2 Literature Reviews

2.1 Personal Innovativeness (PI)

Personal innovativeness (PI) stands to be the user's willingness to explore latest technology (Agrawal & Prasad, 1998) explained innovativeness as a "willingness to change". It being intrinsic to customer's personality and its level may differ from person to person (Gupta et al., 2011). It is how the individual potentially responds to innovations. The analysis of individual actions for creativity involves personal innovativeness as a variable. So this construct can be used to categorise the customers into "innovators" and "non-innovators". This domain-specific innovativeness reinforces customers in the taking up of industrial novelty. Innovation firmly impacts customers to adopt movable trade. PI is influential on usefulness perception (Lu et al., 2005) and useful in influencing the customers to acceptance of technology PI has been an important antecedent for adoption and use of m-payment (Kim et al., 2010) and PI influence PEOU, which leads to the development of users attitude to use m-payment technology. Innovative consumers will intelligently evaluate the usefulness and ease of use of any emerging technology-based services (Lu et al., 2005). In India, as well as other developing countries, all these technologies are entering and are at very early stage, and the majority of peoples are gradually experiencing these technologies. So, PI can influence and play a vital role in OGS adoption.

H1: Personal innovativeness is related with perceived ease of use.

H2: Personal innovativeness is related with perceived usefulness.

2.2 Design Aesthetic (DA)

In mobile games, design aesthetic is a "harmony, psychological attraction or aesthetic" (Merikivi et al., 2017). DA has drawn positive impact of users in mobile games and also showed a positive impact on the perception of mobile system users (Merikivi et al., 2017). Online customers seek to design and aesthetic as vital for the validation of digital webpages for buying (Cry et al., 2006; Harris & Goode, 2010). DA has been found antecedent of TAM in the mobile category and has a crucial impact on PEOU and enjoyment, which leads to customer's loyalty towards mobile services (Cry et al., 2006). In another study, it has been found that perceived attractiveness of website (DA) influences enjoyment, usefulness and PEOU positively (Vander Heijden 2003). Thus, in India, DA can also influence PEOU and PU that eventually contributes to the development of a good

outlook towards using digital grocery buying. Based on the above theory, we can develop a hypothesis,

H3: Design aesthetic is related with perceived ease of use.

H4: Design aesthetic is related with perceived usefulness.

2.3 Perceived Enjoyment (PEJ)

Defines perceived enjoyment, "the degree to which machine work is considered to be entertaining by itself, apart from any expected outcomes consequences (Davis et al., 1992; Carroll & Thomas, 1988; Deci, 1972; Malone, 1981a, b). Davis et al. (1992) incorporated PEJ in extended TAM. In our context, a definition can be modified "to the extent to which users perceive OGS to be enjoyable". In a study, perceived enjoyment showed positive (Davis et al., 1992) relationship to PEOU, which leads to users acceptance (Venkatesh, 2000). Mun and Hwang (2003), in their study of the prediction on information systems which are web based, found a significant association among enjoyment and PEOU and PU. In estimating the impact of the perceived enjoyment and use of innovation among instructors, the two associations were further developed (Teo and Noyes, 2011). Enjoyment factor drive users to use new technology (Bruner & Kumar, 2005; Davis et al., 1992). Shopping enjoyment has played a crucial role in influencing online shopping attitude (Childers et al., 2001) and intention of using new technologies (Chen & Tan, 2004; Davis et al., 1992). So, perceived enjoyment can be a crucial antecedent for PEOU and PU, which further leads to development of attitude to use any online services in the Indian context. On the basis of the above theory, we can initiate a hypothesis,

H5: Perceived enjoyment is related with perceived ease of use.

H6: Perceived enjoyment is related with perceived usefulness.

2.4 Economic Values (EV)

Economic values (EV) assumed as a net gain of online customer's in terms of monetary deals, promotional offers, discounts with time, efforts and money saving on travelling expenses (Cassil et al., 1997, Aylott & Mitchell, 1999). It is a togetherness of transaction value and acquisition (Grewal et al. 1994). It includes a basket of monetary investment, behavioural, temporal and psychological supplies of customers being repaid on investment (Thaler, 1985; Mathwick et al., 2001; Grewal et al., 1998).

Consumers also consider OGS useful, as it can save both monetary and non-monetary costs (Lopez Nicolas et al., 2008, Amoako-Gyampah & Salam, 2004). So, we can conclude that EV can be decisive for PEOU and PE, which leads to the development of attitude for online grocery shopping.

Based on these literature reviews, the study presents the following hypothesis

H7: There is a constructive relationship between economic values and perceived ease of use.

H8: There is a constructive relationship between economic values and perceived usefulness.

2.5 Convenience (CON)

Convenience is the combination of place and time utilities and advantages, which is considered as a critical reason for the development of attitude towards m-payment adoption and uses (Kim et al., 2010). We discuss convenience as a construct all the time in marketing and consumer behaviour study (Berry et al., 2002, Ng-Kruell et al., 2002), and the inspiring stories of mobile trade have been major elements (Xu & Gutierrez, 2006). The benefit of adopting online grocery shopping environment is its insight of convenience to shopping from home or anywhere, anytime by 24×7 days. Convenience provides both options of when and where customers can shop. Customers who perceive the online platform more convenient are likely to consider it "useful" and "easy to use". Customers mindset of this convenience makes shopping a useful and easy process with more appealing by reducing the frustration of psychological cost and making shopping enjoyable (Childers et al., 2001). Thus, the customer perceived online grocery shopping useful and ease of use technology which develops a positive attitude in customers to use it. Therefore, on the basis of the above-mentioned study, the following hypotheses are presented.

H9: Convenience is related with perceived ease of use.

H10: Convenience is related with perceived usefulness.

2.6 Perceived Ease of Use (PEOU)

The perceived ease of use by consumers, according to Davis et al. (1989), is the level of confidence displayed by users that it is easier to use and manage. A study suggests that it is the perception (Schierz et al., 2010) of users about the particular technology which is easy, clear and understandable, and motivate the user to use it skilfully. Perceived ease of use by the customers factor has been adopted from Davis et al. (1992) technology adoption model (TAM). Similarly, some other studies (Peng et al., 2012; Shankar & Kumari, 2016; Shankar & Datta, 2018) on m-commerce and banking also suggest that this attribute has proved to be essential for

adopting and intending to use mobile apps (Madan & Yadav, 2016; Singh et al., 2020). Another study on the adoption of online banking in Malaysia also confirmed this relationship (Lallmahamood, 2007). Study focussing on the intent to use the internet by Chinese adult also confirmed this affiliation that perceived ease of use positively influence intention to use (Pan & Jordan-Marsh, 2010). Focussing into our study, we can assume that if the user's belief that OGS is easy, it will influence the intention to use. The following hypothesis is proposed.

H11: Perceived ease of use by customers has a positive relationship with attitude to use.

2.7 Perceived Usefulness (PU)

The study suggests that the users adopt any specific technology (Venkatesh & Davis, 2000) if they found it useful for them and it will increase their efficiency and effectiveness (Davis, 1989). According to Kim et al. (2010) by using m-payment technologies the customers can complete their task quickly, comfortably and feel pleasure to use that easy technology (Venkatesh & Davis, 2000; Oliveira et al., 2016). PU is "degree the user's belief that by using that technology, his job performance will increased" (Davis, 1989). The study suggests that perceived usefulness is the utility degree of m-payment technology that a customer perceived by using this technology, and it will increase the profitability and probability. Which influence user's intention to increases the usefulness of technology in ordering the food items (Shanker & Datta, 2018). Previous research demonstrates that m-payment technology has a positive and crucial impact on perceived usefulness (Duane et al., 2014; Apanasevic et al., 2016). Customers use technology as they feel that it increases their effectiveness and efficiency (Kim et al., 2012; Duane et al., 2014). Today, the users adopt these technologies in their daily routine and workplaces (Madan & Yadav, 2018; Singh et al., 2020).

Further, in the study of mobile wireless technology adoption, relationship in PU and ITU was confirmed (Kim & Garrison, 2009). So based on the above studies, we can assume that in our study, PU will positively influence to attitude to use. Hence, the study proposed the following hypothesis.

H12: Perceived usefulness has a positive relationship with the attitude to use (Fig. 1).

3 Research Design

3.1 Measuring Constructs

Based on previous literature reviews, the researcher proposed a research framework of this study, and it has

suggested that the above attributes have influenced the attitude to use online grocery shopping. Therefore, all the research items for the proposed independent and dependent constructs have been retrieved from existing literature reviews. Initially, a pilot study was done for the refinement and to increases the face and internal validity of the research items. A final set of 30 items, out of 31 items, have identified by the researcher and used for final questionnaire development. Thus, the questionnaire consists of two parts. First part includes the respondent's population profiles, and the second part includes the information regarding dependent and independent constructs. Each item of research construct was measured in a 5-point Likert scale, showing a wide choice from strongly disagree = 1 to strongly agree = 5.

3.2 Collection Process of Data

For data collection process, structured questionnaire was designed and distributed among young college-going students, friends, relatives, ordinary citizens in a society in February to mid-march 2020, with the assumption that they are online grocery customers. But due to COVID-19 lockdown, it was hard to approach many respondents, so we have to restrict our survey with some limited responses. All the respondents belong to major cities, preferably of Ghaziabad and other cities of NCR in India and of all age group to get more representation of society. After responses collection, we segregated those responses who were using online grocery shopping. Convenience sampling method has been utilised by the researchers to collect responses from the users using online grocery shopping for their consumption. A total number of 232 questionnaires were used in empirical data analysis out of 351 distributed questionnaires. Thus, a 66% response rate was witnessed in the survey, and the precise demographic details of respondents are shown in Table 1.

Among respondents, 76% are male and 24% are female. Our 76% respondents are between age group of 21–30 years, 63% are graduates, and 34% are post-graduate, 64 and 26% are students and employees. Maximum respondents uses OGS either once in month (44%) or week (41%). Majority respondents are using OGS services less than 2 years (67%) (Table 1).

4 Data Analysis and Result

For data analysis process, the structural model analysis (Hair et al., 1998; Davison et al., 2003; Bagozzi & Yi, 1988, 2012) through partial least square method, SmartPLS 3.0 statistical software has been used by the researcher. PLS-SEM method
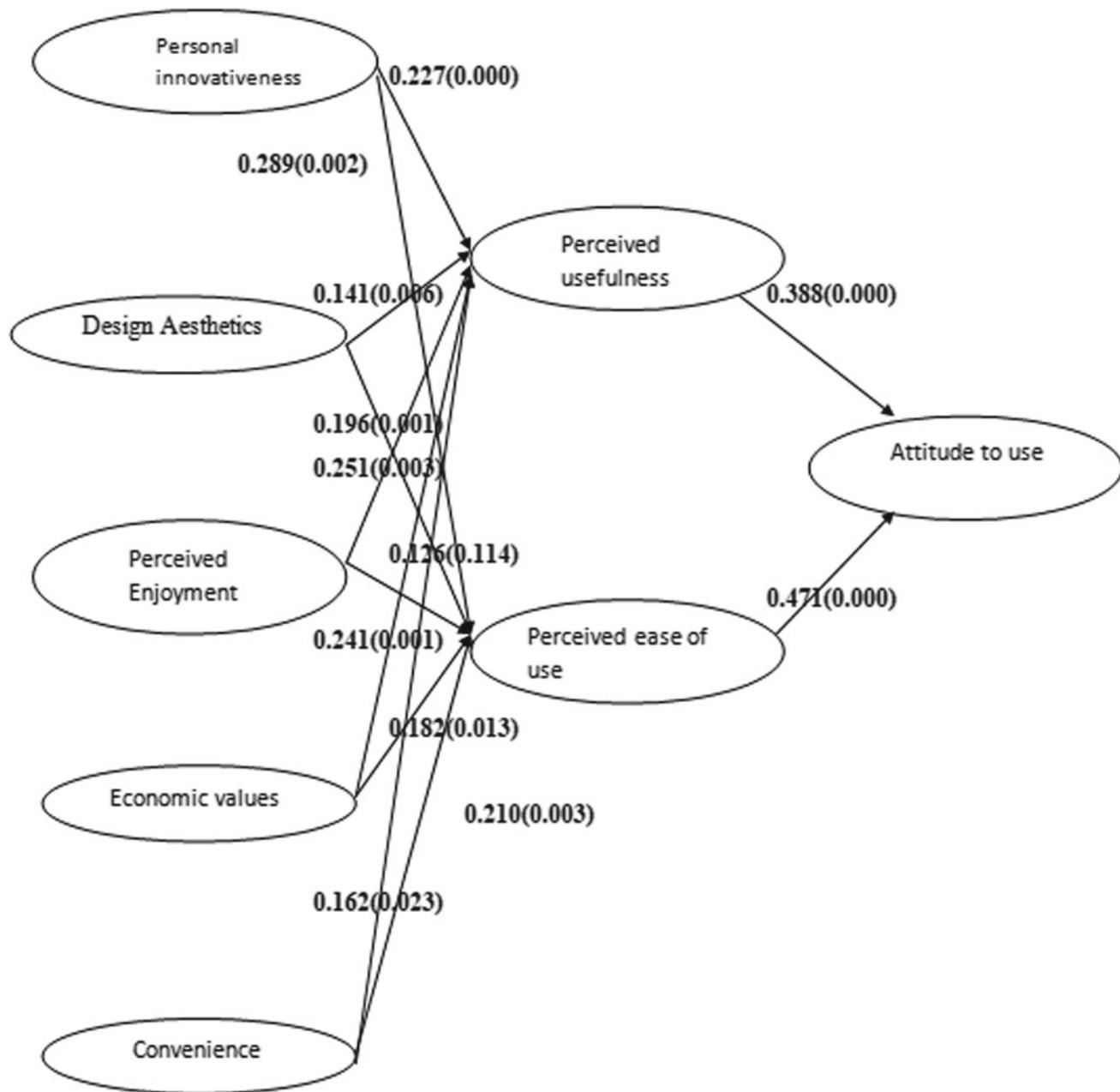
Fig. 1 Proposed research framework

was found to be an appropriate method by the researcher (Hair et al., 2013) because it is considered suitable for both parametric and non-parametric data. It is beneficial for the judgment of the causal relationship between independent and dependent constructs. Along side with this, the study also estimated statistical significance of factor loadings and path coefficients (Chin, 2001; Davison et al., 2003; Henseler et al., 2009, 2015) using a non-parametric bootstrap procedure. The path coefficient is significant, (if the *t* value is higher than 1.96), at a significance level of 5%, then the hypotheses have been accepted by the researcher.

4.1 Validity and Reliability

Conducting reliability and validity analysis ensured the internal consistency of constructs. For measuring the reliability of the research items, the values of composite reliability and Cronbach's alpha (Raykov, 1997) was checked by the researcher used in the proposed research framework, whether the values for both the cases have to be greater than or equal to the minimum standard of 0.70 (Nunnally, 1978). Study findings observe that the values for Cronbach's alpha almost lie from 0.70 to 0.90, and for

Table 1 Detailed demographic profile of respondents

Variable	Levels	Count	Percentage
Gender	Male	177	76
	Female	55	24
Age	Less than 20 years	17	7
	21–30 years	175	76
	31–40 years	19	8
	Above to 40 years	21	9
Education	Intermediate	2	1
	Graduation	147	63
	Post-graduation	78	34
	Other	5	2
Occupation	Student	149	64
	Employee	61	26
	Entrepreneur	10	4
	Other	12	5
Frequency of using OGS	Minimum once in a day	36	16
	Minimum in a week	95	41
	Minimum in a month	101	44
Using OGS since	Less than one year	81	35
	1–2 year	75	32
	2–3 year	40	17
	>3 year	36	16

composite reliability, the value lies in between 0.73 and 0.85 (Table 2).

Similarly for measuring the validity of the constructs, the researcher observes the values of convergent validity (Fornell and Larcker, 1981) through the values of factors loading and AVE that should be higher than 0.50 (Bagozzi and Edward, 1998). Therefore, the values of factor (0.56–0.92) and average variance extracted (AVE) surpasses the minimum standard of 0.50 (0.51–0.73). Parallel to this, the study also observes the values of discriminant validity (Fornell and Larcker, 1981) used for identifying the inter-correlation between constructs, estimated by the square root values of AVE. The research study also identifies the heterotrait-monotrait (HTMT) results for the discriminant validity (Henseler et al., 2015), which represent the level of uniqueness of one construct with other constructs, based on the low correlation among the constructs. Since all the HTMT values are lower to 0.90, which satisfies the conditions of HTMT (<0.9) proposed by Kline (2015) for all constructs of study, thus, it is concluded that the measurement model shows sufficient reliability, discriminant and convergent validity (Tables 3 and 4).

4.2 Structural Model Assessment

The analyst also explored tolerance and variance factor (VIF) values. And for this purpose, latent variable scores

(calculated by SmartPLS) are used as input for calculating multiple regressions. Table 5 indicates VIF values that do not surpass 5 (variable values <3.731) and tolerance level >0.2 (Hair et al., 2011). The result implies no multi-collinearity within independent factors.

4.3 Main Effects and Path Coefficients

The SmartPLS 3.0 software was used to evaluate the proposed assumption based on statistical importance values of factor and route coefficients for a non-parametric bootstrap approach (Chin, 2001; Davison et al., 2003). Table 5 shows the result for each relationship of the standardised path coefficients (β), t value and related meaning levels.

5 Discussion

The study used partial least square structural equation modelling (PLS-SEM) to check the suggested model. PLS-SEM tests the extension of existing structural theory as well as for identifying and predicting the key constructs (Hair et al., 2011). SEM encourages multi-dependent and independent model relation testing (Anderson & Gerbing, 1988). Hence, SEM was used as a measuring tool for the current study. Primary criteria of evaluation for the structural

Table 2 Reliability and validity analysis

Constructs and their observable items	Loadings
Perceived ease of use (PEOU) (AVE = 0.73, CR = 0.92, α = 0.92) (Davis 1989)	
PEOU 1: I like online grocery shopping, as it is easy to use	0.83
PEOU 2: I purchase online grocery skilfully	0.88
PEOU 3: I believe that shopping for grocery online is clear and understandable for me	0.86
PEOU 4: It is easy for me to adopt the process of online grocery shopping	0.85
Perceived usefulness (PU) (AVE = 0.67, CR = 0.82, α = 0.86) (Davis, 1989; Kim et al., 2010)	
PU 1: I like to order my grocery more quickly and easier by using online services	0.77
PU 2: I love to order my grocery more comfortably by using online ordering	0.83
PU 3: Using online ordering services is enjoyable and useful experience for me	0.80
PU 4: Online grocery shopping would be advantageous for me	0.77
Convenience (CON) (AVE = 0.58, CR = 0.84, α = 0.84) (Eastlick and Feinberg 1999; Mathwick et al. 2001; Rohm & Swaminathan 2004; To et al. 2007)	
Con 1: Online grocery shopping saves me time	0.85
Con2: Online grocery shopping made my life easy, as it is convenient to shop	0.84
Con 3: I can shop online grocery anytime from anywhere	0.78
Con 4: Online grocery shopping provides me with access directly to information about all products	0.57
Economic value (EV) (AVE = 0.73, CR = 0.88, α = 0.88) (Mathwick et al., 2001)	
EV 1: Online grocery shopping products are of worth economic value	0.81
EV 2: Overall, I am satisfied with online grocery prices	0.92
EV 3: Prices of online grocery, I purchase are reasonable for their quality	0.81
Personal Innovativeness (PI) (AVE = 0.51, CR = 0.73, α = 0.70) (Agarwal & Prasad, 1998; Bauer et al., 2006; Gupta et al., 2011)	
PI 1: I love to experience new online grocery shopping services	0.84
PI 2:Among my known, I am generally the first one to buy online grocery	0.83
PI 3:My friends usually appreciate my advice regarding online grocery shopping	0.77
PI 4: If I listen about new online grocery shopping service, I like to use it	0.60
Perceived Enjoyment (PEJ) (AVE = 0.62, CR = 0.86, α = 0.86)	
EJ 1: Online grocery shopping is enjoyable	0.79
EJ 2: Online grocery shopping is exciting to use	0.86
EJ 3: Online grocery shopping is interesting	0.83
EJ 4: I feel good while shopping grocery online	0.64
Design Aesthetics (DA) (AVE = 0.57, CR = 0.84, α = 0.84) (CRY et al., 2006)	
DA 1: The website (colour, menus, boxes, etc.) are fascinating	0.82
DA 2: Online grocery shopping website designed professionally	0.78
DA 3: Website graphics have significant meaning	0.72
DA 4: The site's look and feel overall are visually appealing	0.69
Attitude to shop online grocery (AT) (AVE = 0.62, CR = 0.83, α = 0.83) (Kim et al., 2010)	
AT 1: I want to shop online grocery	0.73
AT 2: Shopping grocery online could be excellent and beneficial process	0.86
AT 3: Shopping grocery online would be a pleasant experience, and I want to use it	0.76

model is R^2 value for attitude to use OGS is 0.56, which allocates 56% variance of a consumer to use OGS, 53% of variance to PEOU and 53.7% variance to PU, which are considered to be perfect model (Hair et al., 2011) and all R^2 are statistically significant. For the multicollinearity test, the variance inflation factor (VIF) test was conducted and found to be all values less than the suggested values of 3.3. Model fit has been verified by analysing SRMR, where for the

Table 3 Discriminant validity—HTMT criterion

Constructs	AT	EV	CON	VD	PEOU	PU	EJ	PIN
AT								
EV	0.81							
CON	0.83	0.89						
VD	0.65	0.69	0.74					
PEOU	0.89	0.82	0.85	0.76				
PU	0.90	0.89	0.89	0.79	0.89			
EJ	0.87	0.89	0.90	0.80	0.86	0.90		
PIN	0.79	0.71	0.79	0.73	0.84	0.84	0.85	

Table 4 Fornell Larcker criterion

	AT	EV	CON	DA	PEOU	PU	EJ	PI
AT	0.79							
EV	0.80	0.85						
CON	0.83	0.89	0.77					
DA	0.66	0.68	0.72	0.76				
PEOU	0.92	0.82	0.85	0.76	0.86			
PU	0.92	0.90	0.90	0.79	0.96	0.80		
EJ	0.87	0.89	0.89	0.80	0.86	0.94	0.79	
PI	0.79	0.73	0.76	0.63	0.83	0.86	0.83	0.65

Table 5 Main effects and path coefficients

Hypothesis	Beta	t value	p value	f^2	Result
H1: PI → PEOU	0.289	3.040	0.002	0.29	Supported
H2: PI → PU	0.227	3.781	0.000	0.316	Supported
H3: DA → PEOU	0.196	3.203	0.001	0.14	Supported
H4: DA → PU	0.141	2.761	0.006	0.10	**Supported**
H5: PEJ → PEOU	0.126	1.584	0.114	0.003	**Not-Supported**
H6: PEJ → PU	0.251	3.017	0.003	0.126	Supported
H7: EV → PEOU	0.182	2.503	0.013	0.40	Supported
H8: EV → PU	0.241	3.318	0.001	0.16	Supported
H9: CON → PEOU	0.210	2.972	0.003	0.07	Supported
H10: CON → PU	0.162	2.279	0.023	0.04	Supported
H11: PEOU → AT	0.471	6.193	0.000	0.09	Supported
H12: PU → AT	0.388	4.994	0.000	0.20	Supported

Note Significance level $P < 0.05$, if t value ≥ 1.96, based on two-tailed t test

saturated model is 0.050 and 0.052 for the approximate mould, which are less to the recommended value of 0.1 (Hu & Bentler, 1998). Hence, the proposed model is fit to go further.

Bootstrapping was run with 5000 subsamples, which is suggested by Hair et al. (2011). Except for perceived enjoyment to PEOU, all hypotheses were tested statistically significant.

As already mentioned, this study was conducted primarily to access the crucial factors and their effect on Indian customers to use online grocery shopping.

H1; hypothesis The positive relationship between personal innovativeness and PEOU is statistically supported in this study, which shows Indian customers who are innovative in personality found OGS easy to use. Thus, our results are consistent with the previous study of Okumus R et al. 2018, in which personal innovativeness was found crucial predictors for intentions to use food-ordering app on smartphones.

H2; hypothesis verifies that customers with PI characteristics found OGS useful. They found OGS quicker, comfortable, useful and adventurous for them.

H3 and H4; hypothesis is statistically significant. The study has validated crucial relation in the design aesthetic of website and app to perceived ease of use, which is consistent with the study of Keshwani et al. 2017.

H5; the hypothesis is unsupported, means perceived enjoyment do not influence in developing perceived ease of use, which is contrary to study done by Driedger et al. (2019) on Thai online grocery customer.

H6; the hypothesis is statistically supported, means perceived enjoyment influences customers to perceive online grocery shopping useful which is consistent with the previous study of Driedger et al. (2019) on online grocery Thai customers.

H7 and H8; the hypothesis is statistically significant, which are persistent with a past study of Kesharwani et al. (2017) where economic values and entertainment values have a crucial effect on PEOU for OGS.

H9 and H10; the hypothesis is statistically significant, which reveal that convenience has a significant positive impact on both PEOU and PU and consistent with the previous study of Kim et al. (2010); m, C. et al. (2009) on m-payment customers.

H11 and H12; the hypothesis is statistically significant, which assess that PEOU and PU effect significantly Indian customers to develop a positive attitude to go for OGS which is also supported by the previous study of Driedger et al. (2019) conducted on Thai customers and in another study of Gefen and Straub (2000) on importance of PEOU on the adoption of intention to use in e-commerce.

6 Conclusion

The study's prime aim was to fix factors affecting the use of online grocery shopping in Indian society. For this goal, a research model was suggested consisting of five external variables (personal innovativeness, design aesthetics, perceived enjoyment, economic values and convenience), two belief variables (perceived ease of use and perceived usefulness) and one dependent variable (attitude to use online grocery shopping).

This study strongly extended TAM in online grocery shopping context, which is significantly different from other information systems. This study considered essential and crucial factors affecting online grocery shopping, which were ignored in other previous studies, especially in developing countries like India.

Results of the empirical analysis signified the perceived ease of use and perceived usefulness which were found to be essential precedents for attitude to use online grocery shopping of Indian consumers. PI, DA, PEJ (except PEJ to PEOU), EV and CON have a statistically significant positive relation to PEOU and PU. Both help to develop an attitude in customers for online grocery shopping. Out of all factors, personal innovativeness and economic values were found to be more critical factors in perceiving online grocery shopping useful and easy, since very fewer studies have been conducted on the acceptance of online grocery shopping in countries like India, who explained and validated the extended TAM model for online grocery shopping. India and other neighbouring Asian countries have substantial emerging potential in online grocery shopping, and this paper will help to understand the consumer behaviour of developing country. We cannot formulate the strategies of online grocery shopping of developing countries based on research done in developed countries because the consumer behaviour of both countries is quite different.

Our study explores that in India maximum customers are using online grocery shopping for less than one or two years, so to retain them loyal, companies should keep them engaged with attractive offers. Companies should also offer customers free and flexible delivery options because they prefer the online process due to its convenience. Once they used their services, there are more chances of customers to retain service providers (Smaros et al., 2000).

In India, most customers have preferred online grocery shopping, firstly due to its economic values offered by companies and secondly because of user's innovativeness. Hence, Indian customers want to explore new innovative services, so service providers should take care of these adventurers innovative customers. Thirdly, convenience and design aesthetics factors have influenced customers to develop online grocery shopping easy and useful, which is consistent with the previous study of Driedger et al. (2019 on Thai customers. By this, we can conclude that companies should design their website and apps user-friendly, attractive, impressive with convenience in shopping.

So finally, we can conclude that online grocery services players should incorporate all the above factors in their mind and incorporate them while designing their business strategies for doing good in the market.

References

Adamson, I., & Shine, J. (2003). Extending the new technology acceptance model to measure the end user information systems satisfaction in a mandatory environment: A bank's treasury. *Technology Analysis and strategic management, 15*(4), 441–455.

Agarwal, R., & Prasad, J. (1998). A conceptual and operational definition of personal innovativeness in the domain of information technology. *Information Systems Research, 9*(2), 204–215.

Amoako-Gyampah, K., & Salam, A. F. (2004). An extension of the technology acceptance model in an ERP implementation environment. *Information & Management, 41*(6), 731–745.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411–423.

Anesbury, Z., Nenycz-Thiel, M., Dawes, J., & Kennedy, R. (2015). How do shoppers behave online? An observational study of online grocery shopping. *Journal Consumer Behaviour.* https://doi.org/10.1002/cb.1566/pdf.

Apanasevic, T., Markendahl, J., & Arvidsson, N. (2016). Stakeholders' expectations of mobile payment in retail: Lessons from Sweden. *International Journal of Bank Marketing, 34*(1), 37–61.

Aylott, R., & Mitchell, V. W. (1999). An exploratory study of grocery shopping stressors. *British Food Journal, 101*(9), 683–700.

Bagozzi R. P., & Yi. Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science, 16*(1), 74–94.

Bagozzi, R. P., & Edwards, J. F. (1998). A general approach to construct validation in organisational psychology: Application to the measurement of work values. *Organisational Research Methods, 1*(1), 45–87.

Bagozzi, R. P., & Yi, Y. (2012). Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science, 40*(1), 8–34.

Bauer, H. H., Falk, T., & Hammerschmidt, M. (2006). eTransQual: A transaction process-based approach for capturing service quality in online shopping. *Journal of Business Research, 59*(7), 866–875.

Berry, L. L. (2002). The components of department store image. *Consumer Behaviour Analysis, 3*, 380.

Bruner II, G. C., & Kumar, A. (2005). Applying TAM to consumer usage of handheld Internet devices. *Journal of Business Research, 58*, 553–558.

Carroll, J. M., & Thomas, J. C. (1988). Fun. *SIGCHI Bulletin, 19*, 21–24.

Cassil, N. L., Thomas, J. B., & Bailey, E. M. (1997). Consumers' definitions of apparel value: An investigation of department store shoppers. *Journal of Fashion Marketing and Management: An International Journal, 1*(4), 308–321.

Chau, P. Y., & Hu, P. J. H. (2002). Investigating healthcare professionals' decisions to accept telemedicine technology: An empirical test of competing theories. *Information & Management, 39*(4), 297–311.

Chau, P. Y., & Lai, V. S. (2003). An empirical investigation of the determinants of user acceptance of internet banking. *Journal of Organizational Computing and Electronic Commerce, 13*(2), 123–145.

Chen, L. D., & Tan, J. (2004). Technology adaptation in e-commerce: Key determinants of virtual stores acceptance. *European Management Journal, 22*(1), 74–86.

Childers, T. L., Carr, C. L., Peck, J., & Carson, S. (2001). Hedonic and utilitarian motivations for online retail shopping behaviour. *Journal of Retailing, 77*(4), 511–535.

Chin, W. W. (2001) PLS-Graph User's Guide. CT Bauer College of Business, University of Houston, USA.

Choi, J., Geistfeld, L. V. (2004). A cross-cultural investigation of consumer e-shopping adoption. *Journal of Economic Psychology, 25*(6), 821–838. https://doi.org/10.1016/j.joep.2003.08.006.

Cry, D., Head, M., & Ivanov, A. (2006). Design aesthetics leading to m-loyalty in mobile commerce. *Information & Management, 43*(8), 950–963.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology, 22*(14), 1111–1132.

Davison, A. C., Hinkley, D. V., & Young, G. A. (2003). Recent Developments in Bootstrap Methodology. *Statistical Sciences, 18*(2), 141–157.

Deci, E. L. (1972). Intrinsic motivation, extrinsic reinforcement, and inequity. *Journal of Personnlity and Social Psychology, 22*, 113–120.

Driedger, F., & Bhatiasevi, V. (2019). Online grocery shopping in Thailand: Consumer acceptance and usage behavior. *Journal of Retailing and Consumer Services, 48*(March 2018), 224–237. https://doi.org/10.1016/j.jretconser.2019.02.005.

Duane, A., O'Reilly, P., & Andreev, P. (2014). Realising m-payments: modelling consumers' willingness to m-pay using smartphones. *Behaviour and Information Technology, 33*(4), 318–334.

Eastlick, M. A., & Feinberg, R. A. (1999). Shopping motives for mail catalog shopping. *Journal of Business Research, 45*(3), 281–290.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39–50.

Gefen, D., & Straub, D. W. (2000). The relative importance of perceived ease of use in IS adoption: a study of e-commerce adoption. *Journal of the Association for Information Systems, 1*(1), 8.

Grewal, D., Gotlieb, J., & Marmorstein, H. (1994). The moderating effects of message framing and source credibility on the price-perceived risk relationship. *Journal of Consumer Research, 21*(1), 145–153.

Grewal, D., Krishnan, R., Baker, J., & Borin, N. (1998). The effect of store name, brand name and price discounts on consumers' evaluations and purchase intentions. *Journal of Retailing, 74*(3), 331–352.

Gupta, S., & Nayyar, R. (2011). Determinants of Internet buying behavior in India. *Asian Journal of Business Research, 1*(2).

Hair, J., Anderson, R., Tatham, R., & Black, C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice-Hall.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice, 19*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202.

Hand, C., Harris, P., Singh, J., Rettie, R., & Dall'Olmo Riley, F. (2009). Online grocery shopping: The influence of situational factors. *European Journal of Marketing, 43*(9/10), 1205–1219. https://doi.org/10.1108/03090560910976447.

Hansen, T. (2008). Consumer values, the theory of planned behaviour and online grocery shopping. *International Journal of Consumer Studies, 32*(2), 128–137. https://doi.org/10.1111/j.1470-6431.2007.00655.x.

Hansen, T., Møller Jensen, J., Stubbe Solgaard, H. (2004) Predicting online grocery buying intention: A comparison of the theory of reasoned action and the theory of planned behavior. *International Journal of Information Management, 24*(6), 539–550. https://doi.org/10.1016/j.ijinfomgt.2004.08.004.

Harris, L. C., & Goode, M. M. (2010). Online servicescapes, trust, and purchase intentions. *Journal of Services Marketing*.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A New criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of Academics and Marketing Sciences, 43*(1), 115–135.

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009) The use of partial least squares path modelling in international marketing. *Advances in International Marketing, 20*(1), pp. 277–319.

Hsu, C. L., & Lu, H. P. (2004). Why do people play on-line games? An extended TAM with social influences and flow experience. *Information & management, 41*(7), 853–868.

Hsu, C. L., & Lu, H. P. (2007). Consumer behavior in online game communities: A motivational factor perspective. *Computers in Human Behavior, 23*(3), 1642–1659.

Hu, L., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods, 3*(4), 424.

Hui, T.-K., Wan, D. (2009). Who are the online grocers? *Service Industries Journal, 29*(11), 1479–1489. https://doi.org/10.1080/02642060902793334.

Johnson, V. L., Kiser, A., Washington, R., & Torres, R.: Limitations to the rapid adoption of M-payment services: Understanding the impact of privacy risk on M Payment services. *Computers in Human Behavior, 79*, 111–122.

Kesharwani, A., Sreeram, A., & Sneha D. (2017). Factors affecting satisfaction and loyalty in online grocery shopping: an integrated model. *Journal of Indian Business Research, 9*(2). https://doi.org/10.1108/JIBR-01-2016-0001.

Kim, C., Mirusmonov, M., & Lee, I. (2010). An empirical examination of factors influencing the intention to use mobile payment. *Computers in Human Behavior, 26*(3), 310–322.

Kim, G., Shin, B., Lee, H. G. (2009). Understanding dynamics between initial trust and usage intentions of mobile banking. *Information Systems Journal, 19*(3), 283–311.

Kurnia, S., Chien, J. A. W. (2003). The acceptance of the online grocery shopping. In *Proceedings of the 16th Bled Electronic Commerce Conference, Bled, Slovenia*. Citeseer. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?Doi=10.1.1.529.7050&rep=rep1&type=pdf.

Lallmahamood, M. (2007). An examination of individual's perceived security and privacy of the internet in Malaysia and the influence of this on their intention touse Ecommerce: using an extension of the technology acceptance model. *Journal of Internet Banking and Commerce, 12*(3).

Lopez-Nicolas, C., & Molina-Castillo, F. J. (2008). Customer Knowledge Management and E-commerce: The role of customer perceived risk. *International Journal of Information Management, 28*(2), 102–113.

Lopez-Nicolas, C., Molina-Castillo, F. J., & Bouwman, H. (2008). An assessment of advanced mobile services acceptance: Contributions from TAM and diffusion theory models. *Information and Management, 45*(6), 359–364.

Lu, H.-P., Hsu, C.-L., & Hsu, H.-Y. (2005). An empirical study of the effect of perceived risk upon intention to use online applications. *Information Management & Computer Security, 13*(2), 106–120.

Madan, K., & Yadav, R. (2016). Behavioural intention to adopt mobile wallet: A developing country perspective. *Journal of Indian Business Research, 8*(3), 227–244.

Madan, K., & Yadav, R. (2018). Understanding and predicting antecedents of mobile shopping adoption: A developing country perspective. *Asia Pacific Journal of Marketing and Logistics, 1*, 139–162.

Malone, T. W. (1981a). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 4*, 333–369.

Malone, T. W. (1981b, December). What makes computer games fun? *Byte*, 258–276.

Mathwick, C., Malhotra, N., & Rigdon, E. (2001). Experiential value: Conceptualisation, measurement and application in the catalog and Internet shopping environment. *Journal of Retailing, 77*(1), 39–56.

Merikivi, J., Tuunainen, V., & Nguyen, D. (2017). What makes continued mobile gaming enjoyable? *Computers in Human Behavior, 68*, 411–421.

Mortimer, G., Hasan, S. F., Andrews, L., & Martin, J.: Online grocery shopping: the impact of shopping frequency on perceived risk. *International Review of Retail, Distribution and Consumer Research, 26*(2), 202–223. https://doi.org/10.1080/09593969.2015.1130737.

Mun, Y. Y., Hwang, Y. (2003). Predicting the use of web-based information systems: Self efficacy, enjoyment, learning goal orientation, and the technology acceptance model. *International Journal of Human-Computer Studies, 59*(4), 431–449.

Ng-Kruelle, G., Swatman, P. A., Rebne, D. S., & Hampe, J. F. (2002). The price of convenience: Privacy and mobile commerce. *Quarterly Journal of Electronic Commerce, 3*, 273–286.

Nunnally, J. C. (1978). *Psychometric theory*. New York, NY: McGraw-Hill.

Oh, J., & Sundar, S. S. (2015). How does interactivity persuade? An experimental test of interactivity on cognitive absorption, elaboration, and attitudes. *Journal of Communication, 65*(2), 213–236.

Okumus, B., Ali, F., Bilgihan, A., & Ozturk, A. B. (2018). Psychological factors influencing customers' acceptance of smartphone diet apps when ordering food at restaurants. *International Journal of Hospitality Management, 72*, 67–77.

Oliveira, T., Thomas, M., Baptista, G., & Campos, F. (2016). Mobile payment: Understanding the determinants of customer adoption and intention to recommend the technology. *Computers in Human Behavior, 61*, 404–414.

Pan, S., & Jordan-Marsh, M. (2010). Internet use intention and adoption among Chinese older adults: from the expanded technology acceptance model perspective. Computers in Human. Behaviour, 26 (5), 1111–1119. https://doi.org/10.1016/j.chb.2010.03.015.

Park, C., & Jun, J. K. (2003). A cross-cultural comparison of Internet buying behavior: Effects of Internet usage, perceived risks, and innovativeness. *International Marketing Review, 20*(5), 534–553.

Park, K., Perosio, D., German, G. A., McLaughlin, E. W. (1996). What's in store for home shopping?

Peng, R., Xiong, L., & Yang, Z. (2012). Exploring tourist adoption of tourism mobile payment: An empirical analysis. *Journal of Theoretical and Applied Electronic Commerce Research, 7*(1), 21–33.

Raijas, A. (2002). The consumer benefits and problems in the electronic grocery store. *Journal of Retailing and Consumer Services, 9*(2), 107–113. https://doi.org/10.1016/S0969-6989(01)00024-00028.

Ramus, K., Nielsen, N. A. (2005). Online grocery retailing: What do consumers think? *Internet Research, 15*(3), 335–352.https://doi.org/10.1108/10662240510602726(2005).

Raykov, T. (1997) Estimation of composite reliability for congeneric measures. *Applied Psychological Measurement, 21*(2), 173–184.

Rohm, A. J., & Swaminathan, V. (2004). A typology of online shoppers based on shopping motivations. *Journal of Business Research, 57*(7), 748–757. https://doi.org/10.1016/S0148-2963(02)00351-X(2004).

Schierz, P.G., Schilke, O., & Wirtz. B. W. (2010). Understanding Consumer Acceptance of Mobile Payment Services: An Empirical Analysis. *Electronic Commerce Research and Applications, 9*(3), 209–216.

Schuster, A., & Sporn, B. (1998). Potential for on-line grocery shopping in the urban area of Vienna. *International Journal of Electronic Markets, 8*(2), 13–16.

Shankar, A., & Kumari, P. (2016). Factors affecting mobile banking adoption behavior in India. *The Journal of Internet Banking and Commerce, 21*(1), 01–24.

Shanker, A., & Datta, B. (2018). Factors affecting mobile payment adoption intention: An Indian perspective. *Global Business Review, 19*(3), 1–18.

Singh, A. K., Agrawal, B., Sharma, A., & Sharma, P. (2020). COVID-19: Assessment of knowledge and awareness in Indian society. *Journal of Public Affairs, e2354.*

Singh, N., Sinha, N., & Liebana-Cabanillas, F. J. (2020). *Determining factors in the adoption and recommendation of mobile wallet services in India: Analysis of the effect of innovativeness, stress to use and social influence. International Journal of Information Management*, 191–205.

Slade, E. L., Williams, M. D., & Dwivedi, Y. K. (2013). Mobile payment adoption: Classification and review of the extant literature. *The Marketing Review, 13*(2), 167–190.

Teo, A. C., Tan, G. W. H., Ooi, K. B., Hew, T. S., & Yew, K. T.: The effects of convenience and speed in M-Payment. *Industrial Management and Data Systems, 115*(2), 311–331.

Thaler, R. (1985). Mental accounting and consumer choice. Market-
ing Science 4 (3): 199-214. Downloaded by HACETTEPE
UNIVERSITY, The netherlands. *Information & Management, 40*,
541–549.

Townsend, A. M., Demarie, S. M., & Hendrickson, A. R. (2001).
Desktop video conferencing in virtual workgroups: Anticipation,
system evaluation and performance. *Information Systems Journal,
11*(3), 213–227.

Van der Heijden, H. (2003). Factors influencing the usage of websites:
the case of a generic portal in.

Venkatesh, V. (2000). Determinants of perceived ease of use:
Integrating control, intrinsic motivation, and emotion into the
technology acceptance model. *Information Systems Research, 11*
(4), 342–365. https://doi.org/10.1287=isre.11.4.342.11872.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the
technology acceptance model: Four longitudinal field studies.
Management Science, 46(2), 186–204.

Xu, G., & Gutiérrez, J. A. (2006). An exploratory study of killer
applications and critical success factors in M-commerce. *Journal of
Electronic Commerce in Organizations (JECO), 4*(3), 63–79.

A Study on Role of Digital Technologies and Employee Experience

Jyoti Chandwani, Disha Shah, and Aarfa Shaikh

Abstract

The role of digital technology in a company's long-term development is to avoid undesirable experience in the normal situation and continue being competitive in forthcoming markets. The paper offers a comprehensive study on the role of digital technologies and its important impact on employees in the competitive world. A measure for the role of digital technologies and employee experience was built and tested for its reliability and validity. Descriptive statistics were used to understand the importance of digital technology and its impact on the employee experience in Indian firms. The results show that if a company has to thrive through these testing times, the only solution is through the integration of technology into their organizational structure. This has to be a permanent inclusion instead of a temporary solution for battling the side effects of the Covid-19 lockdown. The results also show that technological resolutions offer sustainable compensations across the business segments, and companies should emphasize investing in updating employee's skill sets. Through the survey, it was also evident that organizations and institutions irrespective of their size or market share had to incorporate employee development including basic technological know-how apart from technical skill sets. These initiatives will help the organization and institutions to maintain their business models and profitability even in post-Covid times. Human resource practices backed by technology have enabled employees to lead a flexible life, grasp learning opportunities, stay safe, engaged, agile and motivated throughout the lockdown and quarantine periods.

1 Introduction

Technology helps employees make their tasks easier, have better collaboration with their colleagues, and also provides them with a secure environment. Technology definitely provides benefits that help create a positive experience for the employees. Our study focuses on employers who have ventured into the domain of technology and have also been able to create employee satisfaction in their organizations. Ultimately, if employees are satisfied, they shall take good care of the customers too.

The usage and application of technology have developed across the world, and the real implementation of novel and emergent technologies across most establishments endures to be less than ideal. Due to numerous barriers, tech implementation (virtual teams) at an executive level is often slow or does not exist. This keeps old inheritance procedures thriving and delays an organization from attaining its full potential proficiently. This delay in embracing has been a huge worry for businesses but now, amongst the pandemic, it is a catastrophe. The future of virtual teams is very promising shortly. It has its pros and cons. Some of its pros are work from home, flex working hours, maximum inclusion of professional at distant places (geographically dispersed), cost-saving due to travelling and sharing knowledge across boundaries which has become easier due to virtual teams. The cons could be communication problems, technical glitches, reduced team engagement, isolation, trust

J. Chandwani (✉) · D. Shah
Vivekanand Education Society's Institute of Management Studies and Research, Mumbai, India
e-mail: Jyoti.chandwani@ves.ac.in

D. Shah
e-mail: Disha.shah@ves.ac.in

A. Shaikh
Talent Development & People Excellence, Bizongo,
Mumbai, India
e-mail: Aarfa14@gmail.com

factor, human touch, etc. (Dulebohna & Hoch, 2017). Virtual tools play an important role in communication in virtual teams (Gibson & Cohen, 2003a). On the contrary, it was also found that virtual teams take longer to complete the task assigned to them (Marlow et al., 2017).

The role of managers plays a vital role in employee experiences. Managers with supremacy motivation would not like to share the required support and power for gender equity in the organizations. They would like to focus more on retaining their power which may lead to gender gaps. On the other hand, managers who believe in status motivation would be more towards the growth of the employees and the organization as a whole. Such managers realize the importance of power-sharing benefits for the growth of the organization (London et al., 2019). Studies have shown that managers who have a collective approach towards the organization support and motivate their employees, and such managers provide all the opportunity to their employees from resource sharing to training and development. They plan and design policies that would benefit the employees and the organization as a whole. They also involve employees in participation management to make and communicate the objectives of the Institutions easily. They also clearly lay down the performance standards which would be further measured for their appraisals and growth (Le et al., 2020).

Jossa et al. (2020) have distinguished amongst the various forms of flexi works culture in the globe. These findings were unique in their form (Reiche et al., 2019). In the area of employee experience related to digital technologies, not much work has been done. As industries have been forced to re-evaluate their business models either partially or fully, many have accepted technology to pledge problematic market conditions—making outwardly facing variations, such as refurbishing their online occurrence to stalk falls in income, or inner ones, such as systematizing payroll functions or using an enterprise-wide device to retain flap of workflows to permit their teams to work efficiently and effectively from home. The work from home has bought different insecurity amongst the employees. The feeling that the career growth of the employees is not in the hands of the organizations is bringing discomfort amongst the employees. Employers may be reluctant to invest in the current employees if they assume that the employees may leave the organization (Griffitha et al., 2019). So, to discuss the motivation, responsibilities, impact, etc., become challenging (Suutari et al., 2013).

Initially, organizations were just focused on employee engagement which has now evolved into the employee experience. This is assumed at the forefront of human resource practitioners. Since the global economy is now ever competitive, talented individuals now have a plethora of options to choose from and while deciding the workplace,

they look at building their careers with. Compensation is not the only motivating factor for employees, they look at workplaces that suit their lifestyle, mindset, provide opportunities to learn and have a strong culture that they can resonate with. The most critical challenges HR are facing is to meet the expectations of the employees in the competitive and ever-changing world. Attracting the right employee and retaining them is also the biggest challenge. This all adds to the challenges faced due to Covid-19 due to work from home setup (Kutaulaa et al., 2020).

Amongst the other global trends and changes in human resources (HR) policies in the competitive world, the focus is also on diversity. Diversity is one of the most important factors for considerations. Studies have shown that although diversity brings innovation and better decision-making in the process to the organization on the other hand, it also adds to the discomfort and demotivation amongst the existing employees. Such demotivation can lead to grouping and sub-grouping in the organizations which is a cause of concern for the organizations in long term (Buengelera et al., 2018).

Employee experience can positively impact an organization's overall brand image by being able to attract the right talent, create a workplace that fosters innovation and also provide a positive exit experience. Designing an employee experience is therefore also not an easy task; HR practitioners, therefore, spend a great deal of effort in making sure they get it just right. One of the most important enablers for HR practitioners in helping shape their organization's employee experience is technology. Employers who have been able to use technology to decode their employee experience are far more ahead in this game. Bagdadlia and Gianecchini (2019) found that when employees are provided with difficult and challenging situations, it allows updating and acquiring new knowledge. This applies also to decision-taking capacity and technology. Such challenges bring the hidden competencies and the potentials the employees have, which they are not aware of. Ultimately, this results in learning and development (McCauley et al., 1995).

Epidemics and pandemics have always been there in the world posing threat to humanity. However, with such conditions that mankind faces, they emerge stronger to combat it each time. The current pandemic state of affairs has elevated diverse technological improvements across all fields globally. One of the most vital and crucial factors which the pandemic has affected worldwide is businesses and industries. Organizations that have already been leveraging technology were able to smoothly manoeuvre around this situation and still be able to provide the experience and comfort to their employees even while staying at home. This has been possible as they adopted digitization in more than one area of their business inclusive of human capital

processes. There have been various studies that have shown the correlation between technology and one facet of HR processes. This research presents the result of an empirical study grounded on data collected from respondents situated in India. A measure of questions was built and verified for its validity and reliability. The literature on the employee experience and the role of digital technology in India is mostly found under employee engagement. Employee experience reports professional articles in specialized and professional journals and websites. These publications along with the track records of employee experience and the role of digital technology have facilitated in classifying employees appropriate for sampling prerequisites of the current study. Based on surveyees responses, the characteristics of employee experience and digital technology in Indian organizations were selected. These characteristics were then deliberated to appreciate the existing position of employee experience and role of digital technology, and effort has been made to find a relationship between them to the content of prevailing literature to comprehend the factors that may help in fruitful expansion and execution of possible explanations to venture into forthcoming marketplaces. The discussion provided in this paper would lead businesses to design an organization that would be more flexible to upcoming marketplaces, and it may possibly help in attaining a stronger market position against the rivalry.

2 Literature Review

In the history of the Internet and technology, opportunities have run high for it to "change everything". Companies are moving from the traditional way to online across the variety of marketing activities, from building responsiveness to aftersales provision. They have also realized that online technology and tools are an important and effective factor in their promotion policies (Meadows, 2008). The expenditures related to procurement, assembly and preservative sites at places of work could be very high and would lead to a loss if the usage of such sites is low. This could be more justified for work which can be directed directly in using electronic technologies that would make communication in different forms such as speech, images and words with the people who are physically not accessible (Bain & Taylor, 2000). Subjective indication, even individual knowledge, proposes that salaried service is no longer limited to elected hours accepted out in a quantified dwelling. This smears particularly to directors, experts and other white-collar labourers. Better technical connectivity enables this procedure by permitting effort to be approved out wherever labours transpire to be and whatsoever the period (Messenger & Gschwind, 2016).

Research has shown that investments in digital technologies and work practices affect the construct of the organization (Garicano, 2000; Garicano & Hansberg, 2006). Research has also proved that a well-designed organization would motivate the employees, and this results in better job performance. Such well-designed organizations bring a positive attitude towards job satisfaction in the employees (Boxall & Macky, 2009). In most of the present studies, the emphasis is put more on progressive work practices, but technologies are mainly abandoned (White & Bryson, 2013). Gratified labours are more creative than others (Böckermana et al., 2012) and have lesser turnover ratios (Beockerman & Ilmakunnas, 2009). Reducing the cost of assembling, distribution and gaining material would make knowledge inexpensive and enables parallel relations (Askenazy & Caroli, 2010) Askenazy and Caroli (2010) use of digital technology also permit employees to handle difficulties in a much better way without taking the help of others.

The use of technology through Internet use brings better results, and it can be absolutely associated with the societal provision, job fulfilment and extra determination (Martin & Omrani, 2015) and with basic inspirations. The uses of digital technologies like online conferencing and emails are familiarized to employees to measure knowledge that enables inner and outside information admittance (Joyce & Slocum, 1984).

When a worker advances association with exterior shareholders, he or she can become a representative or promoter for the organization (Chong, 2011; Gronstedt, 2000; Guillaume et al., 2014) study suggested that discussions amongst clients and staff who were well versed with digital technology were reliable as a sincere source of information. This trust was more effective than building trust through corporate promotion and information from CEOs (Cheney, 1999) contended that it is significant to start to link inner and outside people to attach employee eagerness for a better client facility (Gronstedt 2000).

Research by Mishra et al. (2014) found that motivated employees are loyal towards their employers. Such employees love their work, and this could be seen by the business outcomes which include low absenteeism, turnover ratio, a smaller number of accidents, high production level, etc. Mishra et al. (2014), employees enjoy working in a situation where they share beliefs with their colleagues, and they feel proud to be associated with them. Guillaume et al. (2014) also suggested that organizations that have a transparent and open culture treat their employees well. This trust is strengthening more than the communication comes directly from the top-level rather than through the intermediate level.

Customer Think (2020) also originates that directors' inner message with their personnel inspires their assistants to

offer the greater facility to clienteles. Payne and Clark (2003) believes that the best way for any organization to grow is that it should encourage questions and doubts. This would bring trust to the employees. As a part of the international assignment which works on a long-term basis, the world has become a flexible global workplace. This has become a trend of most of the MNE's global companies (Wood & Salt, 2011). Bozkurt and Mohr (2011) has also shown the importance of value creation of the global work forms in his studies. The major advantages of such global workplaces are its flexi working hours, cost-saving, diversity, etc. (Shaffer et al., 2012; Shankaran et al., 2011; Tahvanainen et al., 2005).

For the review, different studies related to different articles on the role of digital technology in different industries have been studied. We have also studied the human resources policy and the experience of employees that we have systematically organized current literature. Cooke et al. (2020) study has shown that flexible working hours has its own predominant challenges along with its experiences. Therefore, there is a need to bridge older research with newer literature and use appropriate theories to explain discrepancies between results. In response to these gaps, we integrate current literature by organizing it around an overall framework designed to inform future research about the correlation between all HR processes and technology. This study would also extend its impact on the strengthening of employee experience and way forward for the industry as well as society in entirety.

3   Research Method

The following segment describes the methodology used to analyse the data collected from respondents. For the purpose of this study, a questionnaire was circulated, and 308 respondents were approached within Mumbai for understanding the role of digital technologies and employee experience after six months of the Covid-19 nationwide lockdown.

3.1   Data Collection Tools

The study's objective is to find factors that may aid in understanding the impact technology has on employees' work-life during this pandemic and its importance for times thereon. To comprehend the current state of affairs of our country's economy and industries, a large number of respondents were chosen for the analysis. A questionnaire was designed focusing on both categorical data and quantitative questions using a five-point Likert scale (1-strongly disagree to 5-strongly agree). Secondary data sources such

as digital technology reports, employee guidelines, pink papers, academic journals and significant contributions from the accessible work were used to understand the impact on employee's work experience, due to the sudden change in usage of technology for all businesses and profiles. The questionnaire was further divided into sub-segments thereby focusing on all constituents that would help an employee to rate his/her experience using technology to aid their work from home experience. Following are the sub-segments through which it was attempted to give equal focus on all facets of an employee's work sphere:

a. Communication and technology
b. Learning and technology
c. Engagement and technology
d. Rewards and technology
e. Performance and technology
f. Work timelines and technology

3.2   Sampling and Data Collection

The population for the study covered Indian employees related to companies belonging to different sectors having a substantial impact on the organization's operations and sustenance. Employees were selected on the basis of their availability and role in their organisation; thus, a convenience sampling method was used for the study. For data collection, the questionnaire was e-mailed to over 400 employees of different firms & Industries across India. To shelter the general perception about employee experience and the role of digital technology, the questionnaire was emailed to respondents with different employment types and sectors. The effective sample size for the study was 308. The respondents were primarily (72.73%) in the age group of 24–40 years, of which 42.86% were male and 29.87% were female. The majority of the respondents had work experience of more than 10 years 35.71% and between 5 and 10 years 26.62% constituting a total of 62.34% of respondents having work experience for more than 5 years. These analogies of respondents were voluntarily disclosed.

3.3   Data Analysis Methods

Principally in this primary study, data analysis was used to understand if the increased usage of technology has been a boon or bane for the employees and secondly to evaluate the execution of technology in Indian companies and to understand if this may have created a competitive advantage for the employee and their company. Basic statistical tools have been used in analysing the responses of surveyees and have

a deeper understanding of employee preferences towards the increasing usage of technology in light of work from the scenario. A total of 308 respondents participated in this study. Of the 308 respondents, 87% were full-time employees and of these 268 respondents, 59% of them are from Software/IT, Banking and Education Industry (Table 1). The employees surveyed for this study were largely (73%) in the age group of 24–40 years keeping the focus of the study on understanding the extent to which employees have been affected by the pandemic and the aid provided by technology. The survey further showed that 54% of the respondents in this age group and 74% of all 308 respondents have a post-graduate degree or a professional degree making them well versed with the use of technology and the ideal set of respondents to evaluate the pros and cons of technology dependence in these times (Table 2).

4 Research Findings

The questionnaire is designed to cover all aspects of an employee's corporate life that are impacted by the change in technology during the pandemic in the nation as well as across the world. The survey emphasized that over 70% of employees believe that their companies have used and made available latest technologies over the last six months. The survey was divided further into six parts, thereby understanding the dynamics of technology with various factors such as performance, learning, communication, performance and work to enable companies / industries to create a mutually beneficial environment by making clear policies that can make the transition sustainable.

4.1 Factor 1: Communication

Communication is a two-way process; for an employee to perform his duties, the company must follow direct, clear and monitored forms of communications and listen to its employees. Through the responses received and seen in Table 3, it can be inferred that companies have moved from the age-old route of information dissemination such as bulletin boards (10.06%), grapevines (12.99%) to company email (85.06%), company intranet (51.95%) and website (37.66%). With the change in the communication channels by company, majority of employees (88.96%) concur that they are well informed about their company Since the communication now is received from the information owner,

Table 1 Industries and types of employees covered as respondents

Industry	Employee type					
	Consultant /contract based	Freelancers	Full-time employee	Part-time employee	Temporary employee	Grand total
Banking	4		38			42
BPO/KPO/			14			14
Broadcasting/media services			6			6
E-commerce (B2B)			2			2
E-commerce (B2C)			2			2
Education	4	2	28	2		36
Government and public administration			6			6
Health care and social assistance			2	2		4
Hotel/food and beverage services					2	2
Legal/tax/management consulting	2		4			6
Manufacturing			16			16
Others	4	10	42			56
Real estate, rental and leasing			10			10
Retail (non-banking)			6			6
Software/IT industry	8		92			100
Grand total	22	12	268	4	2	308

Table 2 General description of the respondent's work experience and educational qualification

Work experience	Education				
	Bachelor	Others	Post graduate	Professional degree	Grand total
>10 years	20	4	58	28	110
1–3 years	10		48	12	70
3–5 years	20		20	6	46
5–10 years	24	2	40	16	82
Grand total	74	6	166	62	308

Table 3 Types of communications received by employees

Types of communications	Percentage
Benefits	49.35
Company success stories	61.69
Compensation and bonus programs	39.61
Competitive initiatives	40.26
Government affairs affecting the company	24.68
Human resources process	54.55
Issues and trends affecting our business	40.91
Key customer business issues	29.87
Marketing programs	32.47
Products and services of the company	43.51
Technology developments	51.30
The company's capabilities	35.71
The company's strategies for the future	50.65
The overall financial picture of the company	35.71

it is observed in the survey results that over 81.17% of respondents trust the information received. The response from employees also emphasized that all types of communications such as announcements and change in policies in companies have used various technological tools to disseminate them to all employees.

With the shift in the communication mode, during Covid-19 pandemic, over 75.32% of respondents have seen an increase in the organization's efforts to strengthen communication within the organization. This has led to a plethora of information being shared with the employees, as seen in the survey only 16.23% of respondents believe that the emails received are less than required. This has made the employee selective in reading the information shared, the same has been seen in the respondents; only 55.19% read majority or all the information sent. But over 90% of respondents believe that Information received from the organisation via formal communication channels (emails, intranet) are clear and easy to understand. Organizations have made sure that all communication tools used are user friendly and easy to navigate (95.54%). Due to the ease of communicating, it has become increasingly simple for employees to give feedback (57.79%) to companies. Cheney (1999) recommended few principles related to the work

which can be reviewed through the importance of the messages. Translucent administrations tend to segment info extensively. "Dolphin (2005) affirmed that sound relationships can only be developed based on trust and reliable information". Streamlining of organizational roles and duties through internal communication boosts productivity Benner and Tushman (2003).

4.2 Factor 2—Learning

Educating is a lifelong process for anyone who wants to bourgeon in their career and personal life. The recent complete lockdown and partial lockdown gave everyone free time from doing other activities. This culture of learning and enhancing one's job skills was the preferred initiative by most of the organizations to promote (88.31%) Table 4. This culture has seen a multi-fold increase in employees preferring online learning (78.57%) as against in-person learning (21.43%). Various LMS tools have now become the talk of the town, and companies' usage has shown an unprecedented increase to (74.68%) during the last 6 months. Times such as these always pose an opportunity to learn and expand an employees' skillset but 52.60% of our

Table 4 Learning culture in respondents' organization

Organization	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
Promotes learning culture	2.60	9.09	20.78	43.51	24.03
Has witnessed an increase in online learning culture during pandemic	2.60	8.44	23.38	37.66	27.92
Technology-based learning activities (LMS, E-learning, webinars, virtual classrooms and sessions) promote engagement towards the organization for you	2.60	9.09	31.82	44.81	11.69

respondents cited that Indian companies are yet to recognize this opportunity and provide the required incentives. Though companies are increasingly using various technology-based methods to promote their engagement with employees and reduce the physical distance was experienced by 56.49% of respondents. 79% of IT managers surveyed, recognized and understood this need to assess digital mobile strategy within the organization (Chambers, 2015). Thierer (2015) cites that regardless of the trepidations of confidentiality and safety, associated devices and the applications make lives calmer, safer, better and more constructive compared to without these technological developments.

4.3 Factor 3—Employee Engagement

Employee engagement is the tool a company can use to retain its best employees. Due to the integration of technology, companies have been able to motivate and engage their employees even during times of lockdown, which was experienced by 86.36% of respondents. There was seen a transition among employees' preference and ease in interacting through online engagement. Through the response, it was observed 66.23% have the same experience of engagement whether in-person or online, and 10.39% preferred online engagement. Through these last six months of various phases of lockdown, 64.29% of the respondents regularly experienced employee engagement activities initiated by their companies irrespective of their industry. Employee engagement is the amount of employee commitment, both emotive and balanced survive to achieve the mission and vision of the organization (Gupta, 2015). In addition to the rise of modern flexible work, styles are the need for organizations to be supporting employees to work; however, they work best. This is directly related to the notion of employee engagement and maintaining a productive and effective workforce (Chambers, 2015). Extremely involved employees tend to do better than their co-workers by 20–30% (Conzelmann, 2017). Companies with highly involved personnel have an advantage in these unprecedented times, which also indicates that such employees are more flexible than their foils (Macey et al., 2009). Employee

engagement can be wedged from numerous inspirations in the office and can help shift an individual's effects also (Bakker et al., 2006).

4.4 Factor 4—Rewards and Recognition

With the world, we know going through a paradigm shift in how one sees it, feels it and how it works, it becomes imperative to safeguard and appreciate the part which one can hold dear and can salvage from the turmoil. This is exactly what companies have been making efforts towards through recognition and rewards, 70.13% of respondents agreed. The approach of giving rewards and recognition to employees has gone through a change from in-person reward and recognition to online reward and recognition, with 55.84% of respondents' companies having online tools for reward and recognition. There has been a transformation in the employees' preference; 74.03% of respondents preferred online reward and recognition.

Online reward and recognition tool has changed their focus over the years from being a mere communication tool to an evaluation and communication tool. This change can be seen clearly in the features that employees (Table 5) associate with online reward and recognition with nearly 60% of respondents selecting transparency as the primary feature but also giving equal importance to instant gratification (33.12%) and (41.56%) for the variety of rewarding options it offer.

4.5 Factor 5—Employee Performance

Employee performance can be summed up as how an employee performs and executes his duties with effectiveness, quality and proficiency during his tenure with the company. Evaluation of employee performance is a method used by companies to communicate how valuable is the employee and his or her contribution to the organization.

During this unprecedented pandemic, most companies and industries are experiencing challenging times thereby finding it tough to sustain their employees and company with

Table 5 Parameters for online recognition and rewarding options selection

Parameters	Percentage
Gamification	14.94
Instant gratification	33.12
My organization does not have an online recognition tool	29.87
Transparency	59.09
Variety of options to choose from	41.56

a sudden and direct impact on the revenues and bottom lines. This has had a direct impact on the performance management and appraisal system, where only 34.42% of the respondent's companies' re-engineering their performance management process to adapt to the extraordinary circumstances. The remaining 65.58% of respondent's companies have either deferred the process for a future date, cancelled the performance assessment for this year or evaluated the performance on the same lines as the year before. The absence of any modification would result in a sweeping drop in employee's belief towards the organization's competency in assessing employee performance effectively, which through the survey was seen to as high as 82.47%. The questionnaire also revealed that only 58.44% of respondents' companies are equipped with an online performance management tool. The crux is that the possibilities of mobile technology are making our lives easier outside of work, and the same outcome could be extrapolated towards improving our experience at work (Chambers, 2015).

4.6 Factor 6—Work from Home

The Covid-19 pandemic hit India in March 2020, and the nationwide twenty-one days lockdown was imposed on 24th March 2020. During this period, the country and people of the nation were coming to terms with the new rules, regulations and adjusting to the completely alien lifestyle of "Stay Home Stay Safe". This leads all companies asking employees to work from home, and the same is observed through our respondent's replies where 83.77% have shifted to work from home. Of the remaining 16.23%, only 2.60% could not work due to a lack of technological advancement in their organizations. Further, it was observed (Table 6) that 53.25% of respondents' companies assisted them in making the transition to working from home and thus helping them to execute their deliverables.

As the lockdown progressed, companies started adapting to the technological solutions and innovations that helped employees (86.36%) deliver their work in time and without any derailments. These initiatives from companies started displaying results where 55.84% of respondents saw an increase in their productivity. This only reiterates that the amalgamation of technology in a company's operation and

working is not a short-term change but a new inclusion that is here to stay.

5 Discussion and Managerial Implications

The study focuses on the importance of employee experience which is critical in the human resource fraternity and why organizations are exceedingly investing in employee experience as much as customer experience. Despite the quoted benefits of technology and its impact on creating a positive employee experience, some businesses are yet to utilize such platforms. Employees today experience advanced technology in their personal and social lives due to the dynamic and affordable change in technological advancements globally. Hence, they expect the same standards when it comes to their profession. Organizations that shall meet this technological benchmark of employees will be able to have a workforce that is committed, satisfied and productive. Employees in their private lives look for one-stop solutions; hence, they carry the same expectation to their workplace where they can grasp all the requisite tools for communication, work management, work-life enhancement and learning at a single place. Industries will need to create the experience for their employees not just with the presence of the digital technologies, but the equal emphasis needs to be given to user interface, ease of access and navigation, and presence of artificial intelligence.

Technological innovations guarantee employee satisfaction; however, understanding the technology shall help enhance the experience of employees, bring about the desired results and help in ease of adaptation. The study has shown that employees have a high level of expectations with regards to their workplace. However, this cannot be achieved only through digital advancements, but the entire organization and the industry as a whole need to work as a comprehensive ecosystem to truly create a transformation. Gustafson (2012) studies have proved that you cannot separate virtual work from physical work both complement each other. It is not a substitute for one another. The Covid-19 may give options for the intensity of using the work from home concept.

The findings of this study shall also aid organizations and industries to frame vision and groundwork essential for

Table 6 Parameters to understand ease of work from home

Criteria	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
Organization helps you deliver work outputs	1.30	6.49	38.96	44.81	8.44
Technology used by your organization helps you deliver the best at your work	3.90	9.74	26.62	50.65	9.09
Work from home increases your productivity	7.79	14.29	22.08	42.86	12.99

upcoming technologies and markets amongst the constraints and processes. The organization may become effective in implementing digital technological capabilities to identify and enhance employees' skills set. To make the most of the financial returns on employee experience, organizations should also look for favourable up-gradation of technology. This would aid the future body of knowledge in understanding global mobility in a much better way (Farndale et al., 2014), studies have shown that the experience of employees from work from home was taken into considerations. This would help in understanding the HR functions' roles and responsibilities in a better way.

To withstand extensive competition, organizations should endeavour to instruct and impart skills and knowledge of digital technology to employees. Pre-existing skills and information may help in the strong positioning of the organization in the market. The role of top management in investing for up-gradation of technology in the organization shall plays an important role. This investment shall assist the top management to establish more ambitious goals and generate advanced products and services which would be pertinent to the future market requirements. Industry leaders should have a clear vision about the role of technology and employee experience to make the most for their business. Last but not least, the flexible work culture is still at its nascent stage, while many studies on it is easily available in the last few years, but further empirical research is needed.

6 Conclusion

In the onset of the coronavirus global pandemic, work from home (WFH), which had been primarily an option only to IT sector employees, now beckons at the doors of all organizations across industries and employment types. Now, so that business, as usual, can continue, many sectors have started to embrace WFH as seen through the survey. The study's findings have thrown light on various mindsets and widen the acceptance of technology as the "new normal employment type". One has witnessed a change in the perception of employees towards communication channels used by companies and their authenticity. The employees and companies have experienced the merit in promoting online learning culture through various LMS tools and incentivized learning of new skillsets for employees. These testing times have showcased a special bond between employees and employers through innovative ways to retain and engage employees. Parameters of rewards and recognition options have changed with the introduction of online tools, instilling not only transparency and faith but also giving employees instant gratification and choice towards selecting the rewarding options. It was also observed through the survey that many companies in various organizations have re-engineered their performance management systems or deferred appraisals due to the impact of Covid-19. This has impacted not only the company's business and industry but also the national and global economy at large. But there is hope even in these testing times for companies which were discovered through the respondents; over 50% of the respondents have seen an increase in their productivity levels. Technology cannot help avoid the onset of pandemics; however, it can help to curb them through awareness and thereby lessening its impact. Industries through digitization were able to offer safety to their employees through the system of work from home. Remote technologies, collaboration tools, data management through cloud applications and virtual meetings have all facilitated this change seamlessly. The experience that the employees gain through the digitization efforts of their organizations and industries also helps in the overall upliftment of society by creating generations of educated, aware and tech-savvy population. The leap that society has taken during this period is only going to grow exponentially and, in the future, there shall be greater rewards to reap from this accelerated path. Employees have been appreciative of the extra effort that companies have gone through so as to help all stakeholders in their organization to stay afloat. The benefits of making the employees' transition seamless from brick and motor facility to work from home scenario are being reaped by companies immediately. Employees have reported an increase in their productivity as compared to pre-Covid era.

References

Askenazy, P., & Caroli, E. (2010). Innovative work practices, information technologies, and working conditions: Evidence for France. *Industrial Relations a Journey of Economy and Society, 49*(4), 544–564.

Bain, P., & Taylor, P. (2000). *New technology, work and employment* (Vol. 15(1), pp. 2–18). Blackwell Publishers Ltd.

Bagdadlia, S., & Gianecchini, M. (2019). Organizational career management practices and objective career success: A systematic review and framework. *Human Resource Management Review, 29*(3), 353–370.

Bakker, A. Bal., & H. Van Emmerik, M. C. (2006). Euwema.Crossover of Burnout and Engagement in Work Teams. Work and Occupations 33 (4), 464–89 (2006). doi: https://doi.org/10.1177/0730888406291310.

Benner, M. J., & Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review, 28,* 238–256.

Beockerman, P., & Ilmakunnas, P. (2009). Job disamenities, job satisfaction, quit intentions, and actual separations: putting the pieces together. *Industrial Relations, 48*(1), 73–96.

Böckermana, P., Brysonb, A., & Ilmakunnas, P. (2012). Does high involvement management improve worker wellbeing? *Journal of Economic Behavior & Organization, 84*(2), 660–680.

Boxall, P., & Macky, K. (2009). Research and theory on high-performance work systems: progressing the high-involvement stream. *Human Resource Management Journal, 19*(1), 3–23.

Bozkurt, O., & Mohr, A. T. (2011). Forms of cross-border mobility and social capital in multinational enterprises. *Human Resource Management Journal, 21*(2), 138–155.

Buengelera, C., Leroy, H., & Stobbeleir, K. D. (2018). How leaders shape the impact of HR's diversity practices on. *Human Resource Management Review, 28*(3), 2893–3303.

Chambers, R. (2015). *The SAGE handbook of action research*, 3rd edn. USA: Oregon Health & Science University. https://doi.org/10.4135/9781473921290.n4.

Chong, M. (2011). The role of internal communication and training in infusing corporate values and delivering brand promise: Singapore Airlines' experience. *Corporate Reputation Review, 10,* 201–212.

Cheney, G. (1999). *Values at work*. Ithaca, NY: ILR Press.

Conzelmann, J. (2017). *Servant leadership and followership: Examining the impact on workplace behavior*. Cham: Palgrave Macmillan. Junction City, USA: University of Phoenix.

Cooke, F., Dickmann, M., Parry, E. (2020). Important issues in human resource management: introduction to the 2020 review issue. *International Journal of Human Resource Management, 31*(1), 1–5.

Customer Think. (2020). https://customerthink.com/about-us/. Last accessed 2020/10/27.

Dolphin, R. R. (2005). Internal communications: Today's strategic imperative. *Journal of Marketing Communications, 11,* 171–190.

Dulebohna, J., & Hoch, J. (2017). Virtual teams in organizations. *Human Resource Management Review, 27*(4), 569–574.

Farndale, E., Pai, A., Sparrow, P., & Scullion, H. (2014). Balancing individual and organizational goals in global talent management: A mutual-benefits perspective. *Journal of World Business, 49*(2), 204–214.

Garicano, L. (2000). Hierarchies and the organization of knowledge in production. *Journal of Political Economy, 108*(5), 874–904.

Garicano, L., & Hansberg, E. R. (2006). Organization and inequality in a knowledge economy. *The Quarterly Journal of Economics, 121*(4), 1383–1435.

Gibson, C., Cohen, S. (2003). *Virtual teams that work creating conditions for virtual team effectiveness*. New York: Wiley.

Griffitha, J., Baurb, J., & Buckleyc, M. (2019). Creating comprehensive leadership pipelines: Applying the real options approach to organizational leadership development. *Human Resource Management Review, 29*(3), 305–315.

Gronstedt, A. (2000). *The customer century: Lessons from world-class companies in integrated marketing communication*. New York, NY: Routledge.

Guillaume, Y. R., Dawson, J. F., Priola, V., Sacramento, C. A., Woods, S. A., Higson, H. E., & West, M. A. (2014). Managing diversity in organizations: An integrative model and agenda for future research. *European Journal of Work and Organizational Psychology, 23,* 783–802.

Gupta, M. (2015). A study on employees' perception towards employee engagement. *GMJ, 9*(1, 2), 45–51.

Gustafson, P. (2012). Managing business travel: Developments and dilemmas in corporate travel management. *Tourism Management, 33*(2), 276–284.

Jossa, S., McDonnella, A., Conroyb, K. (2020). Flexible global working arrangements: An integrative review and future research agenda. *Human Resource Management Review*, 100780. https://doi.org/10.1016/j.hrmr.2020.100780.

Joyce, W. F., & Slocum, J. (1984). Collective climate: agreement as a basis for defining aggregate climates in organisations. *Academy of Management Journal, 27*(4), 721–742.

Kutaulaa, S., Gillanib, A., & Budhwarc, P. (2020). An analysis of employment relationships in Asia using psychological contract theory: A review and research agenda. *Human Resource Management Review, 30*(4).

Le, H., Newman, A., Menzies, J., Zheng, J., & Fermelis, J. (2020). Work–life balance in Asia: A systematic review. *Human Resource Management Review, 30*(4).

London, M., Bear, J., Cushenbery, L., & Sherman, G. (2019). Leader support for gender equity: Understanding prosocial goal orientation, leadership motivation, and power sharing. *Human Resource Management Review, 29*(3), 418–427.

Macey, W. H., Schneider, B., Barbera, K. M., & Young, S. A. (2009). *Employee engagement: tools for analysis, practice, and competitive advantage*. New York, NY: Wiley-Blackwell.

Marlow, S., Lacerenza, C., & Salas, E. (2017). Communication in virtual teams: A conceptual framework and research agenda. *Human Resource Management Review, 27*(4), 575–589.

Martin, L., & Omrani, N. (2015). An assessment of trends in technology use, innovative work practices and employees' attitudes in Europe. *Applied Economics, 47*(6), 623–663.

McCauley, C., Eastman, L., Ohlott, P.: Linking management selection and development through stretch assignments. *Human Resource Management, 34*(1), 93–115.

Meadows, K. D. (2008). Mobile marketing: Achieving competitive advantage through wireless technology. *Journal of Direct, Data and Digital Marketing Practice, 9,* 406–408.

Messenger, J., & Gschwind, L. (2016). Three generations of telework: new ICTs and the (r)evolution from home office to virtual office. *New Technology, Work and Employment, 31*(3), 195–208.

Mishra, K., Boynton, L., & Mishra, A. (2014). Driving employee engagement: the expanded role of internal communications. *International Journal of Business Communication, 51*(2), 183–202.

Payne, R. L., & Clark, M. C. (2003). Dispositional and situational determinants of trust in two types of managers. *International Journal of Human Resource Management, 14*(1), 128–138.

Reiche, S., Lee, Y., & Allen, D. (2019). Actors, structure, and processes: a review and conceptualization of global work integrating IB and HRM research. *Journal of Management, 45*(2), 359–383.

Shaffer, M. A., Kraimer, M. L., Chen, Y. P., & Bolino, M. C. (2012). Choices, challenges, and career consequences of global work

experiences: A review and future agenda. *Journal of Management, 38*(4), 1282–1327.

Shankaran, G., Murray, R. A., & Miller, P. (2011). Short-term international assignments: Maximizing effectiveness, minimizing cost and risk. *International Tax Journal, 37*(1), 41–60.

Suutari, V., Brewster, C. J., Riusala, K., & Syrjäkari, S. (2013). Managing non-standard international experience: Evidence from a Finnish company. *Journal of Global Mobility, 1*(2), 118–138.

Tahvanainen, M., Welch, D. E., & Worm, V. (2005). Implications of short-term international assignments. *European Management Journal, 23*(6), 663–673.

Thierer, A. D. (2015). The Internet of Things and wearable technology: addressing privacy and security concerns without derailing innovation. *Richmond Journal of Law and Technology, 21*(2), 1–118.

White, M., & Bryson, A. (2013). Positive employee attitudes: how much human resource management do you need? *Human Relations, 66*(3), 385–406.

Wood, P., & Salt, J. (2011). Shifting portfolios of international labor mobility among UK-based business consultancies. *Geoforum, 43*(4), 815–823.

Driving Employee Engagement in Today's Dynamic Workplace: A Literature Review

Saumya Shirina and Richa Sharma

Abstract

Increasing engagement is a primary objective of organizations seeking to understand and measure engagement. Employee engagement is the extent to which employees feel connected, passionate about their duties at work and are committed and put unrestricted effort into their work. Employee engagement strategies have been proven to reduce staff turnover, improve productivity and performance, retain customers at a greater rate and make more profits. Employee engagement today has become interchangeable with terms like employee satisfaction and employee well-being. Professionals have a higher possibility to be "distracted" and "disengaged" at work in the dynamic workplace today. Most importantly, engaged employees have a sense of well-being and are happier both in their personal and in their professional lives. High levels of work engagement are when employees are involved with, committed to, enthusiastic, and passionate about their work. The objective of this research is to do a literature review and analyse the result that focuses on the evolving role of employee engagement practices in the dynamic workplace of today.

Keywords

Employee engagement • Engagement practices • Work engagement • Dynamic workplace

1 Introduction

As a consequence of the global corporate environment and competition among companies, getting happy and committed employees is not enough to produce the desired performance. Satisfied employees can necessarily satisfy job requirements; however, this does not, in fact, translate to better results because of certain factors. In order to succeed successfully, companies need to direct their efforts beyond fulfilment, managers inspire their employees to contribute their maximum ability and abilities to their jobs, if not, and they may lose any of their valued employees. Thus, modern organisations need their employees to be full of passion, anticipation and enthusiastic at their jobs if they want them to work efficiently. Commitment is accomplished as individuals feel that their employer values their efforts, that their work leads to corporate priorities and, most critically, that their personal goals for progress, incentives and compensation are fulfilled. Improving workplace engagement has become one of the most critical priorities for a variety of organizations. That is because higher rates of workplace efficiency offer the company and its employee's different benefits. For example, higher productivity contributes to positive economic development and high prosperity and leads to social change (Sharma & Sharma, 2014). In turn, employees become more successful and will get higher wages, congenial working conditions and more career prospects. Higher efficiency helps to optimize corporate comparative advantage by rising expenses and increasing high-quality performance (Baily et al., 2005; Hill et al., 2014; Wright, 2004). Many of the advantages have rendered the efficiency of employees which are deserving consideration. It is also very important to look at the history of employee engagement in order to study and evaluate factors that incorporate stability and long-term performance. The studies of the 2017 Gallup Poll (Boyle, 2017) analysed just 33% of US employees and found 15% of global employees are working effectively and efficiently. Employee participation is amongst the top three targets amongst the organizational interpersonal relations (Mishra et al., 2014). While communication practitioners use a multitude of platforms to promote interaction (Men & Bowen, 2017; Mishra et al., 2014; Welch, 2011; Welch & Jackson, 2007), they

S. Shirina (✉) · R. Sharma
Amity Business School, Noida, India
e-mail: rsharma25@amity.edu

progressively use social networking as part of their internal contact policy. Cardon and Marshall (2014), Haddud et al. (2016), Neill (2015), Sievert and Scholz (2017), Gartner (2013) estimated that by 2016, 50% of major companies will depend on internal social networking for effective relationships (Weber & Shi, 2016) promoted the development of internal social networking and predicted that by 2017, businesses would spend $2.7 billion in internal social media networks. Today's workforce is becoming increasingly technology-savvy, particularly with the first generation of employees who have grown up in the digital age. The increasing introduction of social networking into companies is contributing to a reshaping of the internal contact approach as businesses try to boost organizational reputations and promote employee involvement (Huang et al., 2013; Madsen, 2017; Men & Bowen, 2017; Neill, 2015; Skrzypinski, 2013; Towers & Watson, 2013). Saxena and Srivastava (2015) stated that job participation has become one of the key challenges which needs to be well handled to achieve the goals of the company. They also showed that there is a need to evaluate its effect on successful outcomes. However, several companies are also trying to draw on the benefits of the numerous emerging technologies and to allow maximum use of such platforms. Wehner et al. (2017) observed that businesses utilize internal social networking to promote workplace communication and information sharing; however they challenge the return on investment (ROI) if optimum returns are not achieved. Employee engagement as key focus in the area of HR is gaining popularity these days. Choudhary and Mohanty (2019) explored the drivers of employee engagement. Many industries strive and survive in competitive environment, and the physical well-being and mental well-being of employees are important aspects that organizations need to focus on in contemporary times. Many drivers of employee engagement have been identified which impact on employee performance. Thus, the main objectives of study are to analyse drivers of employee engagement in today's dynamic workplace and give suggestions to decision and policymakers to enhance the level of engagement with the employees. Therefore, this study throws light on the drivers of employee engagement by analysing four drivers, namely *work-life balance, communication, leadership and organizational culture.*

2   Review of Literature

The objective is to study and understand about the key concepts of employee engagement along with the important factors and characteristics of employee engagement. The study is based on the review of literature collected from different coveted journals, Websites and works of several authors. Mani (2011), Seijit and Crim (2006), Watson

(2009), Hewitt (2004), Pandita and Bedarkar (2015) studied the drivers of employee engagement in various organizations. Engaged employees are considered as a strategic partner which helps in achieving the organizational goals and objectives. The concept of employee engagement has gained popularity over a period of time. Despite of this certain drivers has been identified, which have direct implication on well-being at workplace. According to Forbes, employees who are engaged in their work are more likely to be motivated and remain committed to their employer. The importance of employee engagement cannot be overstated—employee engagement strategies have been proven to reduce staff turnover, improve productivity and efficiency, retain customers at a higher rate and make more profits. Most importantly, engaged employees are happier, both at work and in their lives. "Vigour" can be defined as an employee's degree of energy and mental strength while doing his job. Shirom (2013) suggested that "Vigour" relates to an employee's emotional and physical well-being. On the other side, Harpaz and Snir (2014) have shared their commitment of being deeply active in the research which showcases the embodiment in their feelings of passion, difficulty and significance. The other aspect of work involvement, known as "Absorption", with work which has previously been defined as being entirely concentrated and committed employees. One who is happily attached and committed to one's job, whereby the employee also feels that time passes rapidly in his daily routine and has difficulties in detaching himself from job (Truss et al., 2013). Sweetman and Luthans (2015) described from a psychological viewpoint, commitment is a state-like behaviour that is presented as an affective–cognitive state-like disorder. It is not a transient condition such as mood, nor it is fairly non-malleable as set attributes such as personality traits. It is known to be very secure. According to Gallup's State of the Global Workforce Survey in 142 nations, just 13% of employees in question claim they felt involved in work (Gallup, 2016). This shocking outcome indicates that strongly disengaged staff are negative factors that are actually harmful to the company they work for. Taking into consideration the possible advantages of employee participation, such as improved job efficiency (Gruman & Saks, 2011), decreased absenteeism and attrition (Brunetto et al., 2012) and enhanced consumer satisfaction (Salanova et al., 2005), it also brings value to the strategy in which involvement is a significant source of competitive advantage because it allows the company to win. Public relations involvement is examined in various ways, is described in numerous forms and has specific operationalizations. It is seen as an overarching word that encompasses a broad variety of corporate efforts to include members in its operations and decisions. Swaminathan and Rajasekaran (2015) have argued that commitment is the product of employee

happiness and job encouragement. There are many descriptions of workplace participation in the literature reviewed. Fleming and Asplund (2017) define employee engagement as "the opportunity to seize the minds, emotions and sprits of the employees to instil an inner drive and pursuit for excellence". Some scholars also consider employee engagement as a structure composed of cognitive, emotional and behavioural elements relevant to the function of employee success (Shuck et al., 2011). It represents the engagement and participation of employees in their jobs to enhance organizational efficiency (Sundaray, 2011). Bakker and Demerouti (2008) have described engagement as "a healthy, satisfying, work-related state of mind that is marked by vigour, commitment and absorption".

2.1 Communication

The first driver of employee engagement is communication. Communication plays an important role to ensure engagement level of employee (Wiley et al., 2010). MacLeod and Clarke (2009) stated that poor communication is a barrier to effective employee engagement. Papalexandris and Galanaki (2009), Bakker et al. (2011) found that internal communication is critical for effective engagement. Weber and Shi (2016) divided the social networking industry into two ways, i.e. the third-party business or the patented social network firm. These platforms may involve "organization-based wikis, chatbots, peer-to-peer web portals, instant message apps, Websites and corporate social networking sites". The study that conceptualizes internal social media is to be included in both corporate social media as described by Weber and Shi (2016) and general social media networks such as Facebook and Twitter which are used for internal communication purposes of the employees. Madsen (2016) showed that the identification of a company is socially dependent on the networking of employees through social media. Madsen's study draws "attention to horizontal collaboration and points out that in post-bureaucratic institutions co-employees are no longer treated as inert, hierarchical staff but as involved effective communicators who can control and alter the company". In addition to this, internal social networking will aid business branding, as businesses use employee advertising and lobbying to create awareness and assist with recruiting (Gibbs et al., 2015; Neill, 2015) and help CEOs and HR to make the recruitment process look more personal and affable (Men, 2015). It should be remembered that, given the absence of these academic and empiric attempts, work has been made in the direction to investigate the importance of internal social networking to be beneficial for the advancement of employee participation. The role of print media such as newspapers, journals, brochures is structured means of

contact to keep staff updated. Print newspapers are not inherently the safest way to involve staff in real-time jobs, but they can help provide content that is stagnant and not time-dependent (Men & Bowen, 2017). Haddud et al. (2016) used case study methodology to analyse the extent of dedication of a global corporation between social media and the employees. Their study showed that higher usage of self-reported use of internal social media by employees was correlated with higher self-reported workplace involvement. While this discovery is significant, the study was concentrated only on one organization, and the researchers analysed that there was a need to further investigate internal social networking and employee involvement. Sievert and Scholz's (2017) worked with German businesses and through their studies found that social networking improves interaction by increasing information efficiency, optimizing internal day-to-day processes and promoting effective collaboration. Sievert and Scholz (2017) also observed that social networking is especially well adapted as the voice of employees, a platform where they share their opinions and ideas. A similar study was done by MacLeod and Clarke (2009). In a nutshell, social media and has helped in networking should be utilized for social interaction as well. Friedl and Verčič (2011) recommended that "further work requires to incorporate knowledge from a comprehensive studies can help to understand the real application of social media is and whether it can influence the interpersonal relationship of between the employer and employees". In a similar way, Karanges et al. (2015) stated that deeper qualitative studies could provide greater insight into employees' views on internal communication and how open communication channels can improve employee engagement". According to Bakker and Demerouti (2018), in a research by Karanges et al. (2015), linear regression is used to empirically evaluate the association between internal relationship (i.e. organizational and supervisor) and employee involvement. There is a large beneficial association seen in all regressions. The findings suggest that internal relationship between employees at all levels in hierarchy plays a major role in the productiveness and involvement of the workforce. Further studies show that internal communication aids relationships between organizations, managers and employees, who build strengthened work-related partnerships, thus maximizing employee involvement. According to Neill (2015) study, owing to the shifting tastes of the Millennials, more businesses utilize social networking platforms or communication. One interviewee in Neill's study spoke about the Millennials' dislike for "Rush Messaging-Mass Emailing". Millennial favours virtual communication through smartphones and wants to access details at their convenience as often as they can. In fact, the Millennials wants more discussion through social networking forums. As stated by Sheer (2015), Millennials prefer virtual communication as compared to face-to-face

communication. The digitized world of media deals with rich content and accessibility, e.g. embedded audios and videos, webcams or video, posting, online networking, online chat apps to promote effective relationship strengthening with the employees. Social networking in organization platforms is a sure short two-way communication that fosters interactive/dialogical, collaborative and emotional elements that often promote employee interaction and involvement. It also enables interactions amongst employees and the leaders and encourages the employees to share their viewpoints. Again, the ease of communication through digital transformation represents seamless coordination and workflow in the organizations. Welch (2015) provides an in-depth analysis of the relation between engagement and internal communication. He explains that engagement is under the control of internal communication. She points out that internal contact has the ability to efficiently transmit the principles of the organization to all employees and to include them in the company's priorities. This form of behaviour contributes to new staff (Bindl & Parker, 2013). However, it must be recognized that excessive commitment (over-engagement) can theoretically affect interpersonal relationships. It can contribute to increased tension in the workforce and can contribute to alienation from the organization (Mac Cormick et al., 2014). Increased involvement is not always a positive thing, however. Internal contact as a field is sometimes viewed as associated with intra-organizational contact (Vercic et al., 2015) has become a study source in organizational communication. Van Osch and Steinfield's (2018) findings concluded that organizations would carefully measure the concerns and benefits before determining how to render collective internal work groups available to other employees. Employees will also know how to manage and utilize the enormous amount of knowledge generated by introducing social networking to the internal contact mix (Denton, 2006; Heini Sisko et al., 2014). Finally, Madsen's (2017) study indicated other obstacles, such as having staff to buy into the concept of utilizing social networking for day-to-day activity and inspiring senior management to engage. However, given the known difficulties and threats involved with the usage of internal social networking, current research appears to indicate that the advantages of internal social media to improve organizational connectivity and employee participation exceed the dangers they offer under the context of organizational communication. In a nutshell, especially internal communication scholars and researchers widely believe that efficient and successful communication will lead to the efficiency, success and external consumer focus of the enterprise (Downs & Adrian, 2004; Hargie & Tourish, 2000).

2.2 Work-Life Balance

The second driver of employee engagement is work-life balance. Work-life balance has evolved as a significant driver of employee engagement. Hallberg et al. (2007) found that increased workload increases disengagement and work-life balance is a must for all employee to feel engaged at the workplace (Thiagarajan & Renugadevi, 2017). According to this study, job growth, motivating influences and performance evaluation are linked to employee involvement. The implications are that leaders should be sensitive, involved and participative with employees. Professional growth incentives are most significant and can enhance success and be a promoter to work-life harmony, and such activities are valuable for the rates of dedication (Susi & Jawaharrani, 2016). According to the detailed literature review "employee engagement" is defined as a component of workplace culture, work-life balance strategies and procedures adopted in industries that facilitates employee participation in their companies to improve efficiency and retention levels. Work-life harmony is a primary factor of workplace well-being. Hallberg and Schaufeli (2016) conclude that job participation, workplace interaction and organizational contribution are empirically distinct constructions and therefore constitute specific facets of job connection. According to May et al. (2014), participation is nearest to ensure presence and commitment in the workforce. However, work involvement is characterized as a cognitive condition of psychological identity (Kanungo, 1982), and although work involvement focuses on awareness, participation (as described in most of the definitions) involves emotions and actions (Kular et al., 2018). Buettner (2015) concluded that privacy issues, as well as perceived utility and ease of usage, may adversely affect employees' decisions to usage internal social media. Madsen (2017) described four obstacles that encourage employees to utilize internal social networking: (1) employees might not see the value of utilizing a "private" network for their work; (2) employees may not realize the casual essence of communication; (3) internal social networking was not perceived to be a "normal" part of the day-to-day routine of organizations; and (4) senior managers primarily sponsored interns. Dhanesh (2017) proposed that fame links organizations and the public and that interaction can be conceptualized on the basis of a system of cooperation and power. Prioritizing the problem of salience and recognizing how employees should be active or passive recipients of knowledge will enable internal communication practitioners choose approaches that will allow mutually beneficial results between the company and employees. Centred on a phenomenological analysis of

employee expectations, Lemon and Palenchar (2018) stressed the changing and mutual nature of the communication areas. Verčič and Vokic (2017) looked into the connection between internal contact quality and employee participation, finding that employees appreciate input, casual contact and connectivity more during meetings.

Organizational loyalty suggests that employees remain with the company out of a willingness to continue (affective commitment), awareness that the expense of quitting will be large (continuance commitment) and/or a sense of duty to continue (normative commitment) according to Allen and Meyer (1990). As such, corporate loyalty has a long-term outlook related to employee involvement, which is a short-term workplace disposition towards an employee's work (Pološki Vokić & Hernaus, 2015). Bedarkar and Pandita (2018) performed a report on Workplace Success Employee Involvement Drivers. The study projected three factors of workplace engagement: performance, collaboration and work-life balance (Swathi, 2017). Through various studies, it was found that no particular factor or unique form of factor will be suitable for the individual or industry. The aspect tends to vary from time to time and from sector to sector. Employers need to look into the mental health of their workforce and take necessary steps to ensure that they are happy. For organizational success, it is vital for the biggest assets, i.e. the employees, to be able to balance across all meaningful areas of their lives. And, with an honest effort, achieving this balance is truly possible.

2.3 Leadership

The third driver of employee engagement is leadership. Popli and Rizvi (2016) identified the engagement level of employee in the context of leadership style. Xu and Cooper (2010) identified leadership is a key driver of engagement level of employee. Leadership behaviours are positively associated with engagement level of employee. Studies conducted by Judge and Piccolo (2005) and Erkutlu (2008) showed that leadership behaviours are positively correlated with the followers linked with engagement. Rana and Chopra (2019) identified the engagement level of employee in telecom industries in the context of socio-demographics. Employee participation is also a primary focus of internal collaboration strategies (Jiang & People, 2015; Karanges et al., 2014; Lemon & Palenchar, 2018; Mishra et al., 2014; Ruck & Welch, 2012). Dhanesh (2017), Jin (2016) observed that transformative leadership combines "empathy, kindness, responsiveness, partnership building and creativity". Transformation leaders have a sincere interest in the well-being of employees, promote a culture of confidence, cultivate faith in their followers and facilitate person growth. To this purpose, transformational

leaders also participate in deep conversations with their fans to truly recognize and meet their desires. In terms of decision-making, transformational leaders aim to inspire supporters. They are able to transfer influence and to assign substantial authority to followers to make them less reliant on the leader (Aldoory & Toth, 2004; People & Stacks, 2013). Transformation leaders are also distinguished by engaging, creative, enthusiastic, compassionate and inspiring engagement practices (Hackman & Johnson, 2004). De Vries et al. (2016) analysed the interaction between leadership and behavioural of leaders. It was observed that people-oriented leaders (i.e. transformational leaders) are typically more communicative than task-oriented (i.e. transactional) ones. Out of the different types of leaders, transformational leaders have gained the most important academic interest across disciplines owing to its relationship-oriented existence and abundant analytical proof of its beneficial effect on employee perceptions and behaviour. Samuel Obino Mokayo et al. (2017): According to their report on Employee Commitment was heavily motivated by personal growth and progress, success improvement, remuneration, leisure facilities which is driven by the leadership and the leading culture of an organization. The remuneration of employees reported as the largest contributor to employee retention and the leisure services at work has the least effect on employee engagement. Hung (2016) described "satisfaction" as a good feeling towards the other party; this feeling can be enhanced by optimistic expectations of relationships. According to Ni (2017), of the four commonly researched partnership metrics (i.e. loyalty, responsibility for work, engagement and happiness), has gained the far most recognition in the history of employee engagement and has been used as a critical metric for successful workplace relations. If employees feel happy and fulfilled, they are more inclined to participate in a long-term partnership. Achieving employee engagement is a commitment that starts with leadership. In order to get every individual to contribute their best efforts, leaders must have the ability to recognize the factors that cause employees to participate and those that cause them to disengage.

2.4 Organizational Culture

The fourth driver of employee engagement is organizational culture. Baran and Sypniewska (2020) studied the influence of management methods on employee engagement. Findings of their study revealed that people-oriented management and active participation are the most significant factors for effective employee engagement. Iddagoda and Opatha (2020) investigated the impact of employee engagement on employee performance in companies listed in Sri Lanka. Results indicate that employee engagement has a positive

influence on employee performance. Tensey and Sing (2020) studied the influence of HRM system on employee engagement and organizational performance. Results illustrate that HRM system, employee engagement and organizational performance are significantly correlated (Suhasini & Kalpan, 2018). The research indicates that "workplace motivation" is a rigorous process and that successful training programmes cannot be carried out either. Organizations will increase productivity through incentive analysis, increased workplace decision-making and loyalty. Employee participation results in decreased attrition and improved creative work-related behaviour. Siva Kumar (2015) indicates that the high degree of employee participation enhances the productivity of the company and serves as a success tool. This research indicates that the presence of employees of private banks is not sufficient. Anand and Banu (2016): This research demonstrates that employee motivation is a crucial element in the success of all organizations. Employee motivation is strongly affected by jobs, incentives and appreciation, resources, collaboration and contact. It is working positively like an employee retention device. Kiruthika and Kavitha (2015): According to this report, "compensation and rewards" are the most important element in employee motivation. The study explains the correlation between factors such as position, job climate, training and growth, relationship with superiors and the participation of employees of banks. Employee job participation is one of the key market goals for chief leaders. According to McEwen (2016), commitment relies on employees' impressions and interpretations of their work life, including their managers, corporate members, the day-to-day tasks and the work climate. Echols (2015) recommended that administrators would pay heed to the competence, expertise, abilities and strengths of their employees in order to maximize the participation of employees. The analyst added that once staff become conscious of their abilities and skills their degree of motivation would be greater, which would eventually contribute to improved results. Rothmann and Storm (2013) have shown that "dedication" as a function can be expressed by resources, personal fulfilment, effectiveness and participation. Myilswamy and Gayatri (2017) found that the degree of dedication influences the competitiveness of employees and their desire to remain in the company. Employee participation improves workplace performance by increasing morale, satisfaction, health, competitiveness and profitability. In addition to this, the employees who are really interested in the job become more committed. High-performance cultures clearly outline behaviours and norms that are healthy and supportive. Employees clearly understand their culture and what is expected of them. They feel connected, involved and supported. And, therefore, they feel engaged. Culture and employee engagement are closely tied. To improve employee engagement, its important to start improving the organization's culture.

3 Conclusion

From the detailed literature review done, the four factors that stood out as the key drivers of employee engagement in today's dynamic times were: *work-life balance, communication, leadership and organizational culture* (Fig. 1).

Employees that are committed achieve greater outcomes and do not move to other careers. Employees' degree of engagement relies on several variables. Two of the main reasons are professional growth, motivation, teamwork, incentives and acknowledgement and work climate. Workplace engagement contributes to improved employee efficiency, retention rate, competitiveness and profitability.

Finally, this study indicates that encouraging employees to participate in internal social networking and to act as social media activists will promote participation. The literature review done studied and analysed key drivers of employee engagement. Due to rapid globalization, employee engagement is the toughest challenge confronting the CEOs, HR and leaders. Employee engagement is a critical driver of any organization in this competitive arena as it significantly impacts employee and organization performance. Performance. Organizations use engaged employee as a strategic competence. Companies have to give liberty to their employees to make their work fun and exciting and fostering effective communication through digital platforms and social networking. Organizations have to focus on internal communication because the efficacy of internal communication ensures the high level of engagement. Achieving employee engagement is a commitment that starts with leadership. Work-life harmony has an important role to play in employee engagement. Employee engagement should be integrated with the organizational culture since employee engagement significantly impacts organization performance. Therefore, engaged employees produce better results and contribute to the organizational goals. Companies invest huge amount in creating engagement culture along with career and learning advancement. Thus, it is essential to incorporate such strategies which will have positive impact on engaged workforce.

4 Implications of Study

The discussion from the study has a practical implication for head of organizations and major decision-makers. Engaging employees is crucial for retaining talent in the context of
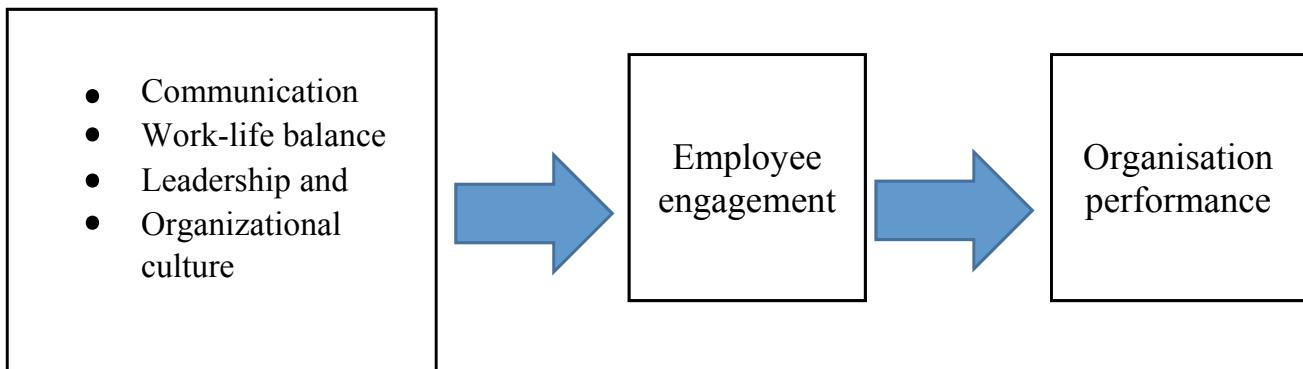
Fig. 1 *Source Authors* Drivers of Employee Engagement

employee satisfaction, as disengaged employees are more likely to leave their jobs. When employees are engaged to their, they are motivated and remain committed to their job. The four key drivers such as *communication, work-life balance, leadership and organization culture* have been found important for engaging employees towards organizational effectiveness. The study recommends CEOs, HR and key decision-makers to concentrate on enhancement of engagement level of employee by effective internal communication, providing flexibility, promote taking vacations and breaks, providing feedback, clarifying goals, providing congenial work environment, ensure work-life harmony, have people-focused culture, encourage collaboration, etc., which will enhance organizational competencies resulting in organizational effectiveness.

5 Limitations and Suggestions for Future Study

More theoretical studies are required to explore key drivers of employee engagement. Thus, we might have included more objectives like enhancing the engagement level of employee, will have an impact on employee performance. However, our study is concentrated on key drivers such as communication, work-life balance, leadership and organization culture. We recommended that future research could consider this limitation as a gap as employee always remains the cornerstone of any organization. We have examined four major key drivers, as these are the core practices in the organization; future research might include a broader range of exploring key drivers of employee engagement.

References

Bakker, A. B., Hakanen, J. J., Demerouti, E., & Xanthopoulou, D. (2011). Job resources boost work engagement, particularly when job demands are high. *Journal of Psychology, 99*(2), 274–284.

Baran, M., & Sypniewska, B. (2020). The impact of management methods on employee engagement. *Sustainability, 12*, 426. https://doi.org/10.3390/su12010426

Boyle, E. (December 13, 2017). *How HR leaders can win a seat the table. Gallup blog*. Retrieved from: https://www.gallup.com/workplace/231644/leaders-win-seat-table.aspx?g_source=EMPLOYEE_ENGAGEMENT&g_medium=topic&g_campaign=tiles

Buettner, R. (2015). *Analyzing the problem of employee internal social network site avoidance: Are users resistant due to their privacy concerns?* Retrieved from: https://pdfs.semanticscholar.org/1fc9/66c9ff1b59f41c198f297fa3f186b1578bbc.pdf

Dhanesh, G. S. (2017). Putting engagement in its proper place: State of the field, definitions and model of engagement in public relations. *Public Relations Review, 43*(5), 925–933. https://doi.org/10.1016/j.pubrev.2017.04.001

Hallberg, U. E., & Schaufeli, W. B. (2016). Same same but different? Can work engagement be discriminated from job involvement and organizational commitment? *European Psychologist, 11*(2), 119–127.

Hewitt Associates LLC. (2004). *Research Brief: Employee engagement higher at double digit growth companies*, at www.hewitt.com. Accessed on October 26, 2020.

Iddagoda, Y. A., & Opatha, H. H. D. N. P. (2020). Relationships and mediating effects of employee engagement: An empirical study of managerial employees of Sri Lankan listed companies. *SAGE Open, 10*(2), 215824402091590. https://doi.org/10.1177/2158244020915905

Lockwood, N. R. (2017). Leveraging employee engagement for competitive advantage. *Society for Human Resource Management Research Quarterly, 1*, 1–12.

MacLeod, D., & Clarke, N. (2009). *The MacLeod review—Engaging for success: Enhancing performance though employee engagement*. Department for Business Innovation and Skills. London: Crown

MacLeod, D., & Clarke, N. (2015). *Engaging for success: Enhancing performance through employee engagement*, a report to the UK Government. Available at: http://dera.ioe.ac.uk/1810/1/file52215.pdf. Accessed December 20, 2016.

MacLeod, D., & Clarke, N. (2019). *Engaging for success: Enhancing performance through employee engagement*. BIS.

Mani, V. (2011). Analysis of employee engagement and its predictors. *International Journal of Human Resource Studies, 1*(2).

Mazzei, A. (2014). Internal communication for employee enablement: Strategies in American and Italian companies. *Corporate Communications: An International Journal, 10*(1), 82–96.

McCown, N. (2017). The role of public relations with internal activists. *Journal of Public Relations Research, 19*(1), 47–68. https://doi.org/10.1080/10627260709336595

Men, L. R. (2015). Employee engagement in relation to employee-organization relationships and internal reputation: effects of leadership communication. *Public Relations Journal, 9*(2).

Men, L. (2017). The effects of organizational leadership on strategic internal communication and employee outcomes. Open Access Dissertations No. 796, Available at: http://scholarlyrepository.miami.edu/oa_dissertations/796

Men, L. R., & Stacks, D. (2014). The effects of authentic leadership on strategic internal communication and employee-organization relationships. *Journal of Public Relations Research, 26*, 301–324.

Meng, J., & Berger, B. K. (2016). Measuring return on investment (ROI) of organizations' internal communication efforts. *Journal of Communication Management, 16*(4), 332–354.

Pandita, D., & Bedarkar, M. (2015). Factors affecting employee performance: A conceptual study on the drivers of employee engagement. *Indian Journal of Management, 8*(7), 112–119.

Popli, S., & Rizvi, I. A. (2016). Drivers of employee engagement: The role of leadership style. *Global Business Review, 17*(4), 965–979. https://doi.org/10.1177/0972150916645701

Rana, S., & Chopra, P. (2019). *Developing and Sustaining Employee Engagement*. https://doi.org/10.4018/978-1-5225-7799-7.ch009

Robertson, B. W., & Kee, K. F. (2017). Social media at work: The roles of job satisfaction, employment status, and Facebook use with co-employees. *Computers in Human Behaviour, 70*, 191–196. https://doi.org/10.1016/j.chb.2016.12.080

Ruck, K., & Welch, M. (2017). Valuing internal communication: Management and employee perspective. In K. Ruck (Ed.), *Exploring internal communication* (pp. 54–64). Pearson.

Ruck, K., Welch, M., & Menara, B. (2012). Employee voice: An antecedent to organisational engagement? *Public Relations Review, 43*(5), 904–914. https://doi.org/10.1016/j.pubrev.2017.04.008

Saks, A. M. (2016). Antecedents and consequences of employee engagement. *Journal of Managerial Psychology, 21*(7), 600–619.

Schaufeli, W. B., & Bakker, A. B. (2015). Job demands, job resources, and their relationship with burnout and engagement: A multi-sample study. *Journal of Organizational Behavior, 25*(3), 293–315.

Schaufeli, W. B., Salanova, M., González-Romá, V., & Bakker, A. B. (2016). The measurement of engagement and burnout: A two sample confirmatory factor analytic approach. *Journal of Happiness Studies, 3*(1), 71–92.

Seijit, G.M., Crim, D. (2006). What engages the employees the most or, the ten C's of employee engagement. *Ivey Business Journal Online*.

Seltzer, T., Gardner, E., Bichard, S., & Callison, C. (2016). PR in the ER: Managing internal organization—Public relationships in a hospital emergency department. *Public Relations Review, 38*(1), 128–136.

Sha, B.-L. (2016). Editor's essay. *Journal of Public Relations Research, 28*(3–4), 123–126. https://doi.org/10.1080/1062726X.2016.1243429

Shen, H. (2017). Organization—employee relationship maintenance strategies: A new measuring instrument. *Journal of Mass Communication Quarterly, 88*(2), 398–415.

Shore, L., Tetrick, L., Taylor, M., Coyle-Shapiro, J., Liden, R., McLean Park, J., & Van Dyne, L. (2014). The employee-organization relationship: A timely concept in a period of transition. In J. Martocchio (Ed.), *Research in personnel and human resource management* (pp. 291–370). JIA Press, Greenwich.

Sievert, H., & Scholz, C. (2017). *Public Relations Review, 43*(5), 894–903. https://doi.org/10.1016/j.pubrev.2017.06.001

Stacks, D. W., & Michaelson, D. (2015). *A Practitioner's guide to public relations research, measurement, and evaluation*. Business Expert Press.

Tensay, A. T., & Singh, M. (2020). The nexus between HRM, employee engagement and organizational performance of federal public service organizations in Ethiopia. *Heliyon, 6*, e04094.

Van Osch, W., & Steinfield, C. W. (2018). Strategic visibility in enterprise social media: Implications for network formation and boundary spanning. *Journal of Management Information Systems, 35*(2), 647–682. https://doi.org/10.1080/07421222.2018.1451961

Towers Watson. (2009). Turbo-charging employee engagement: The power of recognition from managers—Part I. Accessed at http://www.towerswatson.com/en-GB/Insights/IC-Types/Survey-Research-Results/2009/12/Turbocharging-Employee-Engagement-The-Power-of-Recognition-From-Managers-Part-1 on October 26, 2020

Weber, M. S., & Shi, W. (2016). Enterprise social media. In C. R. Scott, J. R. Barker, T. Kuhn, J. Keyton, P. K. Turner, & L. K. Lewis (Eds.), *The international encyclopedia of organizational communication*. https://doi.org/10.1002/9781118955567.wbieoc072

Wehner, B., Ritter, C., & Leist, S. (2017). Enterprise social networks: A literature review and research agenda. *Computer Networks, 114*, 125–142. https://doi.org/10.1016/j.comnet.2016.09.001

Wiley, J. W., Kowske, B. J., & Herman, A. E. (2010). Developing and validating a global model of employee engagement. In: Albrecht, S. L. (ed.) Handbook of employee engagement: Perspectives, issues, research and practice. Edward Elgar. Cheltenham.

UniversityCompass: An AHP-Based Ranking and Selection App for University Prospecting in Developing Countries

Azubuike Ezenwoke, Oluwaseunla Oshinowo, Sanjay Misra, and Ravin Ahuja

Abstract

The university selection problem occurs when university prospects need to make college choices in the face of multiple universities based on preferences. University search web apps are decision support tools used by prospects to ease the search process. A review of such web apps revealed that these platforms were developed for universities in the USA and the UK and do not Nigerian Universities. In this paper, we propose UniversityCompass, an AHP-based ranking and selection app for prospects intending to study in Nigerian Universities. Since its live hosting, UniversityCompass.com had been assessed by over 1,000,000 users in more than 4,000,000 page views, which underscores its usefulness in aiding undergraduates prospecting of Nigerian Universities. We observed the highest spike in page views are the periods that coincides with peak of university search in the country, i.e. January. In addition, more than 85% of the respondents considered UniversityCompass as a suitable platform for university search and rated the app as either "very good" or "excellent".

Keywords

Analytic hierarchy process • University search • Decision support systems • Multi-criteria decision making • Nigeria

A. Ezenwoke · O. Oshinowo · S. Misra (✉)
Covenant University, Ota, Nigeria
e-mail: sanjay.misra@covenantuniversity.edu.ng

A. Ezenwoke
e-mail: azu.ezenwoke@covenantuniversity.edu.ng

R. Ahuja
Shri Vishwakarma Skill University, Gurgaon, India

1 Introduction

The most logical and desirable next step for the majority of secondary school leavers is to advance their educational career by obtaining a university degree (McCarthy & Kuh, 2006). Studies confirm that individuals with university degrees tend to earn more and possibly have a higher standard of living compared to individuals without a degree. University graduates are 24% more likely to be employed (Abel & Deitz, 2014), and university graduates earn about 84% more than their counterparts whose highest formal education is at a secondary school (Carnevale, 2006). Acquisition of a university education has also been linked with better standing in the society and increases an individual's tendency towards greater civic contributions, like voting and paying of taxes, as well as volunteering, leadership, and donations to charities (Trostel & Chase, 2015; OECD, 2012). Therefore, these reasons have made university education desirable. Nevertheless, the plethora of universities, and their varying characteristics, appeal to different individuals, and university prospects are inundated with the overwhelming task of selecting universities in the face of these multiple alternatives.

The university selection process consists of a series of interconnected steps that are broadly classified into two phases: the search and the choice phases. Pre-search activities involve the prospects recognizing the need for a university education (Chapman, 1987). This realization may have been triggered by suggestions from parents and guidance, as well as societal expectations and peer influence. These suggestions are usually strongest during the prospect's secondary school years. At this stage, prospects are expected to identify their career interests, the industry that most fulfils the career, as well as the corresponding course of study to pursue in the university. The search phase is where the prospects make informed inquiries into the universities of choice that would best support the fulfilment of their career aspirations. Some specific activities during the search phase

include personal visits to universities of choice, browsing university websites or meetings with students/alumni for information, collecting information from brochures, and/or magazines. The prospect makes a decision and selects which university to apply in the choice phase.

It was reported that one-half of university prospects interviewed for a Carnegie Foundation study did not have enough facts to make an informed decision about where to apply for admission (Webb & Boyer, 2006). Parents and guardians expressed an even stronger need to be informed amidst the escalating number of universities and the huge cost associated with a university education. The university selection problem occurs when university prospects need to make college choices in the face of multiple universities. The prospects are expected to narrow down to an optimal choice by evaluating each university based on a set of preferences. These preferences may include factors such as cost, location, religious affiliation, perceived ranking (quality) of the university, and campus life.

In a country like Nigeria, the selection process is more complex owing to the unavailability of a one-stop shop with requisite information and the capability to perform such evaluations. As at time of reporting, there are 136 universities in Nigeria, divided into federal, states, and private universities, and these universities are spread across the 36 states of the federation, including the federal capital territory. Universities in Nigeria can be characterized along the following attributes including location, cost of tuition, availability of on-campus housing, religious affiliations, etc. Every year, over 1.5 million prospects seek undergraduate admission into any of these universities. The overwhelming nature of the search phase, due to the plethora of universities in Nigeria and plurality of prospect's preferences, necessitates the use of decision support tools to reduce the cognitive overload associated with university selection activities. Decision support tools automate the choice and selection process and ultimately simplifies decision making (Ezenwoke, 2018). Also, there are system developed for academic advisory (Sowumni et al., 2016) and for various purposes (Azeta et al., 2016; Adewumi et al., 2016) in academic institution but to best of our knowledge no AHP-based ranking and selection app is available specially in developing countries like Nigeria.

University search web apps are decision support tools used by prospects to ease the search process and make optimal university choice that is in line with their predefined preferences. The prospects are expected to complete a preference checklist and the decision mechanism evaluates each university based on the predefined preferences and, in turn, presents the most optimal choice as output. A review of such web apps (e.g. bigfuture.collegeboard.org, collegeview.com, etc.) revealed that these platforms were developed for universities in the USA and the UK and do not include African, and most especially Nigerian Universities. Furthermore, the evaluation methodology employed in these tools is based on ordinary criteria filtering, which does return "no result found" in the event that the user has overstated their preferences based on the criteria listing. In addition, some of these apps do not present their search results in a ranked order, meanwhile, the ranking of alternatives from best to worse, according to a set of criteria, is another means of simplifying the decision-making process.

In this paper, we propose *UniversityCompass*, as a universities ranking and selection tool specifically for prospects intending to study in Nigerian Universities. *UniversityCompass* was envisioned as a one-stop shop for the evaluation of Nigerian Universities based on a prospect's preferences. The proposed tool employed the analytic hierarchy process (AHP) algorithm to rank universities. The collection of universities is modelled as the alternatives; the university attributes were modelled as the criteria; while the user's preferences on those attributes are modelled as the sub-criteria. The choice of AHP was motivated by its flexibility in accommodating heterogeneity in the units of measurements of the decision variables (Helingo et al., 2017; Saaty, 1999).

2 Background

2.1 University Selection as a Decision-Making Problem

Multi-criteria decision analysis (MCDA) is a well-established area in the field of operations research and is effective in solving different complex real-world decision-making problems. MCDA consist of decision alternatives, which represent a finite number of the available alternatives. The goals of MCDA include choosing, ranking, or sorting alternatives (Whaiduzzaman et al., 2014). These alternatives usually have multiple attributes, and the attributes are the decision criteria by which the alternatives are evaluated by a decision maker (DM). The most desirable alternative is one with the highest values for all the criteria under consideration. Selecting a university amidst several universities can be regarded as a MCDA problem, since the properties that define a MCDA problem are similar to the university selection problem.

The university selection problem can be defined using a matrix format as described in (Triantaphyllou, 2000):

Definition 1: Let $U = \{A_i, \text{ for } i = 1, 2, 3, \ldots, m\}$ be a set of universities and $C = \{C_j, \text{ for } j = 1, 2, 3, \ldots, n\}$ be a set of criteria that underpins the evaluation for the most desirable university. The university selection problem is to determine

Criteria

	C_1	C_2	C_3	...	C_n
Alternatives	(w_1	w_2	w_3	...	w_n)
A_1	a_{11}	a_{12}	a_{13}	...	a_{1n}
A_2	a_{21}	a_{22}	a_{23}	...	a_{2n}
⋮	⋮	⋮	⋮	⋮	⋮
A_m	a_{m1}	a_{m2}	a_{m3}	...	a_{m4}

Fig. 1 University selection problem matrix

the optimal university with the highest degree of desirability with respect to all relevant criteria C_j (see Fig. 1).

MCDA-based approaches, such as the analytic hierarchy process (AHP), are best suited for scenarios with multiple finite alternatives, known a priori (Triantaphyllou, 2000; Munandar & Azhari, 2014). The aim is to use the university prospect's (decision maker) preferences to rank the universities and select the university that best satisfies the prospect's preferences. Next, a brief overview of the AHP method is presented.

2.2 Analytic Hierarchy Process

Analytic Hierarchy Process (AHP), introduced by Saaty (1988), is based on the priority theory. AHP is applied in complex scenarios in which multiple criteria and alternatives

Table 1 Saaty's relative rating scale

Intensity of importance	Definition
1	Equal importance
3	Somewhat more important
5	Definitely more important
7	Much more important
9	Extremely more important

are simultaneously considered by reducing the multidimensional problem into a single dimension (Saaty & Sodenkamp, 2010). AHP uses a mathematical structure of consistent matrices and eigenvectors to determine priority weights of each criterion relative to other criteria (Munandar & Azhari, 2014; Forman & Gass, 2001; Garg et al., 2013). AHP employs pairwise comparisons of decision criteria based on the Saaty scale as shown in Table 1, rather than utility and weighting functions. AHP has been featured extensively in choice, ranking, prioritization, resource allocation, benchmarking, quality management, and conflict resolution problems. Forman and Gass (2001) outlined more details of the AHP method.

2.3 Features of a University Selection App

To identify the relevant features of a university selection app, we performed a content analysis and a comparative review of selected existing apps. Most university selection apps provide mechanism to elicit users' preferences, while the app returns the colleges that match those preferences. In some other apps, (e.g. collegeconfidential.com) users can specify the degree of importance of a preference; the priorities on the preferences are also factored in the evaluation process. In addition, filter features on the app help to dynamically narrows down the university choices based on user inputs. Some contained the university profile, while some others presented the search results in a ranked order. Interestingly, all these apps cover universities in the United Kingdom (UK) or United States of America (USA). The list of the five apps surveyed include: BigFuture.com, Collegeconfidential.com, Collegeview.com, Petersons.com, and Niche.com. A summary of the content analysis is provided in Table 2.

As a result of the content analysis performed on these apps, we identified the core and relevant features of a university selection app which includes the following:

- **University Profile**—the user experience is improved by including more information about the universities on the app to beef up the university's profile on the selection

Table 2 Content analysis of university selection apps

Feature	BF	CV	PS	CC	NI
University profile	+	−	+	+	+
Elicit priority on preferences	+	+	+	+	+
Number of preferences considered	10	12	16	19	7
Ranked recommendations	−	−	−	−	−
Geographical/regional coverage	USA	USA	UK/USA	USA	USA

BF BigFutute; *CV* CollegeView; *PS* Petersons; *CC* CollegeConfidential; *NI* Niche

app, while users can visit the university's website for more information;

- **User's Preferences**—the users are able to indicate their preferences such as availability of accommodation, location of the university, perceived quality of the university, etc. In addition, the users can also specify the degree of importance of each of the preferences. The weight of importance attached to a preference is factored in the evaluation process.
- **Ranked Recommendations**—the ranking of alternatives from best to worse, according to a set of criteria, is a means of simplifying the decision-making process.
- **Geographical/Regional Coverage**—we observed that there is no university selection app that covers Universities in Nigeria.

3 UniversityCompass in Action

UniversityCompass was envisioned as a web-based app that elicits user's preferences, evaluates each university based on those preferences using a modified AHP algorithm, and presents the results to the users via the web-based UI. The
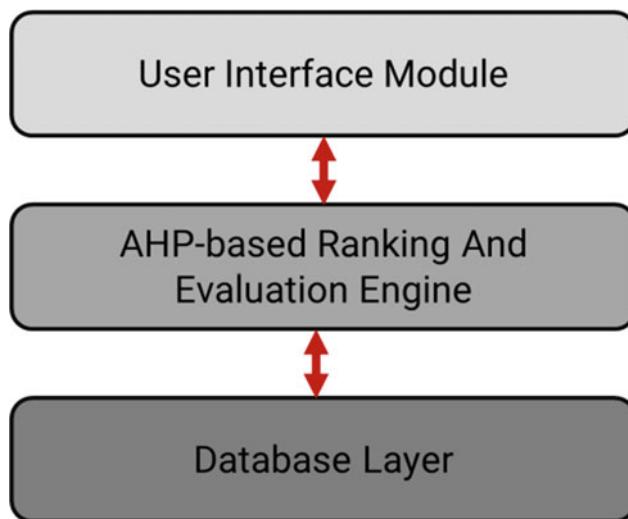
Fig. 2 Conceptual architecture of UniversityCompass

architecture of the app can be described in three main conceptual layers as shown in Fig. 2. The User Interface module collects users' inputs via textboxes and sliders elements and displays the output of the evaluation and ranking results. The middle layer consists of the ranking and evaluation engine that implements the AHP ranking algorithm for evaluating universities based on users' preferences. The database layer stores the data on universities and their characteristics, as well as other users' data.

3.1 University Evaluation Criteria on UniversityCompass

UniversityCompass incorporates six (6) criteria that underscore a prospect's university preferences. These criteria include: location; tuition cost; source of funding; religious affiliation; admission competitiveness; and on-campus housing (see Table 3).

- **Location** criteria refer to the 36 states in Nigeria;
- **Tuition Cost** specifies the range of the fees paid by admitted students;
- **Source of Funding** connotes the major source of funding for the university, which could be by private entities, the federal government or the state government.
- **Religious Affiliation** criteria describe the university's religious bias; which could be Christianity, Islam or neutral.
- **Admission Competitiveness** underscores the chances of being accepted vis-a-vis previous admission rate.
- **On-campus Housing** refers to provision of on-campus accommodation facilities.

Prospects are able to select specific values for each of the criteria as shown in Table 3; for example, users can select "Lagos" for the location criteria, or "No" for the on-campus housing criteria.

UniversityCompass also allows users to designate the importance of each of the criterion as indicative of the priority of their preferences. For example, a prospect may consider accommodation very important, while rating religious affiliation criterion not important. The importance

#	Criteria	Values
1	Location	36 states in Nigeria, including the Federal Capital Territory, Abuja
2	Tuition cost	Range from NGN100,000 to NGN1,000,000
3	Source of funding	Federal/State/Private
4	Religious affiliation	Christianity/Islam/Neutral
5	Admission competitiveness	High/Moderate/Low
6	Availability of on-campus housing	Yes/No

Table 3 Values of the criteria used in UniversityCompass

weights were modelled using the Saaty's 9-point rating scale, as shown in Table 3. These flexibilities further ensure that a prospect's preference is duly captured and factored in the ranking process.

3.2 Nigerian Universities Data UniversityCompass

As at the time of data collation, there were a total of 136 universities in Nigeria categorized into federal government-owned universities, state government-owned universities and private universities. For each of the universities, the values for each of the criteria described in Table 3 were also collected. The sample data for three universities (Covenant University, University of Lagos, and Ekiti State University) is shown in Table 4.

3.3 AHP-Based Ranking on UniversityCompass

The inputs into the AHP algorithm are the users' preferences for each of the criteria. These preferences are the actual values designated for each criterion in Table 3. *UniversityCompass* opts for the most optimal user inputs required to obtain desired results in order to maximize user experience on the platform.

The values for each of the criteria are the subs-criteria, such that when a user selects a value, the modified algorithm assigns the 9-point rating from the Saaty's scale, indicating that the option is "extremely more important" when compared with other values of the criteria. For example, if a user selects "Ogun" as the preference from the location criteria, "Ogun" becomes extremely more important than all other states in the location criteria, and other states in comparison with each other are assigned the rating value 1, signifying equal importance.

The Nigerian Universities represent the alternatives in the AHP problem, and the user's criteria, which are the attributes of these alternatives are the sub-criteria. Based on our algorithm, the weight of each criteria and sub-criteria is computed using the eigenvector method, and the cumulative weight for each university is obtained. The universities are ranked from highest to lowest based on the weights obtained. The higher the weights, the more relevant the university to the user.

3.4 Illustrative Examples

We employed two illustrative examples involving two fictitious users to demonstrate the plausibility of *UniversityCompass*. Figure 3 shows the landing page of UniversityCompass.com.

Example 1: Jason

Jason, an intending undergraduate having fulfilled all requirements for admission in to a Nigerian University is finding it difficult to pick a university, he wants to go to a Christian university in Ogun state, and Jason is particular about going to a private university and knows that his sponsors can afford a tuition between NGN600,000 to NGN700,000. The tabular representation of his preferences is shown in Table 5.

Based on Jason's inputs, UniversityCompass presents Jason with the results as shown in Fig. 4.

Example 2: Jessica

Jessica, an intending undergraduate having fulfilled all requirements for admission in to a Nigerian University is finding it difficult to pick a university, she wants to go to a Christian university in Abuja and is particular about going to a private university, and she knows that her sponsors can afford a tuition above NGN1,000,000. The summary of her preferences is captured in Table 6.

Jessica decides to make use of the college selection application; his choices are shown below in Fig. 5.

3.5 Evaluation of UniversityCompass

UniversityCompass was hosted live at universitycompass.com and Nigerian University prospects used the platform in between July, 2016 to August, 2020, within a space of over

	Preference	Covenant University	University of Lagos	Ekiti State University
1	Location	Ogun	Lagos	Ekiti
2	Tuition cost (NGN)	800,000–900,000	<100,000	100,000–200,000
3	Funding	Private	Federal	State
4	Religious affiliation	Christian	Neutral	Neutral
5	Admission competitiveness	Moderate	High	High
6	Availability of on-campus housing	Yes	Yes	Yes

Table 4 Sample list of universities and their attributes

Fig. 3 UniversityCompass.com home page

Table 5 Scenario one: Jason's college preferences

Criteria	Value
Location	Ogun
Funding	Private
Religious affiliation	Christian
Tuition	NGN600,000–NGN700,000
On-campus housing	Available
Admission competition	High

Fig. 4 Output for scenario one: Jason's college criteria

Table 6 Jessica's college criteria

Criteria	Value
Location	Abuja
Funding	Private
Religious affiliation	Nil
Tuition	NGN1,000,000–Above
On-campus housing	Available
Admission competition	Moderate

49 months. Based on Google analytics, a total number of 1,388,880 users visited the platform and performed 4,233,560 page views. Figure 6 shows the usage trends over the period (Fig. 7).

4 Discussion

The university search problem is a subset of multi-criteria decision-making problem, in which the universities are alternatives with multiple attributes, and each alternative is evaluated with respect to user's preferences on the attributes. A number of multi-criteria decision-making approaches exist, and the university selection and ranking problem in this paper were solved using an AHP algorithm. AHP reduces the multi-dimensionality of the problem into a single dimension and is effective in the solving problems in which the decision variables have heterogenous units of measurements. Based on the examples presented in this paper, we

VERITAS UNIVERSITY

One of the cheapest private universities located in Abuja Niger, The nation's capital is Veritas University. The university was founded in 2007 and is approved by the National Universities commission. Veritas University was founded by the Catholic Bishops Conference of Nigeria. The university has no religious affiliation and has a relatively diverse student body as it amidst students from all parts for the country. Veritas University encourages it's students to be entrepreneurs and to build relevant kills for the work force.

NIGERIAN-TURKISH NILE UNIVERSITY

This university was established in 2009 in Abuja the capital of Nigeria as a private university and was approved by the Nigerian university commission. The university provides it's students with quality education. It is referred to as a school for the rich because it's tuition is quite expensive as a result the university has a pretty low student population. The student body is quite diverse since the university has no religious or ethnical affiliations. Nile University offers degrees in programs cutting across law, medicine, engineering.

AFRICAN UNIVERSITY OF SCIENCE & TECHNOLOGY

Fig. 5 Output for scenario two: Jessica's college criteria
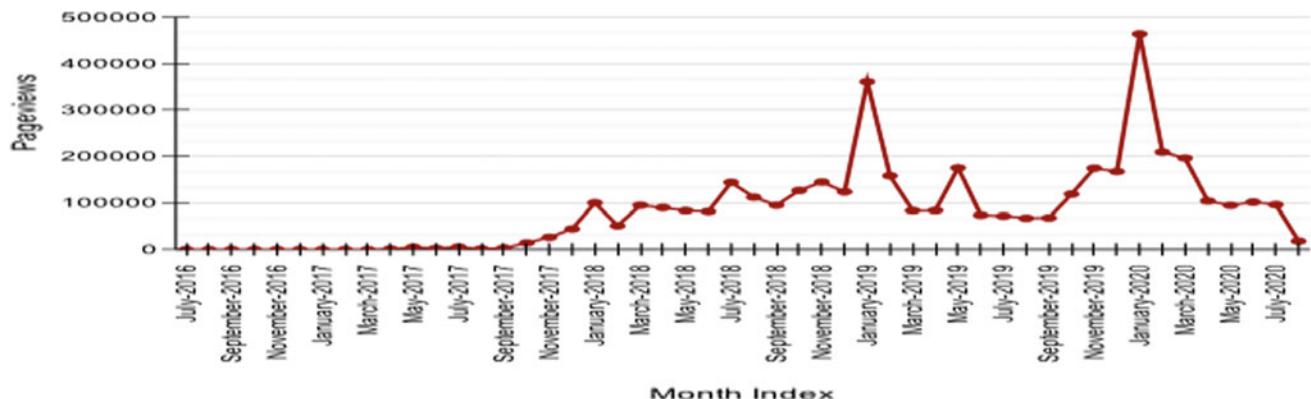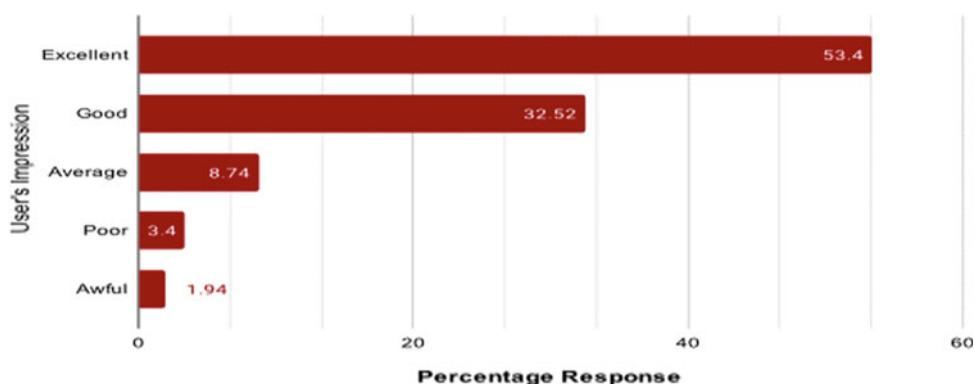
Fig. 6 UniversityCompass.com usage trends

Fig. 7 User evaluation results for UniversityCompass university ranking

observed that there was no university that matches Jessica's preferences 100%. However, *UniversityCompass* ranks all the universities and will still present in a ranked order those universities that are a close match, rather than return "No Result Found". Since its live hosting, UniversityCompass.com had been assessed more than 1,000,000 times, which underscores its usefulness in aiding undergraduates prospecting of Nigerian Universities. We observed the highest spike in page views in the periods that coincides with peak of university search in the country, i.e. January. In addition, more than 85% of the respondents considered *UniversityCompass* as a suitable platform for university search and rated the app as either "very good" or "excellent".

5 Conclusion

Hitherto, prospective undergraduates in Nigeria resorted to painstaking means of determining the most suitable universities given a variety of individual preferences. In response

to the absence of university search platforms in Nigeria, *UniversityCompass*, based on AHP methodology, is a one-stop shop for selecting the most optimal university that matches users' preferences. In the future, the ranking algorithm and preference structure will be subjected to continuous improvements to perform more personalized ranking of Nigerian Universities.

References

Abel, J. R., Deitz, R. (2014). *Do the benefits of college still outweigh the costs?* www.newyorkfed.org/research/current_issues

Adewumi, A., Nwaoyo, C., Parejas, F. J., Misra, S., Crawford, B., & Soto, R. (2016). Mobile-based emergency report and response system for academic institutions of developing countries. *Far East Journal of Electronics and Communications, 2(Special Volume),* 139–145.

Azeta, A. A., Ikpefan, O., Ayo, C.K., … Misra, S., Olowonihi, P. (2016). Closing institutional gaps through academic research management system and implications in Nigeria. *International Journal of Pharmacy and Technology, 8*(4), 22906–22914.

Carnevale, A. (2006). The college payoff . *ASEE Prism, 16,* 68.

Chapman, R. G. (1987). Toward a theory of college selection: A model of college search and choice behavior. *Advances in Consumer Research, 13,* 246–250.

Ezenwoke, A. (2018). Design of a QoS-based framework for service ranking and selection in cloud e-marketplaces. *Asian Journal of Scientific Research, 11,* 1–11. https://doi.org/10.3923/ajsr.2018.1.11.

Forman, E. H., & Gass, S. I. (2001). The analytic hierarchy process-an exposition. *Operational Research, 49,* 469–486.

Garg, S. K., Versteeg, S., & Buyya, R. (2013). A framework for ranking of cloud computing services. *Future Generation Computer Systems, 29,* 1012–1023. https://doi.org/10.1016/j.future.2012.06.006.

Helingo, M., Purwandari, B., Satria, R., & Solichah, I. (2017). The use of analytic hierarchy process for software development method selection: A perspective of e-Government in Indonesia. *Procedia Computer Science,* 405–414. https://doi.org/10.1016/j.procs.2017.12.171.

McCarthy, M., & Kuh, G. D. (2006). Are students ready for college? What student engagement data say—ProQuest. *Phi Delta Kappan, 87,* 664–669.

Munandar, T. A., & Azhari, S. (2014). Comparative study of decision-making techniques for multi-attribute decision making problems. *International Journal of Advanced Research in Computer Science, 5,* 122–126.

OECD. (2012). What are the social benefits of education? https://doi.org/10.1787/eag_highlights-2012-14-en

Saaty, T. L. (1988). What is the analytic hierarchy process? In: *Mathematical models for decision support*, pp. 109–121. Berlin: Springer. https://doi.org/10.1007/978-3-642-83555-1_5.

Saaty, T. L.: *Decision making for leaders: The analytic hierarchy process for decisions in a complex world*. RWS Publications. ISBN: 096203178X.

Saaty, T. L., Sodenkamp, M. (2010). The analytic hierarchy and analytic network measurement processes: The measurement of intangibles (2010). https://doi.org/10.1007/978-3-540-92828-7_4

Sowumni, O. Y., Misra, S., Fernandez-Sanz, L., & Medina-Merodio, J. A. (2016). Framework for academic advice through mobile applications. In *Proceedings of 25th International Conference on Information Systems and Development (ISD2016 POLAND)*, 332–344.

Triantaphyllou, E. (2000) *Multi-criteria decision making: a comparative study*. Springer Science & Business Media. ISBN: 0792366077.

Trostel, P., Chase, M. (2015). It's not just the money: The benefits of college education to individuals and society. *Lumina Issue Papers.* https://www.luminafoundation.org/files/resources/its-not-just-the-money.pdf. Last accessed 2019/04/18.

Webb, F. J., & Boyer, E. L. (2006). College: The undergraduate experience in America. *Journal of Negro Education, 57,* 117. https://doi.org/10.2307/2295281.

Whaiduzzaman, M., Gani, A., Anuar, N. B., Shiraz, M., Haque, M. N., & Haque, I. T. (2014). Cloud service selection using multicriteria decision analysis. *Scientific World Journal, 2014,* 459375. https://doi.org/10.1155/2014/459375.

Employee Experience Practices in MNCs During COVID-19 and Its Impact on Psychological Distance of Employees

Smita Barik and Jaya Yadav

Abstract

People management is a much challenging task nowadays. So practising employee experience and implementing them to their core will definitely bring positive results to experimental organizations. During COVID-19, it becomes a challenging task again when you give concern to productivity and cannot ignore your employee's health and their safety equally to achieve your long-term goals. The objective of this research is to explore what employee experience practices in multinational organizations are practising and to analyse the impact of EE practices on psychological distance among employees during this dangerous pandemic. Our study considers advanced technology, strong communication, trust in leadership and health and well-being of the employees as the important drivers or dimensions of employee experience during COVID-19 phase. Also this study tries to communicate that by implementing these practices how multinationals have stepped forward to reduce psychological distance among their employees. The given scope for further studies could include quantitative testing of the developed model and also checking their effectiveness with respect to productivity of the firm.

Keywords

Employee experience • Employee engagement • Psychological distance

1 Introduction

The people approach is gaining more popularity in recent era of competition. While companies are challenging each other for productivity, they have also been facing challenges of attracting and retaining the existing talent pool. To preserve the talents, companies must make employee-oriented practices in the organizations. While organizations are moving very rapidly towards productivity along with their employees, COVID-19 has made its own path way affecting almost all the companies. After getting declaration as pandemic from WHO, Indian companies announced working with ease and comfort from home for the safety of their employees. And for the time being, technology and other variables become very important aspect of productivity. During this critical time also, companies are much worried about maintaining their employees' morale and welfare so that productivity and company reputation will not be in loss at any stake. Author has made a study on multinational companies who are still practising employee experience and have tried to give an insight into the drivers who still need to be taken care of during this pandemic. Author has also tried to give insight into the psychological distance aspect of employees and how these new employee experience initiatives have tried rethinking these boundaries.

2 Literature Review

Employee experience is a very hot topic in the field of human resource. When organization is talking about employee engagement, organization commitment plays a great role towards achieving it. Employee experience is an extended version of employee engagement which defines long-term commitment towards organization. In today's era, competition among organizations has become not only attracting new talent but also retaining the talented workforce. Retaining and attracting new talents always seeks a

S. Barik (✉) · J. Yadav
ABS, Amity University, Noida, Uttar Pradesh, India
e-mail: bariksmita@gmail.com

good culture and a good experience for the employees in their workplace.

We will focus on some good literature on employee experience:

The theory of employee experience was based on customer experience management which actually starts at the heart of an organization (Harris, 2007).

> Employee experience is an emerging business function which focuses on tracing how employees think and feel during every single touch point of their journey through the company (Source: Bonfyre, 2020).

Experiences are always considered as inherently personal, and it is an outcome of how someone feels and believes, his cognitive perceptions and emotions about inwardly directed external stimuli (Belk, 1975; Gardner, 1985; Hirschman & Holbrook, 1982; Zuckerman, 1971).

Experiences that are targeted towards the actualization of specific needs or emotions result in higher loyalty and stronger bonding (Davenport & Beck, 2002; Gob´e & Zyman, 2001; Pine & Gilmore, 1998, 1999; Reichheld, 1996; Schmitt, 1999).

According to Bersin, it is "the sum total of all the touchpoints an employee has with his or her employer, from the time of being a candidate (active or passive) to becoming an alumnus or alumna". Jacob Morgan defines employee experience as it is having three major components and they are cultural environment, the physical environment and the technological environment of the workplace (Source: Peopledoc, 2018).

> Experiences that are targeted towards actualization of specific needs or feelings results in higher loyalty and more stronger bonding (Davenport & Beck, 2002; Gob´e & Zyman, 2001; Pine & Gilmore, 1998, 1999; Reichheld, 1996; Schmitt, 1999).

According to the Deloitte Report 2017, earlier research in the fields of HR & OB, industrial relations, psychology, psychometric and statistical, the notion of positive employee experience has become a new contract between employer and employee (Deloitte Global Human Capital Trends, 2017).

The notion of employee experience is defined as—"A set of perceptions that employees have about their experiences at work in response to their interactions with the organization" (IBM & Globoforce, 2016, p. 3). Some HR practitioner has also given their personal definition on employee experience, and they are:

> For us, the focus around employee experience is on creating a seamless experience around the things somebody needs to do as an employee while allowing them to focus on the business we hired them for—development, sales, leading new products [and so on]. We've actually created a VP level role to strictly focus on the employee experience.—Adam Khraling, VP of Global HRIS, American Express.

> Employee experience, to me, includes everything our workforce encounters, observes, or feels during the course of their employee journey at our organization. We really want it to be a positive experience and this begins even before someone applies for a job with us.—Amanda Flanagan, Human Resources Specialist, Vanderheyden, Inc.

> For us, employee experience starts from the beginning by providing an exceptional onboarding experience for new employees—that is also the key to retention. HR is the first point of contact for many candidates, from the application process to the interview experience to the first day in the office. As HR, we must pride ourselves on an employee-centered model.—Dottie Ann Stevenson, AVP of Human Resources, The Mental Health Association of Westchester Inc.

> Employee experience is really what the culture feels like to employees. It's not what you say it is or isn't. It's how they experience it through interactions with other employees, interactions with technologies and with the work itself. Employee Experience First is a guiding principle at GoDaddy. It's woven into the fabric of how we make decisions. Before we think about the effort it will take our team to do this thing or that thing, we think about what's best for employees.—Zuri Baker, Director of HR Operations, GoDaddy.

> Employee experience, to me, is the sum of all experiences an employee has during their lifecycle with our organization. Being in HR, and specifically recruiting, I take great pride in ensuring every candidate has the best possible experience and contact with us. I believe in treating every candidate like they're the only candidate—it's the same mentality we take with our customers.—Arlen Oharonian, Global Recruiting Manager, PeopleDoc.

> You can have a product in your hand and not require any training and know how to use it. The employee experience is about that from a technology perspective. [Employees] want to be able to get their information, they want things to be transparent, they want to have it at their fingertips, and they don't want you to have to train them on how to get it.—Marjorie Boursiquot, Former AVP of Business Process Integration and Administrative Systems, Georgetown University.

> Employee experience is, for me, the ABCs of HR nowadays. We want them to feel well and welcomed when they arrive. We want them to feel that what they're doing on a daily basis is valued by their manager and senior management. I'm really convinced that everybody wants to go to work and feel valued. Employee experience is about people feeling like they're a valuable contribution to the organization. I think if HR gets that right, it would be a huge improvement.—Adriana Bokel Herde, Former VP of People Services at Biogen, now Chief People Officer at PeopleDoc.

Various researches and articles suggest that there are very few companies which are working on areas of employee personal and professional work-life demands, aligning the personal goals of employees with corporate goals, conducting programmes catering to all age groups and using design thinking as part of employee experience (Deloitte Global Human Capital Trends, 2017; Foresee, 2014; IBM & Globoforce, 2016).

Johanson and WiedersheimI-Paul (1975, p. 308) described psychic distance as some factors that can prevent information from flowing between a firm and the market in

which it operates; these factors can be recognized as different languages, political systems and cultures as well as the dissimilarities in educational level, the level of industrial growth, etc.

According to Huang (2015), interpersonal psychological disconnect is actually based on communication and healthy interpersonal relationship and a good employee relationship always develops good psychological relations.

When considering human relations, psychological distance can be understood as a feeling of uncertainty or risk, of people in different positions, values and cultural background to the surrounding relationship produced, leading to its intimate or alienated subjective feeling (Wang et al., 2013).

3 Purpose Statement

This study critically aims at answering the following research questions:

- How organizations are working in creating ideal employee experience during this pandemic time?
- What are the positive drivers to employee experience in multinational companies?
- What is the impact of employee experience practices on psychological distance of employees during this pandemic?

4 Research Methodology

To examine the above questions, researcher has used **content analysis** method by analysing few companies' data about their steps taken for employee experience during COVID-19.

5 Organizations Creating Ideal Employee Experience

While creating employee experience, it is also kept in mind that the health and safety of the employees are the biggest concerns during this critical time.

A report given by **Flipkart** shows that they have conducted more than 3000 webinars on awareness with different regional languages to educate their staff and dealing with sensitive time without panic. Also they have equipped their employees with effective tools which will enable them to focus on mental and physical health while working from home. They have also issues banned on non-essential domestic and international travels as precautionary measures and also have promoted use of video conferences for meetings and job interviews (Source: PEOPLE MATTERS, April 2020).

Voltas Limited came up with new ideas with introducing a concept of work-from-home diaries where employees can exchange notes on how their productivity is getting maximized through this new format of work by organizing their day with the help of online workflow solutions, upskilling themselves, and are also been provided 24*7 online consultation by doctors to ease the employees' health problems while in lockdown (Source: People matters, Article on Voltas Ltd, April 2020).

Capgemini came up with different technological solutions to provide its employees a hassle-free work-from-home environment. They have collaboration with Skype and Microsoft teams, and they have divided their VPN usability into 3 zones: green, amber and red to track for smooth operation. They are also committed towards safety and health of employees during this pandemic (Capgemini Article, March 2020).

IBM has come up with an AI-based application "IBM Location Remainder" to fight and protect their employees against COVID-19. Also they have came up with new training programmes related to upskilling their talent and also on stress and time management so that employees can cope up with their work-life balancing stress and can create a healthy and stress-free environment while staying at home (IBM, April 2020).

Cisco has come up with expanding capability of its platform for videoconferencing with Webex and has offered free licence to Webex for its customers around the globe. It has also cancelled its participation in many industry events giving priority to health of its employees first rather than any travelling and gathering. Employees are encouraged to take advantage of Cisco's mental health offerings and maintain open communication with managers, ensuring the well-being of employees and their families remains its top priority. Also weekly global calls with all employees on topics like mental health and medico advices are given.

HP has taken welfare steps towards social distancing and work-from-home arrangements, enhanced safety protocols, employees' guide outlining best practices for working from home, offering additional programmes to assist employees, focusing on well-being, working in a mobile environment and stress management. Also the company is encouraging the employees who are parents to take this opportunity to play a more active role in steering their children's learning, including by creating online resources such as Print & Play that has fun learning activities for children.

In the direction of technology, teams are mobile-ready and have the flexibility to be productive wherever they are working. They are encouraged to work remotely and further optimize their experience with the tools they need, from notebook PCs and peripherals to collaborative software.

Axa XL has activated incident management team and global crisis management team for detecting and supporting corona-affected employees. They have changed their 80% of operations in to work from home. Regular health checks, protective masks and team insurance coverage are upgraded also. Professional counselling service is provided to boost the employee's mental condition against COVID-19. Videoconferencing and virtual townhall meetings are used to engage their employee fully during this pandemic without failing any communication.

Infosys has also come up with various steps to protect its employee from COVID-19 and also engage employees while working from home. These includes increased sanitization, removal of biometric scanners, installation of thermal scanner, restricted movements and avoiding gatherings, restricted non-essential travels, etc. They have also ensured safety of the environment and the employees who cannot work from home and have to come to office for providing uninterrupted client services.

6 Positive Drivers to Employee Experience During Pandemic

Employee experience has various key drivers which not only enhances satisfaction among employees but also claims to increase productivity and long-term good will and success of the company these employees are working with. IBM shares and believes as positive employee experience, and hence productivity of employees can be achieved by proper leadership management and best human workplace practices (Fig. 1).

According to a white paper published by KMWorld, employee experience can be achieved through 6 basic practices and they are: determining objectives and metrics before entering any project, planning implementation strategy, designing a robust knowledge base, developing useful content, optimizing the user experience and improving knowledge continuously (Kelly Koelliker, April 2017).

Deloitte University claims that employee experience can be achieved through the following elements: meaningful work, supportive management, positive work environment, growth opportunity and trust in leadership (Fig. 2).

Josh Bersin Academy adds another aspects to employee experience, and it follows health and safety measures along with the elements mentioned by Deloitte's report on 2017 (Josh Bersin Academy, March 2019) (Fig. 3).

Again some authors compiled and listed the following elements as the key driver to employee experience (Itam & Ghosh, 2020)(Fig. 4):

Some multinational company claims that employee experience can be achieved through three key elements and they are: physical space, technology and culture in which an employee is working (Morgan, 2018).

Now, we will summarize the drivers used by multinational companies during this pandemic for employee experience, although some elements are covered and some are not mentioned (Table 1).

Here, it is necessary to mention that yes and no are given on the basis of different reports on their temporary measure taken for COVID-19 and is valid only for this pandemic duration.

Here, researcher has taken IBM, Infosys, Voltas, Axa XL, HP, Cisco, Capgemini as his study and it is shown that advanced technology, health and well-being, effective communication and trust in leadership are adopted by almost all the companies. But many of them are lacking with positive work culture, flexible work culture and support towards work-life balance. IBM, Infosys, Axa XL and Capgemini are one of them.

7 Employee Experience Framework (Complied by Author for Study)

From the above summary, we can draw a model for key components of employee experience during COVID-19 that are practised by major multinational companies.

Fig. 1 *Source* IBM Analytics; The EX index

Fig. 2 *Source* Deloitte University Press

Fig. 3 *Source* Deloitte University Press

Drivers of Employee experience
1. Employee's experiential needs and desires
2. Embrace holistic thinking
3. Radical participation
4. Experiment and iterate
5. Trust and appreciate the process
6. Make intangible experiences visible tangibly
7. Better workplace practices
8. Leadership and management practices

Fig. 4 *Source* Itam and Ghosh (2020)

Here, the author has summarized health and well-being, effective communication, upskilling through training, trust in leadership and use of advanced technology as the major variables of EE during COVID-19 which are being adopted by most of the MNCs (Fig. 5).

Here, the author has summarized health and well-being, effective communication, upskilling through training, trust in leadership and use of advanced technology as the major variables of EE during COVID-19 which are being adopted by most of the MNCs.

8 Impact of Employee Experience Practices on Employees' Psychological Distance

While previously organizations were demanding only performance at any stake, now they have came up with different ideas to make their employee comfortable while taking work from home. Cherry on the top is IT sector companies like TCS, IBM, Infosys, etc., that have brought a new big change to the country by declaring complete work from home till December 2020. This has gradually became a stress relief as now employee can work positively for their organization while maintaining a healthy work-life balance and this virtual workforce has set an example of being "New Normal". Below points have brought positivity among employees by digitizing relationship between employee and employer, and they are:

Rapid Reskilling: The quick adoption of new, advanced technology is the central catalyst and is likely to lead to an acceleration in the creation of new roles. Changes in workload during the pandemic have sometimes resulted in an imbalance of resource allocation. But reskilling and upskilling are helping employees move from one part of the business to another.

Changing Leadership and Management Competencies: During this pandemic, there is no certain technique to find out the match between what employees are facing and what the corporate world is strategizing to keep up around the world. But one thing is for sure that employees should always be ready to work from at any time. Implementing digital skills and also to improve infrastructure, it is necessary that corporate culture and leadership skills focus on empathetic feelings towards employees as transformation and disruptions become the new normal.

Fig. 5 *Note* Compiled by Author for Study

Table 1 Author self-compilation

Company name/Drivers to employee	IB M	INFOSYS	VOLTAS	AXA XL	HP	CISCO	CAPGEMINl
Use of advanced technology	YES	YES	YES	YES	YES	YES	YES
Improving knowledge (through training)	YES	YES	YES	NO	NO	YES	YES
Health and well being	YES	YES	YES	YES	YES	YES	YES
Flexible work environment	NO	NO	YES	NO	YES	NO	NO
Positive Work culture	YES	NO	NO	NO	YES	NO	NO
Effective communication	YES	YES	YES	YES	YES	YES	YES
Trust in leadership	YES	YES	YES	NO	YES	YES	NO
Support towards work-life balance	NO	NO	YES	NO	YES	NO	NO

Culture of Trust, Transparency and Openness: COVID-19 has left everyone to support each other and not to be self-centric and think about one self. It is making people to learn how to work continuously and with far less oversight: they are learning "on the job" what works and what does not work at home, and holding and managing virtual meetings that might have happened before but never to such an extent.

Individual and Social Well-being: Many of the programmes are found out to be acting as a natural resonance in the COVID-19 situation, in particular those aimed at supporting mental health or filling the gap if psychological disconnect. Many of the corporate companies are trying their best to rebalance and re-strategize their priorities in the near future, so that resilience becomes just as important to their strategic thinking as cost and efficiency.

Working in a More Agile Way: Business leaders now have developed a sense and are thinking of what can and cannot be done outside their companies' traditional processes, and COVID-19 is putting impact on both the pace of work and scale of workplace innovation. Many of the companies are finding simpler, faster and less expensive ways to operate.

Yet some of the companies like Accenture, Silicon Valley, MakeMyTrip and many other companies have introduced pay cuts or layoffs during this pandemic. It has brought a long gap in employee psychological distance. Employees have their job at stake because of less production during pandemic.

9   Conclusion and Findings

Employee experience always gives much more importance to employees' personal space equipped with advanced technology and continuous training for the upliftment of employees and hence their positive impact on outcome of the organization. But during COVID-19, most of the companies are not able to focus on all the points that increase employee experience and maximum of them are giving their first and foremost concentration to employees' safety and security first and then the employees are equipped with technology so that productivity will not stop for a long time. As everyone is working from home, so communication also plays a crucial role here. Top management is taking care of a proper flow of communication by implementing different strategies. Although these things are aligned towards a hassle-free production, still employee experience needs to be checked at every point so that employee should not get frustrated at any point of time due to overburden of work and causes of disengagement should be handled equally before it arises. Psychological distance if not taken care of timely can

create a severe loss to the company as its talented and hard working work force will be gone. From the above study, many suggestions can be given to companies in the field of enhancing their mental and moral support towards managing work-life and to the families of employees. Moreover, employees are facing a very strict work environment even from home. In that area, we can suggest the companies to take some positive steps so that employee will come up with mindfulness and stress. Moreover, job insecurity and pay cuts always demotivate employees, so there should be proper explanation to these measures.

10   Future Scope of Study

This study also suggests a model of employee experience drivers which are majorly used by the multinationals during COVID-19. So it further finds that some drivers are still ignored by the companies. A further study can be done on steps taken by the companies to enhance flexible work culture and support towards work-life balance which are the major parts of employee experience. Again a study also can be done on service sector employees and employee experience practices used by these sectors. We can also start a study on taking primary research and finding out whether COVID-19 and employee experience could increase the employee engagement or not.

References

Belk, R. (1975). Situational variables and consumer behavior. *Journal of Consumer Behaviour, 2*(3), 157–164. https://doi.org/10.1086/208627.

Davenport, T., & Beck, J. (2002). *The attention economy: Understanding the new currency of business*. Boston: Harvard Business School Press.

Deloitte. (2017). *Global human capital trends—Rewriting the rules for the digital age*. Deloitte University Press.

Harris, P. (2007). We the people: The importance of employees in the process of building customer experience. *Brand Management, 15*(2), 102–114. https://doi.org/10.1057/palgrave.bm.2550123.

Huang, Y. N. (2015). Research of psychological distance in interpersonal relationship. *Journal of Chifeng College, 31,* 114–116.

IBM and , & Globoforce. (2016). *The employee experience index—A new global measure of a human workplace and its impact*. NY: Software Group.

Itam, U., & Ghosh, N. (2020). Employee experience management: A new paradigm shift in HR thinking. *International Journal of Human Capital and Information Technology Professionals (IJHCITP), 11*(2), 39–49. (Fig. 4).

Morgan, J. (2018). The technological environment in employee experience. *Leader to Leader, 2018*(87), 28–35.

Wang, L. P., Yu, Z. C., & Wang, S. H. (2013). Research of impacts of psychological distance on knowledge sharing behavior—Based on the mediation of perceived organization support. *Sci. Sci. Manag. S T, 34,* 37–45.

Link References

https://www.protocol.com/ibm-covid-19-plan-supercomputing-new-inventions-tracking-employees. Accessed on April 23, 2020.

https://www.capgemini.com/2020/03/a-forced-shift-digital-workforce-transformation-enabled-by-work-from-home/. Accessed on March 31, 2020.

https://www.crn.com/news/networking/cisco-employs-mandatory-work-from-home-policy-due-to-coronavirus. Accessed March 12, 2020.

https://press.ext.hp.com/us/en/press-releases/2020/hp_response_to_covid_19.html. Accessed March 13, 2020.

https://www.peoplematters.in/article/employee-engagement/heres-how-voltas-is-enhancing-employee-experience-amid-lockdown-25422. Accessed on April 24, 2020.

https://axaxl.com/covid-19/our-actions

https://www.infosys.com/newsroom/features/2020/covid-19-update.html.

https://www.ibm.com/downloads/cas/JDMXPMBM. (Fig. 1)

https://www.kmworld.com/Articles/White-Paper/Article/Six-Best-Practices-for-Enhancing-Customer-and-Employee-Experience-with-Knowledge-Management-117219.aspx. Accessed on March 31, 2017.

https://www2.deloitte.com/us/en/insights/focus/human-capital-trends/2017/improving-the-employee-experience-culture-engagement.html. Accessed on February 28, 2017. (Figs. 2 & 3).

https://joshbersin.com/2019/03/the-employee-experience-its-trickier-and-more-important-than-you-thought/. Accessed on March, 25 2019.

https://www.mycustomer.com/customer-experience/engagement/culture-technology-and-physical-space-the-three-simple-drivers-of. Accessed on August 28, 2019.

Communication and Digital Culture in Present Scenario

Kiran Sanjay Degan

Abstract

Today's world is facing digital revolution. The world has become a global village with the Internet connectivity. Business, corporate world, industries, media, educational institutes, and financial sector are all geared up for industrial and sectoral digitalization. Digital marketing and e-commerce have changed the business as usual communication caters to information and data exchange between individuals, groups as well as companies. Communication about sales, marketing, production as well as developments in various fields of digitalization is interrelated and dependent. This paper address the key connection between communication and digital culture, particularly in the present COVID-19 situation. Internet dependability for online education, digital banking transactions, and most IT companies allowing employees to work from home has become a new normal. This situation has created new challenges of maintaining seamless communication between stakeholders, vendors, clients, and society. IT companies, telecom sector, and apps supporting online ordering for groceries, vegetables, and medicines have demonstrated close relation between communication and digital platforms. This paper encompasses the roles, defines the key steps, and deals with opportunities and challenges faced by the stakeholders.

Keywords

Digital revolution • Industrial digitalization • Communication • Digital culture

1 Introduction

Communication is the most important tool to achieve desired mission. Human beings communicate, verbally or nonverbally in every walk of life. An individual as well as organization requires effective communication. The future of every organization is based on channels of communication business communication involves communication that fosters strong partnerships and promotes products or services. Communication should be done clearly efficiently and effectively as it impacts on company's credibility and reputation and spreads message about professionalism.

Communication starts from the early days of toddlers to teens to adulthood. Communication starts with listening. Recall a small baby listens to his/her parents and others in surrounding environment and speaks the first word. A kid will call his mother as Maa in Hindi speaking family while MOM in English speaking family. Similarly, the kid would call his/her mother as AAI in Marathi families. This reference explains the rational of correlation between listening and speaking. The mother is the first school/institution of every child.

Communication plays a very important role in one's life and this continues for a lifetime. Education is an end in itself and a cultured mind is its prize. Education teaches an individual about arts, science, commerce, accounts, etc. One may like to become a doctor or an entrepreneur or a fashion designer. Each field requires a set of studies to be accomplished, studying various associated subjects, but communication remains the single-core thread that binds every individual with others in society.

Very commonly, we confuse communication with language one study. Normally, there is a taboo in Indian society that good communication means speaking English. Good communication is related with correcting explaining the requirement to other person, be it in vernacular or English or Hindi. Expressions, body language, tone, and gestures are many tools that complement and supplement effective

K. S. Degan (✉)
Symbiosis Law School, Noida, India
e-mail: kiran.degan@symlaw.edu.in

communication (Mahajan, 2015; Andreja Tonc & Ildiko, Simon).

Tony Robbins (Meenakshi & Sharma, 2011) well stated that "to effectively communicate, we must realize that we are all different in the way we perceive the world and use this understanding as a guide to our communication with others." Communication process involves a sender who send out the message, a channel for message transmittal and the receiver to receive the message. The receiver on receiving the message provides the feedback to sender. This completes the process of communication. It has been a subject of debate, who is responsible for communication, or what is the % responsibility between sender and receiver. Some holds the sender as main responsible person and few states the equal responsibility of sender and receiver for communication (Fig. 1).

The most important element in communication is the feedback provided by receiver. References can be taken from various fields, be it education institutions where a professor delivers a lecture in very fast speed. Few students did not understand the content, but the professor may not come to know, till the students provide feedback to the professor to proceed little slow or repeat the concept for clarity. Similarly, one sided communication in business organizations in form of wall posters or signboards can be communicated to large audience, but may not reach to 100% employees or the desired population. That is why media and channel of communication selection plays a vital role.

2 Types of Communication

Communication can be broadly classified on basis of:

2.1 Communication Channels

Verbal Communication is a process of transmitting meaning with words in oral or written expression. Characteristics of verbal communication are

- Words are symbolic expression of thoughts
- The meaning of words are agreed upon
- Communication makes sense from the verbal context in which words are used.

Nonverbal Communication is the transmission of meaning in direct contact by all means that are not verbal. Facial expressions, body movements, tone, and pitch of voice are all means of communication whose meanings are culturally based.

2.2 Based on Style and Purpose

- **Formal**
- **Informal**

Communication could be face to face or distant communication via phones or video calls. Communication could be between two individuals or between one professors delivering a lecture to many students in a class. Communication in a social gathering could be informal where people interact more freely and may talk many topics without time limit. Business meetings on other hand have agenda and specified time. The participants are expected to be having effective communication to convey the correct message within stipulated time. The professionals prepare well in advance with correct message and data to be effective and yield best results out of meetings (Fig. 2).

Communication includes verbal and nonverbal mix. The verbal would include words and sentences spoken, vocal variety while $\sim 50\%$ communication would be nonverbal. The pie chart below shows a typical percentage split between words, vocal variety, and nonverbal communication. It may vary from person to person or from place to place, again depending on the language spoken, cultural background, country-specific manners, and body languages are used (Fig. 3).

Nonverbal communication that contributes $\sim 50\%$ of communication plays an important role in effective communication. The listener watches the body language, hand, and head movements and tries to correlate the verbal and nonverbal communication. Nonverbal communication include

- Body language
- Posture
- Head movements—some persons knod their heads
- Hand movements—many persons have inbuilt habit of moving hands while talking
- Facial expressions
- Eye contact/movements
- Body contacts—shaking hands
- Sounds—laughing, modulating pitch, etc.
- Ways of talking—pauses
- The below picture captures the nonverbal communication subsets that complement and supplement verbal communication. A general reference can be made of two persons meeting each other and greeting "Good Morning" can differ from person to person or from country to country. Japanese have a very polite manner of greeting Good Morning with bowing their body forward, showing respect for the other person. Japanese pay a very high regard to

their educational background and professional career. They feel humbly proud to share their professional designation by exchange of visiting cards in business and social meetings. British are professionals in greeting persons by shaking hands softly, without bowing their heads.

There are many psychological studies related with body language. Most interviews have a HR person in the meeting who evaluates an individual on the basis of body language (Fig. 4).

One's body language, facial expressions, sitting postures, and way of greetings all are important in deciding effectiveness of communication as well as reflects one's persona.

Many educational institutions have introduced personality development classes/cells that complement the placement cells to support students/professionals to develop good and effective communication, practicing the art and science of communication (Shikha 2012).

3 Sector-Wise Communication

Education—Education communication is the process of teaching between professors and students. This could be classroom teaching, case study, group discussions, etc., which changes from moment to moment as the conversation unfolds and the thoughts, attitudes, and behaviors of both parties influence each other in some way.

Medical Communication—It is the development and production of materials that deal specifically with health care. AMWA are professional medical communicators to write, edit or develop materials about health care and medicines.

Marketing Communication—Marketing communication varies from organization to organization depending on type of company, manufacturing/FMCG/retail/service organization like insurance or banking or tourist, etc.

4 Major Elements of Effective Communication

- Consistency of verbal and nonverbal communication
- Listening
- Raising questions
- Assertiveness

Listening is the key element of effective communication. Active listening refers to a listener's efforts to understand the message clearly, correlating verbal and nonverbal communication. Messages are non-precise and unclear, but speaker may not realize this aspect. A basic principal of active listening is subquestions and indirect questions. Direct questions are sensitive and may provoke uncomfort in case of personal questions may lead to defensive communication. Facts finding and data collection during sampling techniques and marketing campaigns are examples were effective listening is very essential.

Business is a kind of interpersonal communication. The stakeholders include employees, shareholders, internal and external stakeholders. Effective communication is important for company executives, business managers, sales and tendering fraternity, company employees, team members, and even job applications for them to know how to utilize communication tools and techniques to serve their purpose and reach the desired goals. Effective communication is an essential component of organization success, whether it is interpersonal or intrapersonal or external levels.

> Developing excellent COMMUNICATION Skills is absolutely essential to effective leadership. The leader must be able to share knowledge and ideas to transmit a sense of urgency and enthusiasm to others. If a leader can't get a message across clearly and motivate others to act on it, then having a message doesn't matter (stated by Gilbert Amelio).

Importance of Effective Communication for Professionals

- **Motivation**—Motivated employees are an asset to a business organization. Effective communication centers around the usage of words, speed of delivery of words, pitch modulation, and body language.
- **Impress the Client**—Good communication skills are required to impress the client. Oral presentation is a common tool used in business. Well prepared and practiced communication create good impression on customers.
- **Raising Morale—This means to inspire persons to work efficiently**. It is the product of motivation and self-start that leads to success
- **Business Proposal**—Business proposals are required to present project proposals to stakeholders including finance organizations. If one seeks out for venture capitalists or angel investors, a decent written business proposal is required.
- **Facilitate Business Meetings**—Streamlining the agenda, inviting right participants and mentoring the sessions.
- **Managerial Efficiency**—Communication helps in smooth operation of management. Managerial task can be performed when communication system is effective.
- **Decision Making**—The success of organization can be measured, when data and information are effectively communicated.

5 Seven C's of Effective Communication

First appeared in business with the significance to have correct communication in first place. These represent seven most paramount important factors and principals of communication that start with letter C.

The seven "C" of communication are briefly described below:

5.1 Clarity

Clarity is the quality or condition of being clear or easy to understand. Clarity is best demonstrated by individuals or groups by using simple language and easy words that describe the intent and support to achieve the end result. As a reference, I practice one discipline in email communication. The subject of email communication describes the action required. Clarity is interconnected with the principle of completeness and concreteness.

5.2 Conciseness

Conciseness refers to compactness of communication. The best way is to correlate this with SMS of mobile phones which means short message service. One texts few limited words to get the message communicated most effectively. The quality of being short and clear, and expressing what needs to be said without unnecessary words: Concise message appeals all and saves time and energy for all. Conciseness is interconnected with the principles of concreteness and consideration.

5.3 Concreteness

Concrete message is like a factsheet put to words. Concrete messages avoid vague words such as "may be," "it is likely," etc. Concreteness of statements is very important particularly for data-driven professionals like banking, stock markets, and scientists presenting case studies and hypothesis, where each word and sentence need to be solid backed by data. Concreteness is interconnected with the principles of clarity, conciseness, and consideration.

5.4 Completeness

The communication message should contain all facts and data required by audience. The message needs to be self-explanatory. Indian industry follows the conventional bidding process of release of invitation to tenders, floating of tenders, followed by bidders conference, clarification meetings, etc. This process can be streamlined by introducing the concept of completeness at the release of tender documents itself, attaching all required datasheets, drawings and functional description. Completeness is interconnected with the principles of clarity and courtesy.

5.5 Correctness

Correctness refers to the grammar, syntax, language, factual, and linguistic accuracy. The data and information presented to clients or stakeholders regarding profit and loss, balance sheet, etc., steam from valid and audited reports. Wikipedia is not considered as information source for scientific publications. Correctness of information is the key responsibility of sender of communication. In the recent times, social media like WhatsApp is flooded with forwarded and as received messages. It is paramount important for all individuals to verify the data and authenticity of information prior to sending across on common groups, as this becomes a grapevine. Correctness is interconnected with the principle of consideration.

5.6 Courtesy

Courtesy refers to showing of politeness in one's attitude and behavior toward others. Courtesy in communication refers to addressing people during welcome address, keynote speakers, common audience, etc. It is considered apt to conduct vote of thanks at the end of seminars, events, or even formal meetings. Courtesy takes into account the completeness of message, time allocation and maintaining schedules, equal chances to all to communicate, ask questions per requirement, etc. Courtesy is interconnected with the principle of completeness.

5.7 Consideration

It refers to careful thought over a period of time. Professionals in the field of commerce, management, supply chain, marketing or finance are flooded with data and information. Data sufficiency and data adequacy are two important factors that need consideration of all in communication. It is important to provide sorted and orderly data in form of bar charts, pie charts, and the best is to also provide additional footnotes in case of financial data. Consideration requires correct grammar and linguistic with intent of completeness and correctness. The above seven C″ of communication are

paramount important in today's COVID conditions as to have most effective communication across all stakeholders, maintaining seamless continuum between business, common public, government and regulators.

6 Digital Technology

It has changed the lifestyle of a common man. Digital has created change; amongst business systems, technologies, customer relationships, and workforces. Each common man use digital tools and techniques in his day to day life. One of the biggest sectors that digital technology has changed is the educational sector. 'The future of the world is in my classroom today,' says a wise quote by Ivan Welton Fitzwater, an American educator. A traditional classroom having black or white board, a professor teaching the class, with students attending in the class face to face has become a past reality in 2020. All schools and colleges are running online classes in preset COVID situation. Thanks to digital revolution that has made this possible for educational institutions to keep up with the current digital world. All leading educational institutions are developing apps and launching channels online. Banking has become so convenient using Internet banking via laptops or mobiles. Making online payments using Paytm or Bhima apps are so simple. One can order food online using websites like Zomato, Swiggy, etc. Traveling via cabs using Uber or Ola cabs is digitization of conventional taxi system. Digital marketing using Amazon, Flipcart, etc., has become a usual habit of today's generation. It is difficult to separate business and financial transactions from digitalization. Digital world does cause a sense of insecurity in minds of conventional buyers or old persons, who are habitual of making cash payments or doing marketing face to face. COVID-19 has posed a big challenge and 75 days lockdown of our country made us all to sustain life via online purchase of food and vegetables, daily consumables like milk, bread, and butter. Medicines could be ordered online. Communication and digital culture are interdependent for today's business scenario. (Tony Robbins —Communicate more effectively; Martin Talks—Steps to build a digital culture) All business require digital culture and effective communication to steer thru the uncertainties and succeed for growth and sales turn over. Basic steps required for digital transformation to have sustainable digital culture are described as below:

6.1 Knowledge and Awareness

Knowledge is like a big ocean. One can take a dip and assimilate as per his/her hunger to learn. Awareness about current business trends and shift in technologies in future are good trends to be followed for own as well as business growth. Today, one needs to learn how to continuously learn and update one's skill sets throughout life. Soft skills play a very important role in today's emerging world. HR fraternity is facing challenges to prepare the job content of certain domains which were very conventional. Earlier in 2020, with COVID forcing most organizations to work from home, IT sector in India are changing their hiring plan for next years to come. Preference shifting to B2 cities like Raipur, Indore, Bhopal, etc., while earlier IT Hub to be Pune and Bengaluru. The world is changing fast. Recall the development phase starting from agriculture to manufacturing to service industry. Today's world and business are undergoing digitalization.

6.2 Transparency

Creating digital culture means that everyone in the company —regardless of their role—is aware of the impact digital can have on revenue, sales, and productivity. Transparency is the key for any transformation and changes. Human being by very nature is averse to change. This can be achieved through internal communication, senior leaders keynote addresses, social media groups, Web sites, etc. These forums offer open communication opportunities for management to interact with employees and create transparent culture.

6.3 Digital Culture Require Managerial Transformation

Organizations need to review their traditional policies and practices. Digital culture disrupts the geographical boundaries as well as organizational traditional framework. Internet which are characterized by their decentralized and horizontal nature. Companies adopting digital culture require managerial transformation. This needs close introspection of individual mechanisms and tools and software's used as well change in mindset of employer and employees by proper training, positive mindset, and freedom form company model (Shikha, 2012).

6.4 Collaboration Among Stakeholders

Business as usual has changed since digitization. Work culture including work ethics has changed. Today's generation is more frank and wish to work freely in open environment. Employees enjoy spending time and working together, which improves productivity. Informal meetings, brain storming sessions, talk while walk, and breakout

sessions during coffee breaks are few techniques advocated by communication experts to develop collaboration among all.

Sharing learnings and insights and develop collaboration among stakeholders are the key ask.

6.5 Skills Required for Twenty-First Century

Digital transformation keys in significant IT skills required for stakeholders. Government of India being aware of the basic fact that technical knowledge to be accompanied with associated practical knowledge that encompasses required hands on practice in laboratories and internships with business world. Few key soft skills required for twenty-first century include critical thinking, networking, collaboration, good knowledge of computers, associated application, media literacy, etc. Understanding the tech ecosystem, disruptive technology in your market and awareness of key tools and apps in the industry and mastering them is a key to success. The most effective way to ensure that employees have a knowledge of digital and its impact on the business is to arrange training session and development program. Companies like banking and insurance spend lot of sessions on digitalization to make their employees aware of their own financial instruments and policies to spread correct and effective communication to the stakeholders including investors and clients.

6.6 Risk and Opportunity Analysis

Any commercial decision is backed with a risk and opportunity study. Risk and opportunity are two sides of a business coin. Digital is moving at fast pace and has transformed business and practically all industrial sectors. Digital is a reality that needs to be embraced by all stakeholders of industry, commerce, regulatory bodies, and government. Business leaders and managers to communicate digital policy of their company to all employees, including internal and external stakeholders. This would generate employees confidence and associated risks emerging from mindset can be converted to opportunities with progressive mindset. Empathy and candor to be practiced at all levels. Training as discussed above needs to facilitate growing mindset rather than conventional stagnation. Startups with disruptive thinking as well as inhouse IT experts can develop combo programmed to suit the very business requirements.

6.7 Promote New Habits and Methodologies

Culture is behavior practiced by a group or persons displaying similar habits. Daily practice of time management and addressing people queries on priority basis are few common HR practices that can inculcate similar habits in the employees. Leaders can practice use of simple digital tools like addressing employees thru video calls or MS Teams, etc., thereby sending messages of digital transformation. Any new action becomes a practice or habit if performed for 21 days. Time management and punctuality are simple habits, but difficult to practice similarly organizations set up reference time for routine tasks like replying simple emails in 30 min and so on.

7 Conclusion

Communication process involving sender and receiver from conventional mode has changed to digital communication. IT development, artificial intelligence has changed the communication patterns and styles. Use of Instagram, WhatsApp, Facebook are few social media platforms that have evolved over last few years have improved the connectivity of people across the globe. Communication has evolved thru phases of from the conventional days of letter writing/use of post offices, etc., to emails/SMS/mobile phones to video calls. Thanks to new softwares like MS Teams, Zoom, etc., which are in wide use particularly in COVID-19 situation to have supported online education, online business transactions, and day to day life. The
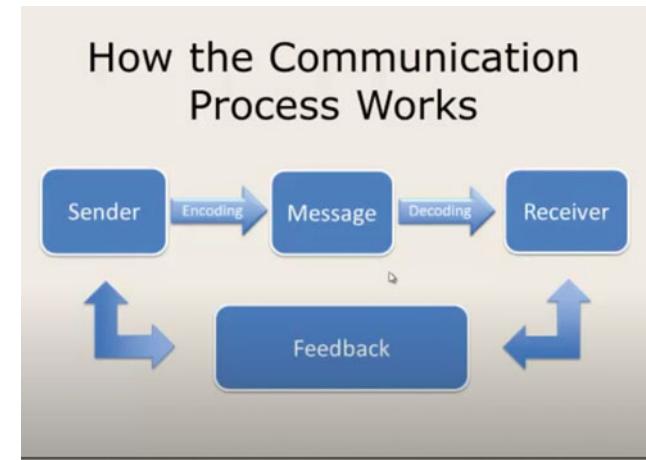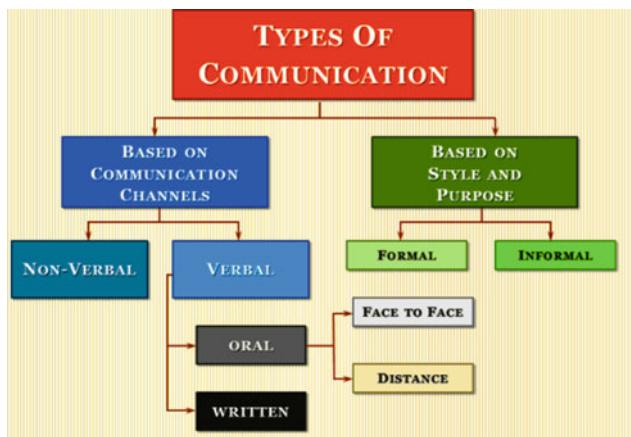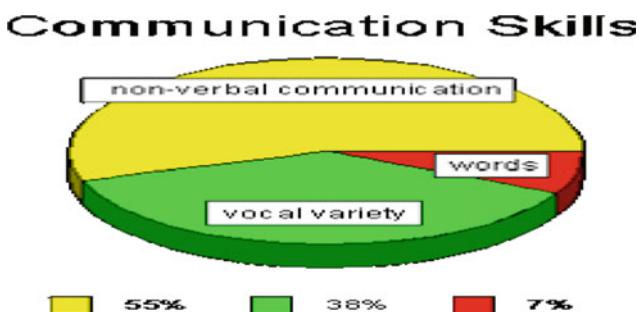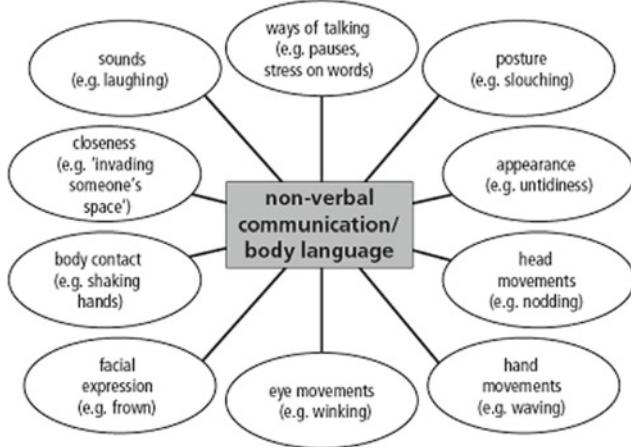
Fig. 1 Communication process

Fig. 2 Types of communication

Fig. 3 Communication skills—percent spread

Fig. 4 Nonverbal communication

changes in the communication that have taken place over the past few decades are due to a massive technological development. Furthermore, this is a cultural and technological evolution. In this information age, we cannot survive without digital communication. Through digital communication, cross-border cultural issues can be dealt effectively. On the basis of this literature, we can conclude that the use of digital communication encourages cross-cultural collaboration and promotes business.

References

Communication styles. www.oxfordlearnersbookshelf.com website.

Mahajan, R. (2015). The key role of communication skills in the life of professionals. *IOSR Journal Of Humanities And Social Science (IOSR-JHSS), 20*(12), Ver. II, 36–39.

Martin Talks—Steps to build a digital culture. www.matomico.com

Meenakshi, R., & Sharma, S. (2011). *Communication skills*. India: Oxford University Press.

Shikha, S. (2012) Communication skills for engineers in global arena. *IJAMH, 1*, 1–6.

Tonc, A., & Simon, I. (2002) Presentation and Communication, Regional Centre for Eastern & Central Europe

Tony Robbins—Communicate more effectively. www.tonyrobbins.com

www.Mindstool.com website—Active Listening

Digitisation of Financial Markets: A Literature Review on White-Collar Crimes

Raji Pillai and M. Lokanadha Reddy

Abstract

This is an empirical study which describes the financial issues with an increasing usage of the virtual currency in the present situation. With the introduction of the democratising, the influence of the ICT and its effect involved in various aspects of our lives like the economic, political, and the societal requirements. The financial frauds in various forms and its impact on financial market had been identified in the earlier research. The economic structure of the markets has been facilitating these. The frauds in the financial sector are identified as the lending frauds, identity frauds, and the investment frauds. The financial frauds are purely dependent on the market segmentation and the involvement of the various market instruments. The present study is carried out to understand the recent developments happening in the field of financial frauds, various developments like the free entry exit of participants, global currency involvement, increasing types of transactions in the financial sector, and the financial innovations involving technological and legal aspects. Technical problems in maintaining the secrecy and confidentiality of the dealings of the banking transactions. The present study tries to connect the different types of financial crimes to the facilities brought in by the ICT, and it needs more attention and more transparency to fight the white-collar crimes.

Keywords

Digitalisation • Market system • Information technology financial transparency

1 Introduction

The term 'market' describes a place where people gather to buy and sell provisions, livestock, and other commodities. While describing a financial market, the meaning extends by saying that the place where people gather to buy and sell financial securities and assets like the equities, bonds, and currencies. These markets help investors increase their investments with different levels of risk. These markets work as agents by helping them to mobilise their investments.

Further to this, the stock market permits investors to buy and sell openly company shares. Where the new issue market is termed as a primary market and an already existing share belong to the secondary market. These markets include:

- **Bond markets**—where investors invest in securities issued by state governments, municipalities, etc., with a predefined period and rate are traded,
- **Derivatives market**—trades in securities and they are regulated by the market price,
- **Forex market**—the most liquid market where investors trade in currencies throughout the world,
- **Money market**—securities with a very short maturity period of less than one year are traded, and.
- **Over the counter market** (OTC)—where the share which are non-listed to any exchange are traded.

The sudden dramatic change in the field of IT in the past few years is a remarkable achievement for the global upgradation but when it comes to induction of a new system technical problems are there. As the concept introduces a method where the whole transaction moves ahead without any face to face interaction between the two parties, nor the product is physically seen. The transaction is completed with the online mode of communication, using telecommunication network. In this process, Internet also plays a vital role. The entire information is provided to the customer using a

R. Pillai (✉) · M. Lokanadha Reddy
REVA University, Bangalore, India
e-mail: rajipillai04@gmail.com

network communication and websites are created for the purpose (Graham 2012).

The customers are given options to compare the product price, and other characteristics from suppliers across the globe. This also provides an option to other types of selling activities like context selling, direct selling, etc., and some other types of services like advertisements, demonstration, etc., are added to these. In an earlier regular study carried out by the Federal Bureau of Investigation (FBI) reveals that the loss as well as physical and emotional damage incurred to the society by a white-collar crime is much more than a traditional crime such as robbery and burglary.

1.1 History of White-Collar Crimes

In the year 1939, the concept of white-collar crime was first introduced by Edwin Sutherland, and American sociologist who was one of the most influential criminologists. This was a concept that went against the general myth of the people that aristocrats cannot do things wrong or in other words kings cannot do anything wrong. There were many people who tried proving the concept after Edwin, where they introduced the blue-collar crimes also which were associated with people of the underprivileged section. (Gottschalk and Gunnesdal 2018).

The white-collar crime was difficult to detect and it always involves violent methods of committing crimes. These criminals are not afraid of the law bureaus, because they know the maximum limit of punishment to be levied in case they are caught. The white-collar crimes are thousand times higher economic loss to the society, whereas the blue-collar crimes are very nominal in value. A white-collar crime takes place due to selfishness, and for its execution, they use very well-intended approaches. But when we compare the blue-collar crimes these are carried out because of fury, retaliation, and other emotional reasons. The white-collar crimes are socially acceptable than the street crimes as the media, and other sources of news have prevented the information from reaching the public.

1.2 Common Types of White-Collar Crimes

There are many types of white-collar crimes, which has mainly:

Fraud: it involves offenders who replicate an account to withdraw money from another person's account. These frauds also include identity manipulation or theft of identity.

Bank fraud: these frauds use illegal means to obtain money, financial assets, and other properties owned by an organisation or by individuals. These can be again categorised as:

Frauds by Insider: Ghilarducci et al. (2009).

Rogue Traders—Banker using bank money for personal highly risky investments.

Fraudulent Loans—Loans issue to individuals who may not even exist, and these loans are taken with the help of inside staff.

Wire Fraud—These frauds are done at the time of interbank fund transfer system by misleading transfers, and once the transactions are carried out, it is impossible to cancel reverse these.

- **Bribery:** it is use of power or position to make financial benefits. These are difficult to prove and sue.
- **Cyber Crime**: crime caused due to Internet problem. In this process, the credit card details are collected. There are individuals who develop virus to infect the computers and send spam messages, which perform task of malfunctioning of the system and helps to generate funds.
- **Insider Trading**: it is an illegal practice of buying and selling of stocks for one's own advantage **through the confidential information**.
- **Ponzi Schemes**: A fraudulent scheme where the payments of the original investor come from new investors, where high returns are promised on these investments. These opportunities do not even exist in actual. Telemarketing fraud, legal assistance, pyramid schemes, tax evasion, etc., are a few to list.

2 Literature Review

2.1 Lim (2017)

Financial management has two objectives namely profit maximisation and wealth maximisation. Profit maximisation helps companies to determine the best output at a certain price level, whereas wealth maximisation is to increase the value of a business and in turn increasing the value of stocks held. The information technology has affected the human life by helping them understand the importance of forecasting and to obtain an asset, and the working capital requirements are understood with the short and the long term. It also helps in planning and simplifying the work and caters to the projection of income and expenses, and in certain cases, losses too can be predicted. Internet help companies to acquire additional capital and understand their paying capacity through credit scores. It also helps investors to measure their investments and take required decisions, and

the government is also taking measures to promote the use of technology by introducing online services to the investment and security sector.

2.2 Scholars and Soley (2017).

The author has tried to understand the relationship between the components of a business organisation and the commission-based crimes. The major phases of businesses are identified as areas where crimes are committed. Firstly, these crimes are influenced by relationships, social bonds, and situations. Secondly, it is concerned by the biological, psychological, and human personality. It is understood that the white-collar crimes generally occur because there is a lack of the sense of 'wrongness', which means the person never feels doing such crimes are wrong. İt is understood that the three primary areas which can contribute to the potential contribution of occupational crimes, keeping in mind all the aspects of the crime, and the study is based on the concept, namely opportunity, motivation, and rational, and further classified based on their intensity and again classified as structured and unstructured crimes. The author also developed a fraud triangle which included three factors opportunity to commit the crime, motivation to commit the crime, and the rationalisation of the crime. Finally, it is identified that the aspect of the organisation can either encourage or hinder the ability for a white-collar criminal and this will rationalise the decision taken.

2.3 Garg (2016)

The study tried to understand the impact of digitalisation in the banking sector, and the time taken to complete a process of traditional banking to the modern techniques. It is also understood that the digital network is removing the geographical barriers and adding new dimensions to banking system, but it is also posing strategic risk of loss. The customers are always concerned to the simple and easy access of any system, but accuracy and efficiency are also expected.

2.4 Martinez (2014)

One of the most serious issues relating to crime is the white-collar ones which are responsible for the major economic damages every year. While talking about the white-collar crime and the street crime, both causes immeasurable waves effect damages to the individual as well as to an economy. The intensity of punishment what any offender gets as well as the justice any sufferer receives is not comparable. The society has been able to accept the

white-collar crimes easily as compared to that of the street crimes. The white-collar culprits have the extra safety barrier, and to get evidence against these types of people, the investigations should go deeper to find traces of the crime. The weakness in the legal system gives chances to the culprits to have an easy access to the legal representations. Most cases the white-collar criminals are jailed for long durations with huge fines along with the repayment of the misappropriated funds. The white-collar criminals infiltrate the financial and the economical schemes, without the knowledge of the general citizens. The supervisory organisations have been proved incompetent to protect the interest of the public, as well as prosecuting the culprits.

2.5 Rashad Yazdanifard (2011)

With the online banking industry growing over the years, it is experiencing an increase in the financial institutions encouraging the customers to carryon banking transactions. With the increase in banking transactions, the Internet-based crimes and frauds are also increasing. This article tries to explore the online banking frauds, and the activities have negatively affected the customer's trust in the ability. The customers are fighting for the protection of their rights and to improve the security of their investments and to enhance the customers trust in online banking.

2.6 Almiron (2007)

With the democratised, dimension of the new information and communication technologies (ICT) are widely accepted. The negligence of the information technology system that deals with economic, social, and the political theories even after repeated reminders. The ICT system generally approached from the point of view of the globalisation of knowledge or from the economic productivity point of view. Even though democratising has played a major role in providing economic and global changes in the economy, but lack of transparency in the political, economic, and social system is the main reason for the different types of frauds and the white-collar crimes.

2.7 Wang et al. (2006)

This study was carried out in Taiwan to understand the financial frauds, and the use of technology was worsening the situation of the economy. The financial crimes are carried out for personal gains and it has become one of the major crimes. The widescale use of technology has increased in the recent past. The use of IT-enabled platforms is making it

easier for people to become victims of the frauds. The most common type of fraud identified is the financial frauds involving transactions involving credit card fraud, telemarketing frauds, e-commerce, etc. The frauds are further classified into two categories based on the type of attack they belong to, system attack—which misuses the loopholes in the security system or non-system where the control system is retrieved. Measures were suggested to increase the security of the existing framework.

3   Need for the Study

In the present situation, where digitalisation is the need of the hour and it is giving more scope for the white-collar crimes by making people get involved without their knowledge. This paper tries to understand the situations under which these types of crimes happen and its impact on economy.

4   Objectives

- To understand the concept of white-collar crimes in the present scenario.
- To study the financial impact of white-collar crime and virtual currency on an economy.

5   Research Gap

After extensive review of literature, it is found that most research papers have tried to measure the losses incurred by the technology adopted, technical lags, etc., but no study has tried to give solutions to the problems. This paper tries to analyse the problem and give suggestions.

6   Sources of Data

Empirical observations based on secondary data have been used. Data has been collected from various journals, websites, books, and e-books.

7   Scope of the Study

This study leads us to the increasing number of white-collar crimes using the technical lags for personal gains using the various online payment modes including banking services. These services were introduced to give customers an advanced and reliable services to customer through electronic banking.
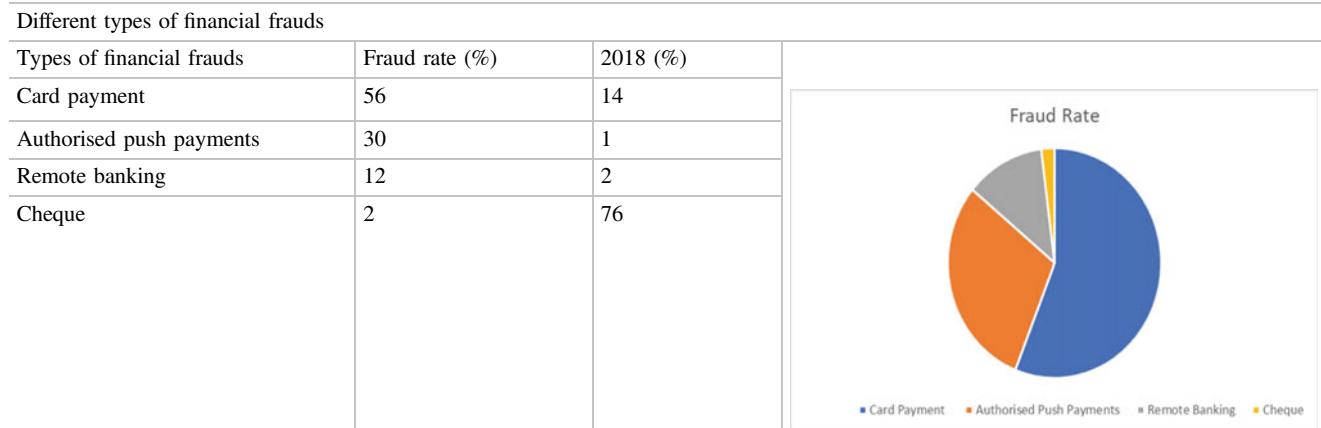
8   Understanding the Financial Impact of White-Collar Crime Through Survey Reports

According to a Global Survey, Indians are the victims to the highest number of online banking frauds at 18%, followed by 8% in Germany and 6% in UK (Rivera, 2020). USA tops the list of countries with maximum Internet frauds followed by Russia, India, Australia, Canada, France, Luxembourg, Germany, China, and Italy. Further, it is seconded by the RSA Quarterly Fraud Report during the period between 01 January to 31 March 2018, phishing accounted for 48% of all cyber-attacks (Rivera, 2020).
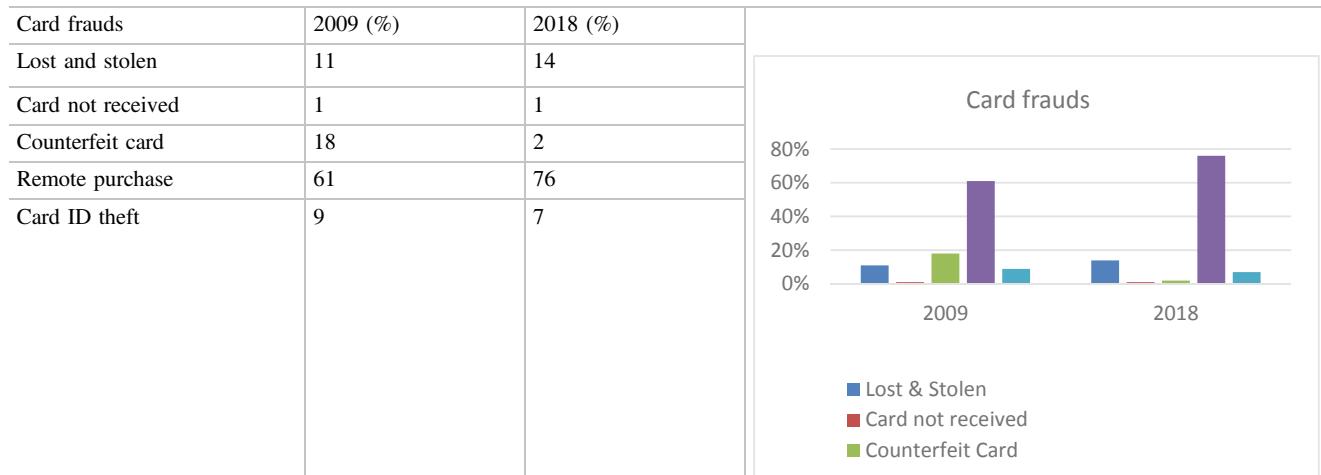
According to PWC's Global Economic Crime and Fraud Survey report 2018 (Rivera, 2020):

Year	Rate of economic crime (in %)
2001	43
2003	37
2005	45
2007	43
2009	30
2011	34
2014	37
2016	36
2018	49

Source PWC's Global Economic Crime and Fraud Survey Report 2018 (Rivera 2020)

Different types of financial frauds

Types of financial frauds	Fraud rate (%)	2018 (%)
Card payment	56	14
Authorised push payments	30	1
Remote banking	12	2
Cheque	2	76

Source Fraud the Facts 2019 (The definitive overview of payment industry fraud 2019)

Card frauds	2009 (%)	2018 (%)
Lost and stolen	11	14
Card not received	1	1
Counterfeit card	18	2
Remote purchase	61	76
Card ID theft	9	7

Source Fraud the Facts 2019

The above study reveals that the maximum number of frauds happen in the card payments, which is because of the technical lag caused by the Internet service providers and this stopgap is used by the hackers. The frauds are carrying out and the victim realises it very late as it is not easily detected.

Comparison between frauds from 2009 and 2018

The above table reveals that telemarketing and other types of purchasing sites, where the maximum online banking transactions are used. This is also the place where customers require a support of the Internet services and they tend to lose money (The definitive overview of payment industry fraud 2019).

9   Findings

- Frauds or risk of losing money is a common problem faced by most companies.

- The companies are regularly facing these storms of regulatory, internal, external, or reputational risk.
- Lack of transparency in the system is one of the major reasons.
- The absence of awareness and education is another factor to be blamed.
- The lack of technical knowledge in which white-collar criminals claim to be well versed in.
- Using of technology is only appreciated if the reason behind the use is also understood.
- Playing with the sentiments is the public is another cause which white-collar criminals take advantage too.
- The public image of the white-collar criminals is a major reason which also a lack of awareness and education.
- About white-collar crime and criminals is also to blame for this public sentiment.

10 Suggestions

It is suggested that people should be educated regarding the different frauds which can be victim to like:

- Investment in direct personal transactions rather than in digital currencies.
- Identify the fraud in advance.
- A genuine bank will never try to contact its customers asking for PIN or any personal details.
- Bankers do not provide any financial services through telephones.
- Banks never send emails asking customers to click on links and explore new facilities.
- Never respond to unexpected mails or automatically generated mails.
- Use valid antivirus for software security.
- Do not trust everyone over the telephone call asking for account details.
- Keep changing the pin codes and passwords regularly.
- Explore the protective power of technology.

11 Conclusion

White-collar crimes are the threats that pose too high on an economy. The economic development of any county cannot be taken too lightly. When it comes to managing frauds or risk, it is very systematic balancing between the detection of any fraud and the customer's technical knowledge. Where the consumers can tolerate the digital transformation at various degrees of life from basic consumer needs to their financial needs and also to protect the interest and safety of their e-commerce and digital transactions. These threats influence the economy from white-collar crimes which is too high. It is a leading cause in today's world as the underdeveloped economies, and it is a simultaneous cause of the poverty of any country. Whereas the white-collar criminals are easily engaging institutional weakness and bad leadership and governance. The white-collar corruptions are increasing day by day in our daily life. Until and unless the law is seriously enforced with proper prosecution of the culprits, especially against those who are never punished.

So, every culprit should be brought to the limits of the law and proper enforcement of law should be implemented.

Plagiarism Report

6% Similarity Index, 4% Internet Sources, 0% Publications, 4% Students papers.

References

Almiron, N. (2007). Icts and financial crime: An innocent fraud? *International Communication Gazette, 69*(1), 51–67. https://doi.org/10.1177/1748048507072779.

Garg, S. (2016). Digitization-A study with reference to customer satisfaction towards E-banking. *International Journal of Control Theory and Applications, 10*(40), 41–48.

Ghilarducci, T., Nell, E., Mittnik, S., Platen, E., Semmler, W., & Chappe, R. (2009). Memorandum on a new financial architecture and new regulations. *Investigacion Economica, 68*(267), 147–161. https://doi.org/10.22201/fe.01851667p.2009.267.37391

Gottschalk, P., & Gunnesdal, L. (2018). White-collar crime in the shadow economy: Lack of detection, investigation and conviction compared to social security fraud. *White-Collar Crime in the Shadow Economy: Lack of Detection, Investigation and Conviction Compared to Social Security Fraud.* ISBN 978-3-319-75292-1,1–155. https://doi.org/10.1007/978-3-319-75292-1

Graham, M. (2012). White collar crime and the United States' Economy. *University of New Hampshire Scholars' Repository, 49*, 5–55. https://scholars.unh.edu/honors%0Ahttps://scholars.unh.edu/honors

Lim, F. P. (2017). The Impact of Information Technology in Corporate Financial Management. *Advanced Science and Technology Letters*, Vol.146 , Nov, 114–119.

Martinez, J. P. (2014). *Digital commons @ EMU unpunished criminals: The social acceptability of white collar crimes in America recommended citation* (Vol. 11, Issue 4, 2016). https://commons.emich.edu/honors/382.

Rashad Yazdanifard, W. F. (2011). Electronic banking fraud; the need to enhance security and customer trust in online banking. *International Journal in Advances in Information Sciences and Service Sciences, 3*, 505–509.

Rivera, K. (June, 2020). Fighting fraud: A never-ending battle. *PwC's Global Economic Crime and Fraud Survey 2020* (Survey Report).

Scholars, J. W., & Soley, S. (2017). *Scholarly commons white collar crime: The role of the firm in occupational crime* (Vol. 35, pp. 5–24). https://repository.upenn.edu/joseph_wharton_scholarshttps://repository.upenn.edu/joseph_wharton_scholars/35

The definitive overview of payment industry fraud. (2019). *Fraud the fact 2019 UK*.

Wang, J. H., Liao, Y. L., Tsai, T. M., & Hung, G. (2006). Technology-based financial frauds in Taiwan: Issues and approaches. In *Conference Proceedings—IEEE International Conference on Systems, Man and Cybernetics*, November 2006 (Vol. 2, pp. 2–6).

A Study on Intervention of Chatbots in Recruitment

K. Anitha and V. Shanthi

Abstract

The greatest dare across the HR industry today across the globe is that they all have bulk numbers of resumes in their application tracking system (ATS) and customer relation management (CRM) systems, but filtering those resumes and mapping candidates to job openings from these systems manually plays a very tiresome task for recruiters. Finding qualified candidates from the applicant pool and fitting them in the right place is the key to successful recruiting. Technological innovations though help recruiters on a day-to-day basis, bringing out the most effective and efficient strategy is still a question. This is possible with the help of technology advancement in the form of artificial intelligence (AI) which could play a key role in making the recruitment process more operative. AI takes several forms, but this paper focuses on the role and impact of chatbots in recruitment industry. This study was conducted among 120 IT/ITES recruiters in South India. This paper highlights on the impact of an artificial intelligence chatbot on recruitment process. The authors have used correlational analysis and multiple regression analysis to test the facilitated hypothesis. This paper augments that artificial intelligence chatbots are very effective techniques which need to be implemented in recruitment process as it automates the whole process which eases the job of a recruiter. This study also details on the usage of various chatbots across the globe and its benefits for the recruitment process to be effective and efficient for the organizations to sustain in the competitive environment.

Keywords

Chatbots • Recruitment • Artificial intelligence • AI

K. Anitha (✉) · V. Shanthi
Meenakshi Academy of Higher Education and Research, Chennai, India

1 Introduction

With the dynamic and complex business environment, technological innovations are modernizing the setting of economy and organizations (Snow et al. 2017). The digital transformation of business has key allegations on our society, commercial life, administration and labour market (Brynjolfsson and McAfee 2014). The change has been into every part of the organization. The use of technology in human resource management started from applicant tracking system, talent acquisition systems, customer relationship management and talent relationship management. The exemplar has shifted to more new novelties such as SAS, augmented reality and artificial intelligence which are slowly being implemented into human resources where these inventions impact right from recruitment, screening, training and development and retention. A research study emphasizes that artificial intelligence tries to apply novel changes in HRM practices like recruitment, training, talent management and retention, and its effect is more remarkable in future (Merlin & Jayam, 2018). Recruitment obliges to be the base of an effective human resource management as it is the principal function where the employees are brought into the organization. Comprehensive recruitment strategies are on the go where more ground-breaking methods are deployed to hire the right fit. With the era of digitization, recruitment process has to be re-invented. The process of automation has to be brought in as recruiters spend endless time in monotonous work of pooling resumes and matching the right candidate. On this context, the authors have brought the concept of artificial intelligence techniques such as chatbots into the human resource management functions to mark a quick and easy process of recruitment. In line with this, a recent survey conducted by Hr.Com stated that almost all HR professionals agree that in near future, they will be working along with AI in workplace. AI-powered technologies along with human experience are an asset to build effective HR organization globally.

The term artificial intelligence (AI) coined by John McCarthy in 1956 is in common use as a software, machines, system and computers. Artificial intelligence has leaped onto the global market very recently across the industry and plays generous role in human resource management as it primarily shrinks the workload of HR professionals using chatbot agnostic solutions and algorithms in the entire process like recruitment, selection, training, development, etc. With the rise of technological boom, chatbots appear to be part of the future of recruitment. A recruitment chatbot is a replica of a human recruiter which uses artificial intelligence to converse with the candidates during the recruiting process. An effective chatbot helps to make HR professionals work much easier by hurtling the hiring process, like stripping out bad candidates or fact-finding or to help in report building. Chatbots are the dream assistant for the busy recruiter, taking on almost all the administrative jobs and doing them in an efficient manner, and in large volumes. This paper entitles about the impact of using a chatbot in recruitment process right from screening resumes to on-boarding of candidates.

2   Related Works

AI affords favourable solutions for recruiters to augment talent acquisition by changing over time-consuming tiresome tasks such as sourcing and screening applicants, to improve the quality of the hire and neutralize human biases (Hamoud and Laszlo 2019). The impact of AI on human resources takes a digital shift within the organization and also human recruiter's needs to upgrade their skills. There is also a positive effect on the usage of AI in HRM practices like recruitment, training and development, career path and performance analysis (Marwan Mohamed Abdeldayem, 2020). Studies on AI enumerate the constructive impact on sustainable growth of the organizations through comprehensive recruitment strategies, employee well-being and psychological contract (Anitha & Shanthi, 2020). A research study evidenced that AI is the most innovative technology being used in recruitment process that simplifies recruitment repetitive tasks strategically which has a significant effect on the performance of employees (Vedapradha et al., 2019). Research study by N.Nawaz proved a positive effect of using artificial intelligence in recruitment in Bangalore. The study also observed the opportunities, risk and utilization of AI on recruitment (Nawaz, 2019a).

In line to this, a research study further proved that artificial intelligence is taking its shape in swapping human involvement in the recruitment process (Nawaz, 2019b). Further studies state that the recruitment process can enrich

its quality with implementation of AI, as it will assist recruiters to select suitable candidate immediately and to ensure whether the candidate is suitable or not (Nawaz, 2017). HR professionals will have many tasks to do, but they have to use chatbots wisely to get their solutions effectively (Circle Homepage, 2020). One of the major challenges lies in selecting the appropriate candidate from the large applicant pool of resumes. This can be done easily with the help of chatbot where few basic questions can be pre-recorded and asked to the candidates (Faiyaz, 2018). A chatbot helps the job-seeker in answering questions which are related directly with recruiter such as about the salary, incentives, leave facilities, FAQ, workforce diversity, complex queries and other related questions (Nikhila et al., 2019). AI chatbots have constantly developed over the time to provide deeper insights. This will make sure that the recruiters not only hire the right candidate for the organization but also with right skill (Gikopoulos, 2019). Adams, 2018, states that chatbots are renovating the entire recruitment process right from the effective communication between a candidate and a recruiter in identifying a qualified candidate and to schedule an interview.

Globally, recruiters have more added errands to meet the daily allocated business goals, track of competitors, accurate challenges via benchmark, tracking of employees' satisfaction level in all the stages and a lot more. For this, chatbots are useful, because there is a daily conversation database, which will eventually be useful to resolve complex issues (Joshi, 2019). The AI chatbots are expected to execute the same human conversation in messaging, the unique way of using words, shorthand, emotions (Sheth, 2018); at the end, it will work on the basis of natural language to support the entire conversation process between a candidate and HR professional (Folstad & Brandtzæg, 2017). Chatbots are intended to carry over the repeated administrative tasks and leave the recruiter with the qualified candidates. Chatbots necessarily eliminate the routine work in the recruitment process, as it automates the end-to-end recruitment process and enables the recruiters and HR team to move towards success to ensure organizations lead in digitalized era. (Kuksenok and Prab, 2019). Many studies have explained how well the digital technologies such as AI in common play a significant role in process of recruitment. Few research studies have proved the impact of using AI techniques in recruitment industry, and in this research paper, the authors try to analyse and focus on the benefits and associations of an AI chatbot being utilized on recruitment process to select cities in South India. Several other benefits are being served by the chatbots to make the work of recruiters much easier. The other benefits have been discussed further in the study.
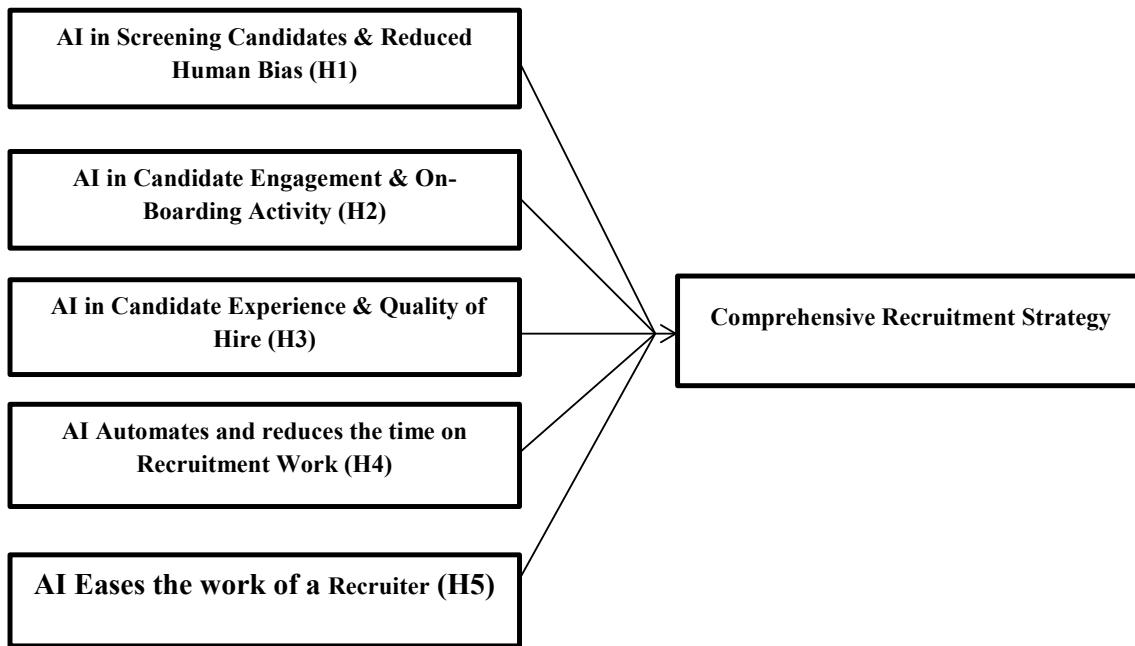
Fig. 1 Conceptual framework on the hypotheses development

3 Methods

3.1 Problem Statement

With the dawn of technology into HRM, as it aids in effective decision making and other aspects, it is imperious to employ the use of artificial intelligence to the fullest extent. On this aspect, the authors have taken this research in hand.

To be more specific, the following research questions need to be addressed.

1. How effective is an artificial intelligent chatbot used in recruitment process?
2. What would be the benefits of using a chatbot in recruitment process?

With the above research questions, the following hypotheses were framed.

H1 AI Chatbots screens candidates effectively and has a positive effect on reduced human bias in a recruitment process.

H2 AI Chatbot enhances candidate engagement and has a positive effect on the On-boarding activities in recruitment process.

H3 AI Chatbot improves candidate experience and has a positive effect on the quality of hire in recruitment process.

H4 AI Chatbots automates the whole recruitment process and has a positive effect on the time spent by a recruiter.

H5 AI Chatbots eases the work of a recruiter.

The link between the hypothesis and its development is conceptualized in Fig. 1.

3.2 Methodology

The data for the research were collected from a total of 120 samples using questionnaire. All samples were people working as HR in IT/ITES industry. The typical method for collecting demographic details of the sample as well as for administration of questionnaire was implemented to accumulate applicable data for the research. The questionnaire was adapted from Oracle 2019 State of Artificial Intelligence in Talent Acquisition (Hr.com Homepage, 2020). Statistical correlational analysis was conducted using IBM SPSS 23. The data collected were imperilled to reliability test utilizing Cronbach's alpha which was above 0.845. The numeric results of reliability test are revealed in Table 1.

Table 1 Cronbach's alpha reliability test

Instruments	Cronbach's alpha	No. of items
Artificial intelligence chatbots	0.845	12

3.3 Conceptual Framework

See Fig. 1.

4 Research Analysis and Results

The data collected were subjected to descriptive statistics to know the frequency and percentage of the respondents. The samples belonged to only three major cities of South India, namely Chennai, Coimbatore and Bangalore. The data were collected through LinkedIn contacts. It is observed that most of the respondents belong to the age group of 20–30, being 52% male and 48% female. The detailed descriptive analysis of the respondents is shown in Table 2.

Results of the study indicate that AI chatbot is a technology which can work as effectively as a human brain in varied scenarios. It gains attention and influences in automating recruiting system when compared to traditional recruitment methods. Recruitment is the essential activity of all organization to move on. It is clear that recruitment industry is coming up with growth by implementing smart ways to recruit, i.e. recruiting through artificial intelligence.

Professionals try to adopt smart methods for collecting data of the candidate to make the progress by end number of techniques (Hill et al., 2015) such as to identify potential candidate to approach, try to respond to the unsuccessful candidates, screening the present candidate, in sending job offer, and bringing selected candidate into company (Parry & Battista, 2019) also in other possible way to connect and collect all the information of employee into a one-stretch single database, and it reveals new insights for better candidate profile to hire and improve the effectiveness of the recruitment process (Cappelli et al., 2019).On this context, the hypothesis was framed, and statistical analyses like correlational and multiple regression were used.

The authors have chosen correlational analysis as it best identifies the relationship between two variables. The results of the correlational analysis matrix are displayed in Table 3. From the table, it is evident that chatbot plays a vital role in the process of recruitment. The authors have streamlined the use of AI chatbots into four major effects such as candidate screening, candidate engagement, candidate experience and automation of recruitment process. These constructs have been identified in line with the hypothesis development. The four effects are evidenced with the correlational figures displayed in Table 3. It is also illustrated (Fig. 2) and discussed further in the discussion section. Screening candidates from resume pool and being biased during the screening process lie to be the major flaw in recruitment process which is significantly correlated that an AI chatbot can effectively screen potential candidates, and it eventually reduces human bias (H1). The study proved to have the variables significantly correlated (p value = 0.000, $p < 0.05$). On this context, implementation of AI chatbots in recruitment process will prove to be a comprehensive strategy for organizational development in identifying the right and potential candidate, thus trying to be globally sustainable.

Chatbots are in use to collect data from candidates using a text conversation rather than asking them to fill out lengthy forms. A SmashFly report found that 74% of candidates who start filling the job applications will drop off before completing it which maybe because it is too long or it is a time-consuming process. It was told that employers using chatbots can save 74% of recruitment marketing efforts, time and budget. On this aspect, the authors have framed the hypothesis on candidate engagement and its relationship with the on-boarding activities (H_2) and on candidate experience and its relationship with the quality of hiring candidates (H_3). The study reveals that it is significantly correlated (p value = 0.001, $p < 0.05$) and is to be
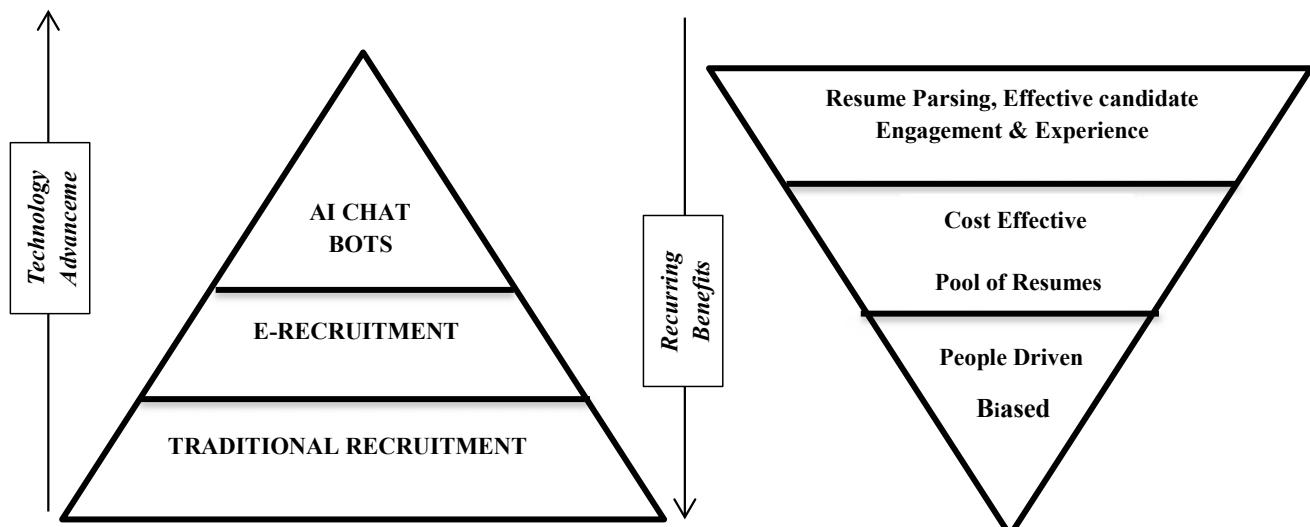
Table 2 Descriptive statistics of the respondents

Items	Description	Frequency	Percentage
Age	20–30	90	75
	30–40	30	25
Gender	Male	62	51.7
	Female	58	48.3
Designation	HR Manager	33	27.5
	HR Executive	21	17.5
	HR Recruiter	26	21.7
	Trainee HR	40	33.3
City	Chennai	74	61.7
	Coimbatore	26	21.7
	Bangalore	20	16.7
Organization sector	IT	70	58.3
	ITES	50	41.7

Table 3 Results of correlational analysis matrix

Hypothesized relationship on chatbot intervention in recruitment activities			On-boarding activities	Reduces human bias	Quality hire	Reduces time spent on a candidate
H1	Screens candidate effectively	Pearson correlation	Not applicable	0.514[**]	Not applicable	
		Sig. (2-tailed)		0.000		
		N		120		
H2	Enhances candidate engagement	Pearson correlation	0.572[**]	Not applicable		
		Sig. (2-tailed)	0.001			
		N	120			
H3	Improves candidate experience	Pearson correlation	Not applicable		0.615[**]	Not applicable
		Sig. (2-tailed)			0.000	
		N			120	
H4	Automates the recruitment process	Pearson correlation	Not applicable			0.461[**]
		Sig. (2-tailed)				0.000
		N				120

Correlation is significant at the 0.01 level (2-tailed)

Fig. 2 Top-down bottom-up approach on AI chatbots

understood that usage of AI chatbots in recruitment will enhance the candidate engagement which will be much easier for the recruiters to handle on-boarding activities. Usage of AI chatbots in recruitment also improves the candidate experience and has a positive effect that it also improves the quality of the candidate hired (p value = 0.000, $p < 0.05$).

Empirical researches state that the recruitment process is an in-depth and a time-consuming process. To bring a

solution to this context, authors have identified the technological innovation of AI chatbots into the process. These chatbots try to combat the whole process and reduce the time spent by recruiters on administrative tasks. With this note, the hypothesis was framed (H4), and it is significantly correlated that usage of AI chatbots will automate the whole recruitment process and has a positive effect on the reduction of time spent by a recruiter on each candidate (p value = 0.000, $p < 0.05$).

Table 4 Results of multiple regression analysis

AI chatbots	Standardized coefficient	Sig.
	Beta	
Chatbot can easily guide new hires on company policies	0.509	0.000
Chatbot reduces the human bias	0.200	0.000
Chatbot is used to walk recruits through on-boarding paperwork	0.218	0.000

The authors have used the multiple regression analysis to test the last hypothesis. It was assumed that higher the influence of using a chatbot in recruitment process will ease the work of a recruiter (H5).

Based on beta coefficient in Table 4, it is found that a chatbot being a guide to the new hires on company policies is the strongest item that positively impacts the work done by the recruiter. Guiding each and every hire on the company policies would be a tedious job for the recruiter as they have other significant tasks on concentrating on the employee well-being and engagement of the employees. It is to have taken into account that AI chatbots will ease the work of the recruiter in umpteen ways right from screening the candidates to the on-boarding formalities of the new hire.

5 Discussions

With the era of Recruitment 4.0, it is to be understood that technological innovations have mediated each and every aspect of human resource management. This study outlines the intervention of artificial intelligent chatbots in recruitment process. It also entails the list of various chatbots being used globally in recruitment process. A small comparison between a human recruiter and a chatbot given in Table 5 would be a best illustration to understand the ease of using a chatbot in recruitment process.

5.1 Outcome of Using Chatbots in Recruitment Process:

It is observed that chatbots are setting a new drift in the industry to manage time-consuming or repetitive administrative tasks which makes the recruiters' job easy. Table 3 highlights the effective use of chatbots in a recruitment process through the constructs framed by the authors. It is also supported by the correlational scores. The authors try to illustrate the need of a chatbot and the benefits of using an AI-driven chatbot in recruitment process in Fig. 2. Certain benefits of using chatbots in the recruitment industry as identified by the authors are:

Screen Candidates Effectively
Almost half of the recruiters report that scrutinizing through prospective candidates is the hardest part of their work (Homepage, 2020). There are thousands of millions of candidate profiles and resumes across the Internet. It is to be noted that not even a Boolean black belt recruiter can cope with these high quantities of resumes (Daily and Homepage, 2020). Chatbots surpass Boolean search in its ability to find matches that do not contain specific keywords which are identified as they interact with the chatbots. This is done based on parallel associations and through relentless knowledge as it determines what skills and other attributes are similar and/or often appear in combination. Chatbots can ask a variety of questions about a candidate's knowledge,

Table 5 Comparison of human recruiter and chatbot

	Human recruiter	Chatbots
Resume parsing	Analysing and selecting an applicant from a pool of resumes is a tedious and ongoing task	Analyses each resume according to the keyword given in minutes and help the recruiter to filter resumes
Screening	Screening each applicant in midst of other HR related works is a tough task	Makes significant enquiries to filter the applicants for the screening process
Engagement	HRs lack in engaging the individual applicants which eventually results in biased risk	Keeps the candidate posted on day-to-day status of the application which increases the candidate engagement with the company
Experience	Most of the HRs today do not have a positive experience with the candidates	Collects feedback about the entire recruiting process, thus enhancing the experience with each of the applicant
Resources	Traditional recruitment process takes more time because it has lots of limitations	Saves time by answering most of the FAQ

skills, qualifications and experience. This helps to qualify the whole lot according to the criteria of the employer and serves the recruiter with a small lot of potential candidates. Xor is a chatbot used by many organizations in hiring of new employees, which is almost alike Jobpal and Mya.

Improve Candidate Engagement

67% of the candidates believe that continuous updating about interview progress will have good impression about the organization says a report from CareerBuilder. It is a hectic process for the recruiters to update each and every applicant about their status as they would have no time in updating status rather than sourcing candidates. It always expected that 75% of the applicants never hear back from recruiters. This is where chatbots play a significant role and transform the applicant engagement experience to a new level. For example, according to CEO, Eyal Grayevsky, Myaa chatbot—engages in intelligent conversations with each and every candidate. She reviews their application with them, answers questions about the hiring process and also assesses the candidate as qualified and according to the interest schedules their first interview. Mya discards candidates quietly, signifying them with similar job openings and inviting them to register with the appropriate talent acquisition team.

Improve Candidate Experience

Identifying candidate experience with the organization turns to be a major differentiator in this global market. Getting feedback and suggestions about candidates experience is a success mantra to differentiate from its competitors and build relationships. AI enables chatbots to collect feedback and process it further. Chatbots interact with the applicants by asking simple questions about the job application and the screening process which serves to be a best feedback to enhance the screening process further in future. Chatbots help the candidates in the entire application process and enquire about the reasons if suppose that candidate does not go further with the application. Also, the point of improvement feedbacks can be taken from the applicants to improve the recruitment process further.

5.2 Some of the Popular Chatbots Used by Recruiters Across the Globe Are (Reviews and Homepage, 2020):

1. **Allyo**—focuses more on text module, asks few questions like "Are you willing to relocate" to the candidate and analyses whether they are a suitable match for the company and then tries to schedule a personal meet with the hiring manager.

2. **XOR**—uses AI to convert more candidates into your ATS, automate screening and handle candidate scheduling. Their solution works across 100 different languages, and many different modes of communication including SMS, Facebook, Web, email.

3. **Brazen**—tries to convert more career site traffic into applications and helps to navigate them through filling the application. It is told that 40% of the candidates who engage with the chatbot are likely to get hired.

4. **Olivia**—tries to recruit only through chat. It does not ask the candidate to fill any form. Through a minimal chat, it tries to get more information about the candidate like area of interest, preferred location, working hours, etc.

5. **Ideal**—saves recruiting time by screening and staging candidates throughout the hiring process, helps in automated resume screening, and quality of the hire is increased.

6. **Mya**—does almost all the pre-work for selecting a candidate. It sources, screens potential candidates, answers FAQ and schedules interview. Most widely used chatbot across the globe is Mya.

7. **Eightfold**—It is designed to engage jobseekers on the career site, tries to answer the candidates' questions and directs them through the site according to their interest and background. It is being successful in converting more applicants into right jobs.

8. **Wade and Wendy**—It helps the talent acquisition team to focus on more strategic initiatives and gives apt solutions to provide better matches. This chatbot sources passive candidates, screens candidates and does various other activities to provide the best match for the employer.

9. **My Ally**—focuses on coordination of interviews, collects feedback of interview and also prioritizes pipeline management for candidates.

10. **Debra**—a chatbot which focuses on psychometric testing of candidates. It tries to recommend and customize personality traits for each job.

11. **Lisa**—It helps to pre-screen multiple candidates at one go. It acts as a bridge linking candidate and the recruiter, helping candidates to know their application status, addresses their queries, etc.

6 Future Scope and Conclusions

This emerging technology has vast benefits for the recruiters doing right from their administrative tasks to matching the right fit into the organization. It also acts as a bridge between the candidates and recruiters to build relationships, thus

improving candidate experience and engagement on the go. In a survey conducted by Randstad, it was found that 82% of job seekers believe that the ideal recruiter collaboration with the candidate is a blend between innovative technology and personal, human interaction. This study focuses on that interaction and concludes that almost all HR professionals are in search of that technology-driven interaction. If that attitude continues to emerge, so will the recruitment chatbot be implemented in almost all organizations in mere future and will ease the work of a recruiter. The study needs to be further conducted on a broader perspective of using a chatbot in all recruitment activities as this study only focuses only on the benefits and effectiveness of using a chatbot. It can be further improved and researched on the aspect of other AI techniques into the HRM industry. Also, this study was conducted among few responses in a smaller context, where it can be explored in a much bigger phase.

This study elucidates a clear picture on the effect of using AI chatbots in recruitment process and also gives varied types of chatbots being used worldwide in recruitment industry. It is evident from the study that almost every organization today should start implementing chatbots to have gain efficient and effective work from the HR professionals. It should be noted that in the upcoming days, almost every recruiter will leap help from chatbots to make their job easier which is efficient and effective either. This ultimately proves to be a comprehensive strategy for recruitment in attaining organizational development.

References

Abdeldayem, M. M., & Aldulaimi, S. H. (2020). Trends and opportunities of artificial intelligence in human resource management: Aspirations for public sector in Bahrain. *International Journal Of Scientific & Technology Research, 9*(1), 3867–3871.

Anitha, K., & Shanthi, V. (2020). Artificial intelligence—A driving way for sustainable organizational growth. *Management Matters, 17*(2), 5–18.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. New York: WW Norton & Company.

Cappelli, P., Tambe, P., Yakubovich, V. (2019). Artificial intelligence in human resources management: challenges and a path forward. *California Management Review, 61*(4).

Faiyaz, Md. (2018). Iqbal: Can AI change the way in companies recruitment, development, training and managing in HR. *Asian Journal of Social Sciences and Management Studies, 5*(3), 102–104.

Folstad, A., & Brandtzæg, P. B. (2017). Chatbots and the new world of HCI. *Interactions, 24*(4), 38–42.

Gikopoulos, J. (2019). Alongside, not against: Balancing man with machine in the HR function. *Strategic HR Review, 18*(2), 56–61.

Hamoud, B., & Laszlo, V. (2019). will artificial intelligence take over human resources recruitment and selection. *Network Intelligence Studies, 7*(13), 21–30.

Hill, J., Randolph Ford, W., Farreras, I. G. (2015). Real conversations with artificial intelligence: A comparison between human-human online conversations and human-chatbot conversations. *Computational Human Behaviour, 49*, 245–250.

Ideal Homepage. (2020). https://ideal.com/ai-recruiting/.2016. Last accessed on 2020/10/24.

Select Software Reviews Homepage. https://www.selectsoftwarereviews.com/hr-chat-bots. Last accessed on 2020/10/24.

Hr.com Homepage. https://www.oracle.com/a/ocom/docs/artificial-intelligence-in-talent-acquisition.pdf. Last assesses on 2020/10/25.

Kuksenok, K., Prab, N. (2019). Transparency in maintenance of recruitment chatbots in where is the Human? *Bridging the Gap between AI and HCI Workshop*, 1–4.

Merlin, P. R., Jayam, R. (2018). Artificial intelligence in human resource management. *International Journal of Pure and Applied Mathematics, 119*(14), 1891–1895.

Nawaz, N. (2017). A comprehensive literature review of the digital HR research filed. *Information Knowledge Management, 17*(4), 15–20.

Nawaz, N. (2019a). Artificial intelligence is transforming recruiting effectiveness in CMMI level companies. *International Journal of Advanced Trends in Computer Science and Engineering, 8*(6), 3017–3021.

Nawaz, N. (2019b). Artificial intelligence interchanges human intervention in the recruitment process in Indian Software Industry. *International Journal of Advanced Trends in Computer Science and Engineering, 8*(4), 1433–1442.

Nikhila, P., Jyothi, G., Mounika, K., Kishor, M. C., Reddy, K., & Murthy, R. (2019). Chatbots using artificial intelligence. *Journal of Applied Science in Computers, 6*(2), 103–115.

Parry, E., & Battista, V. (2019). The impact of emerging technologies on work: A review of the evidence and implications for the human resource function. *Emerald Open Research, 1,* 5.

Recruiting Daily Homepage. https://recruitingdaily.com/artificial-intelligence-recruiting-future. Last accessed on 2020/10/24.

Sheth, B. (2018). Chat bots are the new HR managers. *Strategic HR Review, 17*(3), 162–163.

Snow, C. C., Fjeldstad, O. D., & Langer, A. M. (2017). Designing the digital organization. *Journal of Organization Design, 6*(7), 1–13.

VC Circle Homepage. https://www.vccircle.com/how-ai-and-machine-learning-will-impact-hr-practices/. Last assessed on 2020/10/24.

Vedapradha, R., Hariharan, R., & Shivakami, R. (2019). Artificial intelligence: A technological prototype in recruitment. *Journal of Service Science and Management, 12,* 382–390.

"Is Online Teaching–Learning Process an Effective Tool for Academic Advancement"

Seema Verma, Deepa Tyagi, and Rakesh Verma

Abstract

In modern times, especially in the current prevailing COVID-19 period, a system of studies came into the picture replacing the classroom learning with online classes. Although there are many challenges which the teachers and learners are facing during their online process of interaction, it has become the need of the hour. There may be various questions related to the online methods of teaching and learning such as the quality of online teaching, problems of students, the question of recognition, health issues, Internet connection, professional space, and still, its popularity is incredible. The online work environment now involves using communicative teaching tools and different software to interact with the learners as required. Microsoft Teams, Google Meet, Olympus, Zoom, and many more names are enlisted in the category of online assistance tools for academic advancement in the teaching–learning process. In the online mode of teaching, the teachers may choose their own schedules and timings, but is this flexibility adds to learning, or is it only a facility? Moreover, salaries for online instructors or teachers solely depend on the organization for which they are teaching, and it hardly matters what is their qualification and experience. It may be said that online teaching–learning provides a golden opportunity to meet people across the world while staying at home and it may be a rich experience for them to learn new things about the culture of other learners. They can share their way of life including their foods, clothes, behavior, etc., contributing to the mutual understanding and building global bridges: they can have a wonderful experience of all kinds of lifestyles.

1 Introduction

Before COVID-19, the online teaching–learning process was popularized as a distant learning course. Most commonly, it was used for the higher education programs. This process was opted by the persons who were not able to go to the institutions/universities/colleges, but they are willing to study, and they study by themselves with the study materials provided by the institutions. In the process, the students were communicating through the correspondence process via postal/courier media along with telephonic conversations and e-mails. The number of students in online teaching/distant learning is increasing continuously and everyone is considered in their career program with their online courses.

The onset of COVID-19 is very much unexpected and became the name of a terror for the public in general because it is leading to toll. Students are children, and children are more sensitive toward the contagious diseases, mainly upper respiratory tract infection and lung infection diseases. The pandemic of COVID-19 created an awkward condition of lockdown in almost all the places, therefore, all schools, colleges, and workplaces were closed which lead to employees to be suffered from their income and students were suffered in their education. In the month of March 2020, it was understood that COVID-19 will be limited by 2 or 3 months, and in the earlier phases of COVID-19, it was the time for examinations along with the high time for the studies, so students suffered a lot in the academics. So, to

S. Verma
ABES Engineering College, Ghaziabad, India
e-mail: Seema.verma@abes.ac.in

D. Tyagi
JSS Academy of Technical Education, Noida, India
e-mail: deepatyagi@jssaten.ac.in

R. Verma (✉)
MIPS College, Ghaziabad, India
e-mail: rv.hvpe@gmail.com

complete the session of students, the online method of the teaching–learning process with the digital technology of smartphones, laptops, and the Internet was utilized.

The pandemic of COVID-19 as assumed did not end in 3 months but keep spreading and exaggerating daily to month on month time. This is the third week of September 2020 in running and approximately fifty-five-lakh-sixty-eighty-thousands cases have occurred in India with total death of approximately eighty-eight-thousands-nine-hundred-ninety, and approximately seventy-lakh cases are reported in America with total death of approximately two-lakhs-four-thousand-five-hundred have been reported (data sources—world-o-meter—corona-virus cases). Currently, 2% death rate out of infected cases is running for COVID-19, which was fearsome with more than 3% just 2 months back (data sources—world-o-meter—corona-virus cases).

Nowadays, it is the time of advancing in technology, Internet connections with high-speed broadband, and 4G are popularizing in the society, business world, and institutions. Side by side, high speed, compatible and loaded with software, machines like computers, laptops, tablets, and smartphones are available which are supporting all the commercial work of the business, promotion, teaching, learning, communication, etc. Therefore, students are getting benefits for their academics from the teachers and institutions. Applications like Microsoft Team, Google Meet, Olympus, WebEx, etc., are playing an important role in the teaching–learning process.

1.1 Microsoft Team

Microsoft Team is a platform that helps in communication for business propagations and collaborations. So, because of its importance and utility, Microsoft Team is used for the conversation, explanations, and presentations by the teaching community to the students who are at distant places in their home. With the use of Internet facility, audio–video and presentation along with slide share, etc., can be easily done; which gives easy accessibility to the students as well to the teachers. Microsoft launched the Microsoft Team on March 14, 2017, all over the world by Brian McDonald (Corporate Vice-president). Microsoft professionals are approaching the institution and installing teams with their institutions for teachers and students for audio–video, presentation, attendance, assignments, quizzes, etc. The growth of users of Microsoft Team is remarkable and mentioned in the following table from November 2017 to April 30, 2020. The sources of the data are mentioned in Table 1 (Fig. 1):

1.2 Google Meet

Google Hangouts and Google Chat combined to become Google Meet and launched in March 2017 for video conferencing. It is used for business purposes as well as for academics' purposes by students and teachers/professors. It is easy in handling and offers satisfaction to the users. From the January 2020 month, the use has increased very much. It can be used through smartphones, laptops, tablets, and desktops. Currently, Google Classroom is used by more than 100 million students which are doubled when compared to March 2020 starting (according to CEO Sundar Pichai). Approximately 100 million participants are using Google Meet nowadays. (*Source* https://www.google.com/search?q=ggogle+meet+growth+in+India&rlz=1C1CHZL_hiIN767IN767&oq=ggogle+meet+growth+in+India&aqs=chrome..69i57.26003j1j4&sourceid=chrome&ie=UTF-8).

1.3 Growth of the Internet

We are nearly 700 million users across the country in India in 2020, and users are increasing in a good proportionate in urban areas as well as in rural areas. India stands second position on the Internet (online) market globally as per the year 2019 while China stands for number 1 in 2019. In India, the number of users of the Internet with growth is shown in Table 2: (as compared to other years, 2020 is an incomplete year, therefore, data is accordingly) (Fig. 2).

The growth of broadband users in India is also increased because of COVID-19 and people are required to work from home and students must take classes online. The data for February and March 2020 is shown in Table 3 (Fig. 3).

The number of 4G users, i.e., users of the Internet with smartphones is increasing at a very fast rate which became 348 million in 2020 (year not complete) as compared to 183 million in 2019. As because of COVID-19, people are using more and more smartphones for academic purposes mainly and also for other purposes. Students are more comfortable with smartphones for an audio–video conversation with their teacher (Fig. 4).

2 Literature Review

Research study is based on primary data and subject matter is relatively new, so more secondary data and literature is not required.
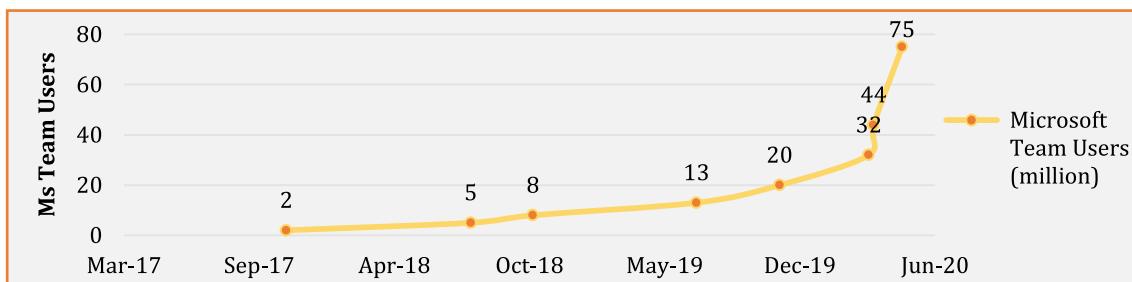
(1) Bao [1], he states that corona closed all university campuses, so students and teachers shifted to online education platforms.
(2) Sophia [7], she states that to ensure accessibility, students need support for online classes. Positive output and challenges were seen in online classes.
(3) Kaup et al. 3, they state that because of keeping social distance and restricted movements, online education substituted traditional education.
(4) Kim [4], he states that COVID-19 made online education ubiquitous and online teaching–learning plays an indispensable role.

Table 1 Active Microsoft Team users worldwide

Month	Microsoft Team users (million)		
		Growth	Growth%
Nov-17	2		
Aug-18	5	3	150.00
Nov-18	8	3	60.00
Jul-19	13	5	62.50
Nov-19	20	7	53.85
12-Mar-20	32	12	60.00
19-Mar-20	44	12	37.50
30-Apr-20	75	31	70.45

Source https://www.statista.com/statistics/1033742/worldwide-microsoft-teams-daily-and-monthly-users/#:~:text=Microsoft%20Teams%3A%20number%20of%20daily%20active%20users%202019%20and%202020&text=The%20number%20of%20daily%20active,2020
Source https://www.businessofapps.com/data/microsoft-teams-statistics/

Fig. 1 Microsoft Team users (million) (*Sources* Table 1)

Table 2 Growth of the Internet in India

Year	Number of Internet users in India (millions)		
		Growth in users	Growth %
2015	302.36		
2016	342.56	40.2	13.30
2017	422.2	79.64	23.25
2018	493.96	71.76	17.00
2019	636.73	142.77	28.90
2020	696.77	60.04	9.43

Source https://www.statista.com/statistics/255146/number-of-internet-users-in-india/

Fig. 2 Number of Internet users in India (millions) (*Sources* Table 2)

Table 3 Broadband subscribers in India

Month	Broadband subscribers in India (million)		
Feb-20	19.07	Growth	Growth %
Mar-20	19.18	0.11	0.58

Source https://www.telecomlead.com/broadband/indias-wired-broadband-subscribers-reach-19-18-mn-in-march-2020-96017#:~:text=India's%20wired%20broadband%20subscribers%20reach%202019.18%20mn%20in%20March%202020,-July%2019%2C%202020&text=India's%20wired%20broadband%20subscribers%20rose,661.45%20million%20in%20February%202020
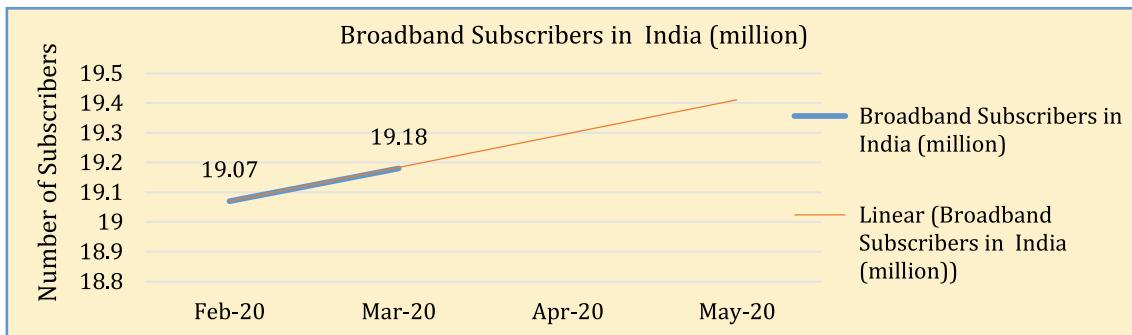
Fig. 3 Broadband subscribers in India (million) (*Sources* Table 3)

Table 4 4G connections (millions) in India

Year	Number of 4G users in India (million)		
2016	15	Growth	Growth %
2017	42	27	180.00
2018	82	40	95.24
2019	183	101	123.17
2020	348	165	90.16

Source https://indiaincgroup.com/india-ready/#:~:text=We%20expect%20to%20provide%20at,of%204G%20BTS%20are%20233%2C695
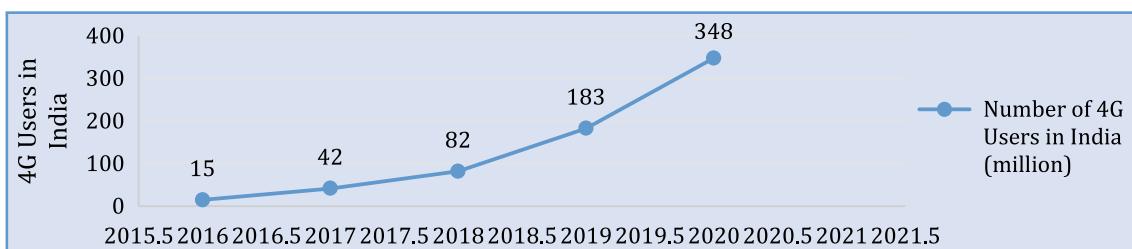
Fig. 4 Number of 4G users in India (million) (*Sources* Table 4)

(5) Dhawan [2], she states that in an early period many institutions were not ready for online classes, but, later on with SWOT analysis and with the importance of online classes they are shifted.

(6) Rapanta et al. [5], they said that there are significant challenges like face to face classes must shift online and for this learning activities need certain characteristics.

(7) Sindiani et al. [6], they said that new methods of teaching were adapted for online learning. Advantages and disadvantages along with experiences of students and teachers was accessed with the help of 18 questions survey.

3 Objectives

(1) To judge the use of online classes at different educational qualification

(2) To explore the effectiveness of online teaching at students and teachers' level

(3) To understand the utility of online classes

(4) To find the familiarity for the use of different gadgets for online classes

(5) To access the attitude of the public toward the online teaching–learning process

(6) To see the advancement of online classes.

4 Methodology

Online teaching–learning is supported by the Internet, broadband, Wi-Fi, Microsoft Team, Google Meet, etc., to understand the growth and uses of these supports secondary data is explored through the Internet which is discussed above in Sects. 2, 3, and 4. To understand the effectiveness and advancements, categorical primary data is collected with the help of a structured questionnaire, and with the help of many attributes and social factors. Place, profile, age group, and educational group are considered as social factors. Nine attributes are selected for the usages and utility of online classes with variables of 'easily', 'with extra efforts', 'difficult', and 'not'. Seven attributes are selected for the attitude and advancement of online classes with dimensions of 'yes', 'may be', 'no', and 'cannot say'.

Hypothesis:

For usages and utility: If the number of responses is more with variables 'easily' and 'with efforts', it means that students and teachers wish to use online classes more with better utility, thus, online teaching–learning is an effective tool.

H_{0E}: Students and teachers understand that online classes are effective tool.

H_{AE}: Students and teachers understand that online classes are not effective tool.

For Attitude and Advancements: If the number of responses is more with 'yes' and 'maybe', it means that students and teachers want to use online classes for academic advancement.

H_{0A}: Students and teachers understand that online classes help in academic advancement.

H_{AA}: Students and teachers understand that online classes do not help in academic advancement.

To judge the null hypothesis and alternate hypothesis percentage analysis, the chi-square test, p-values, C-values, and φ-values will be applied. Chi-square test is calculated through excel. The lower value of χ^2 state that H_0 cannot be rejected and p-value higher than the significant value (α) support this, therefore, H_0 is accepted.

Tools of Analysis:

Percentage tools, pivot table, probability (p) value for chi-square (MS Excel), chi-square Inv RT value (χ^2) (MS Excel), coefficient of contingency ($C = \sqrt{(\chi^2/(\chi^2 + N))}$), and phi coefficient ($\varphi = \sqrt{\chi^2/N}$), etc., are used.

Sample Area:

A structured questionnaire is circulated through Google Form in September 2020 to a few thousand people via the forwarding process. The response received from 78 places, which belong to different 11 states of India.

Sample Size: The questionnaire circulated through WhatsApp and the data from 267 respondents received as primary data which is used for analysis and testing the hypothesis.

Sample Design: Categorical samples as the questionnaire are used to obtain to judge the utility of the online teaching–learning process as an effective tool with four variables, and few sample questions are designed to judge the advancement of the online teaching–learning process.

Research Design: Descriptive and exploratory research design is used to judge the online teaching–learning process is an effective tool and help in advancement.
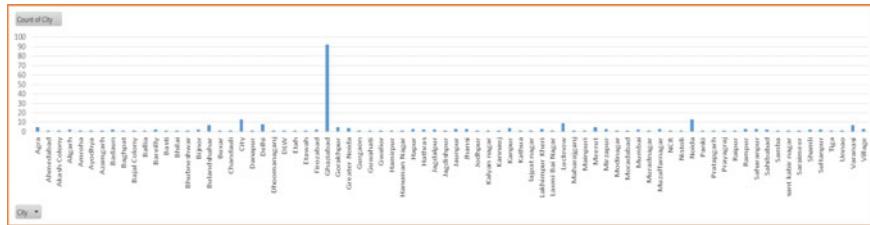
5 Analysis

Based on primary data, tables and graphs for social values with the percentage of respondents are drawn below, which are self-explanatory (Table 5).
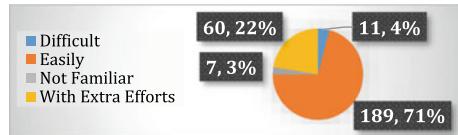
Respondents responded from 78 places, out of that 92 are from Ghaziabad. Wide coverage with more variety of primary data is obtained which will lead to trustworthy inference in the study. The percentage of the city, metro city, and villages are in Table 6.

Statistical Analysis:

To judge that a teaching–learning process is an effective tool, following χ^2, p, C, and φ values are analyzed with the primary data (sources questionnaire with Google Form September 2020) ($N = 267$). Social groups of students, teachers, and others are explored with selected attributes. Respondents are able to use online classes with variables 'easily' and 'with extra efforts' and 'yes' and 'maybe' are considered as positive effect toward online classes and the variables 'not' and 'difficult' and 'no' 'cannot say' are considered as negative effect toward online classes (Fig. 5; Tables 7, 8, 9, 10, 11, 12 and 13).

Table 5 Place where you live:

Table 6 Type of place you live

Row labels	Count of place you live (%)
City	59.93
Metro city	20.97
Village	19.10
Grand total	100.00

Fig. 5 How you became familiar with the gadget?

Table 7 Respondents profile:

Row labels	Count of profile (%)
Other	11.24
Student	75.66
Teacher	13.11
Grand total	100.00

Table 8 Age group of respondents

Row labels	Count of age group
>50	4.49
13–18	4.49
18–25	71.54
25–35	7.49
35–50	11.99
Grand total	100.00

Table 9 Educational group of respondents

Row labels	Count of educational group (%)
Class 1–8	0.37
Class 9–12	5.24
Graduate	71.16
Other	4.87
Postgraduate	8.99
Teacher	9.36
Grand total	100.00

Table 10 Internet connection respondents have

Row labels	Count of Internet connection you have (%)
3G	8.24
4G	53.93
Broadband	8.61
No Internet	2.62
Wi-Fi	26.59
Grand total	100.00

Table 11 Respondents use the gadget
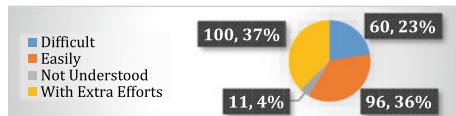
Row labels	Count of for online teaching, the gadget, you (%)
Borrowed	5.24
Had already	77.53
Have to purchase	11.99
Shared with someone	5.24
Grand total	100.00

Table 12 Respondents have gadget for online teaching

Row labels	Count of which gadgets you have for online teaching? (%)
Desktop	1.12
Laptop	38.58
Smartphone	59.55
Tablet/iPad	0.75
Grand total	100.00

Table 13 How you became familiar with the gadget?

	Respondents	Others	Students	Teachers
P-value	0.999989327	0.622723686	0.785157195	0.99540176
χ^2 value	13.70773102	4.399925891	5.537582436	3.019917662
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.220981339	0.127326212	0.142543331	0.105754693
$\varphi = \sqrt{\chi^2}/N$	0.226582913	0.128371037	0.14401392	0.106351084

Fig. 6 Are you able to understand through online teaching?

value state that H_0 cannot be rejected, which is supported by high P-values which are much higher than $\alpha = 0.05$. The C-values and φ-values very small which shows less association and support χ^2 values. This means that respondents became familiar easily with gadgets for online classes and have independency of the use of gadgets (Fig. 6; Table 14).

1. **How you became familiar with the Gadget?**

93% of respondents responded that they became familiar with gadgets easily and with extra efforts in online classes. The calculated χ^2 values are quite lower than the critical value and show acceptance of the null hypothesis. Lower χ^2

2. **Are you able to understand through Online Teaching?**

73% of respondents responded that they are able to understand easily and with extra efforts in online classes. The calculated χ^2 values are smaller than the critical value,

Table 14 Are you able to understand through online teaching?

	Respondents	Others	Students	Teachers
P-value	0.143645238	0.274061598	0.049006228	0.892699407
χ^2 value	51.76541308	7.536522919	16.98151559	6.433054167
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.402980699	0.16568586	0.244536216	0.153385073
$\varphi = \sqrt{\chi^2}/N$	0.440315741	0.168007969	0.252192748	0.155221892
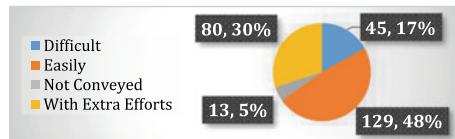
Fig. 7 Are you able to communicate properly in online classes?

Table 15 Are you able to communicate properly in online classes?

	Respondents	Others	Students	Teachers
P-value	0.984769525	0.827399024	0.587342253	0.978510853
χ^2 value	24.67138829	2.850206787	7.479340924	4.249075541
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.29083715	0.102772473	0.1650733	0.125159291
$\varphi = \sqrt{\chi^2}/N$	0.303977307	0.103319561	0.16736939	0.126151261

thus, overall respondents and teachers are able to understand through online teaching. The χ^2 value for students is nearly the same as the critical value and the p-value is also near to α, therefore, it is clear that the students have difficulty in understanding through online classes. These both different responses are supported by p-value, C-value, and φ-value accordingly. So, it means that students have some dependency on online classes (Fig. 7; Table 15).

3. **Are you able to communicate properly in online classes?**

78% of respondents responded that they are able to communicate easily and with extra efforts in online classes. The calculated χ^2 values are quite lower than critical values, and it states that respondents are easily able to communicate in online classes. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be
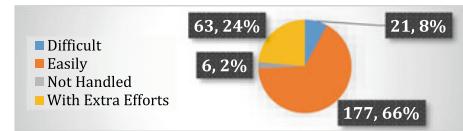
Fig. 8 Are you able to operate the gadget in online classes?
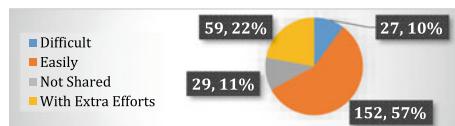
rejected. So, the null hypothesis is accepted, and respondents have no dependency on communication in online classes (Fig. 8; Table 16).

4. **Are you able to operate the Gadget in online classes?**
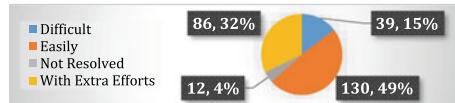
90% of respondents responded that they are able to operate and handle the gadgets easily and with extra efforts in online classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents are easily able to operate/handle the gadgets in online classes.

Table 16 Are you able to operate the gadget in online classes?

	Respondents	Others	Students	Teachers
P-value	0.999945135	0.586319197	0.858963193	0.997867436
χ^2 value	15.38264259	4.673486607	4.708251946	2.576351594
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.233397648	0.13115863	0.131637138	0.097760107
$\varphi = \sqrt{\chi^2}/N$	0.24002686	0.132301531	0.132792705	0.098230631

Fig. 9 Are you able to share PPT, video, numerical, etc.?

Table 17 Are you able to share PPT, video, numerical, etc.?

	Respondents	Others	Students	Teachers
P-value	0.917155612	0.722230244	0.314102496	0.910361346
χ^2 value	29.99394476	3.662566086	10.46586532	6.111422602
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.317792026	0.116326494	0.194215009	0.14958954
$\varphi = \sqrt{\chi^2}/N$	0.335166931	0.117121629	0.197984842	0.151291848

Fig. 10 Are you able to resolve the objections/queries/issues?

The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and respondents have independency to use the gadgets (Fig. 9; Table 17).

5. Are you able to share PPT, Video, Numerical, etc.?

79% of respondents responded that they are able to share PPT, video, numerical, etc., easily and with extra efforts in online classes. The calculated χ^2 values are much lower than critical χ^2 values, and it states that the respondents are easily able to share PPTs, video, etc., in the online classes. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and respondents have independence in sharing the PPTs, videos, etc. (Fig. 10; Table 18).

6. Are you able to resolve the objections/queries/issues?

81% of respondents responded that they are able to resolve the objections/queries/issues easily and with extra efforts in online classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents are easily able to resolve the objections/queries/issues in the online classes. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and respondents have independency in handling to resolve the objections (Fig. 11; Table 19).

Table 18 Are you able to resolve the objections/queries/issues?

	Respondents	Others	Students	Teachers
P-value	0.998972221	0.707939272	0.970241826	0.906460648
χ^2 value	19.28221906	3.768731868	2.841691276	6.18518206
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.259526266	0.117977276	0.102620452	0.150469222
$\varphi = \sqrt{\chi^2}/N$	0.26873416	0.118806989	0.103165103	0.152202089
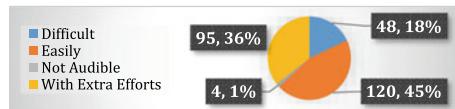
Fig. 11 Are you able to listen to the voice clearly?

Table 19 Are you able to listen to the voice clearly?

	Respondents	Others	Students	Teachers
P-value	0.951754496	0.181483856	0.553891304	0.997487223
χ^2 value	28.02351661	8.862090356	7.805191803	2.663958629
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.308200259	0.179234693	0.168530816	0.099392196
$\varphi = \sqrt{\chi^2}/N$	0.323970664	0.182184933	0.170976396	0.099886802
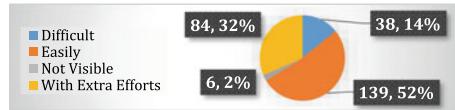
Fig. 12 Are you able to visualize the presentation?
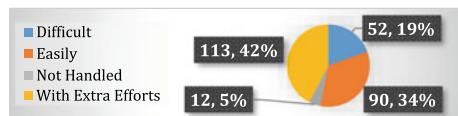
Table 20 Are you able to visualize the presentation?

	Respondents	Others	Students	Teachers
P-value	0.992834156	0.235881026	0.909415296	0.983179529
χ^2 value	22.89915376	8.030448831	4.030174593	4.014159469
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.281051717	0.170875391	0.121941942	0.12170301
$\varphi = \sqrt{\chi^2}/N$	0.292855973	0.173426029	0.122858809	0.122614457

7. **Are you able to listen to the voice clearly?**

81% of respondents responded that they are able to listen to the voice clearly, easily, and with extra efforts in online classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents are easily able to listen to the voice clearly in the online classes. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is

Fig. 13 Are you able to handle the challenge of online classes?

Table 21 Are you able to handle the challenge of online classes?

	Respondents	Others	Students	Teachers
P-value	0.452528415	0.325559625	0.248745436	0.690927585
χ^2 value	42.42777227	6.949318861	11.40847418	9.140008747
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.370292972	0.159270743	0.202428919	0.181931809
$\varphi = \sqrt{\chi^2}/N$	0.398629545	0.161330132	0.206708412	0.185019573
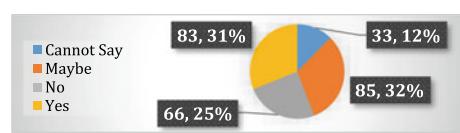
accepted, and respondents have independence in voice clarity (Fig. 12; Table 20).

8. Are you able to visualize the presentation?

84% of respondents responded that they are able to visualize the presentation clearly, easily, and with extra efforts in online classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents are easily able to visualize the presentation in the online classes. The high *p*-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and respondents have independence in the presentation (Fig. 13; Table 21).

9. Are you able to handle the challenge of online classes?

76% of respondents responded that they are able to handle the challenge of online classes easily and with extra efforts in online classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents are easily able to handle the challenges in the online classes.

Fig. 14 Do students wish to learn from online classes?

The high *p*-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and respondents have independency in handling the challenges (Fig. 14; Table 22).

10. Do Students wish to learn from online classes?

63% of respondents responded, 'yes and maybe', that they wish to learn from online classes. The calculated χ^2 values are smaller than critical values for overall respondents, students, and teachers, and it states that they wish to learn from the online classes. The high *p*-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and overall respondents have independence in learning. But other than

Table 22 Do students wish to learn from online classes?

	Respondents	Others	Students	Teachers
P-value	0.345269305	0.01504645	0.438921563	0.713632078
χ^2 value	45.05653881	15.76944117	8.982171346	8.87424899
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.37998134	0.236152156	0.180405658	0.179353651
$\varphi = \sqrt{\chi^2}/N$	0.410793235	0.243025878	0.183415079	0.182309867
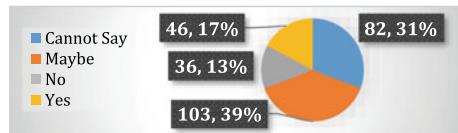
Fig. 15 Are teachers happy with online classes?

Table 23 Are teachers happy with online classes?

	Respondents	Others	Students	Teachers
P-value	0.133631307	0.649114461	0.766980248	0.041016229
χ^2 value	52.24422583	4.203828768	5.726173936	21.70055007
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.404536417	0.124501505	0.144900158	0.274164718
$\varphi = \sqrt{\chi^2}/N$	0.44234744	0.125477795	0.146445704	0.285088527

students and teachers, for example, parents or others, they do not want the online classes for schooling or learning; therefore, the calculated χ^2 value is higher than the critical value and is supported by the p-value also. Overall respondents are accepting the advancement of online learning (Fig. 15; Table 23).

11. Are Teachers happy with online classes?

56% of respondents responded, 'yes and maybe', that teachers are happy with online classes. The calculated χ^2 values are smaller than critical values for overall respondents and students, and it states that they are happy with online classes. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted. But teachers are supposed to be burdened with online classes, a change in technology and pedagogy, preparation of PPTs, video, checking assignments online, conducting examinations, etc., has created an extra work as the additional workload on the teachers, therefore, the χ^2 value is almost same and the p-value is also nearby to
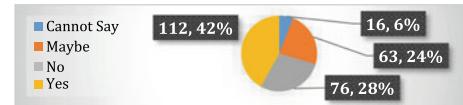
Fig. 16 Are assignments, question-answers easy with online classes?
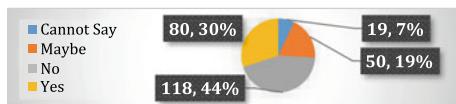
α. But the overall scenario shows the advancement in the online classes with satisfactory happiness in the attitude of teachers. Ultimately, these are the teachers who have to take care of everything about online classes and enhancement of the student's performance (Fig. 16; Table 24).

12. Are assignments, question-answers easy with online classes?

66% of respondents responded, 'yes and maybe', that assignments, question-answers easy with online classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents are easily able to handle the assignments and question-answers in the online classes. The

Table 24 Are assignments, question-answers easy with online classes?

	Respondents	Others	Students	Teachers
P-value	0.992420473	0.155229925	0.876335585	0.898771143
χ^2 value	23.02233308	9.342158944	4.489695215	6.325891396
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.28174677	0.183865418	0.128597272	0.152131967
$\varphi = \sqrt{\chi^2}/N$	0.293642583	0.187054429	0.129673968	0.153923608
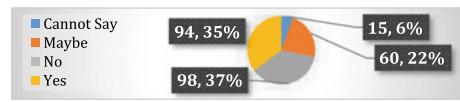
Fig. 17 Do you receive the same/better advantage with online classes?

Table 25 Do you receive the same/better advantage with online classes?

	Respondents	Others	Students	Teachers
P-value	0.80350603	0.199892774	0.274144659	0.475043789
χ^2 value	34.05695808	8.559750655	11.02286872	11.63955877
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.336340057	0.176247378	0.199116412	0.204383989
$\varphi = \sqrt{\chi^2}/N$	0.357147239	0.179050248	0.20318502	0.20879141

high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted, and respondents have independency in handling the assignments and question-answers (Fig. 17; Table 25).


Fig. 18 Is the interaction between students and teacher easy in online classes?

13. **Do you receive the same/better advantage with online classes?**

49% of respondents responded, 'yes and maybe', that they receive the same/better advantage with online classes as they were receiving from regular (offline) classes. The calculated χ^2 values are quite lower than critical values, and it states that the respondents receive the same/better advantage with the online classes as they were receiving through regular classes in their institutions. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So, the null hypothesis is accepted (Fig. 18; Table 26).

14. **Is the interaction between students and teachers easy in online classes?**

57% of respondents responded, 'yes and maybe', that the interaction between students and the teacher easily converses in online classes. The calculated χ^2 values are quite lower than critical values, and it states that the interaction between students and teachers is easy with the online classes. The high p-values than α and smaller C and φ values support this. Therefore, H_0 cannot be rejected. So the null hypothesis is accepted, and respondents have independence in interaction (Fig. 19; Table 27).

Table 26 Is the interaction between students and teachers easy in online classes?

	Respondents	Others	Students	Teachers
P-value	0.908728681	0.166394445	0.478986371	0.864375144
χ^2 value	30.38467173	9.130063437	8.558475721	6.896524911
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.319645051	0.181836076	0.17623466	0.158679891
$\varphi = \sqrt{\chi^2}/N$	0.337342954	0.184918885	0.179036913	0.160716151
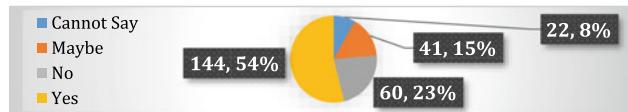
Fig. 19 Is the workload more with online classes than offline?

Table 27 Is the workload more with online classes than offline?

	Respondents	Others	Students	Teachers
P-value	0.267959355	0.270397458	0.161598002	0.539964295
χ^2 value	47.21374225	7.581457179	13.02234005	10.87147498
χ^2 Crit	58.12403768	12.59158724	16.9189776	21.02606982
α	0.05	0.05	0.05	0.05
df	42	6	9	12
$C = \sqrt{(\chi^2/(\chi^2 + N))}$	0.387633788	0.166165455	0.215649361	0.197798162
$\varphi = \sqrt{\chi^2}/N$	0.420512182	0.168508073	0.220845668	0.201784872

15. **Is the workload more with online classes than offline?**

69% of respondents responded, 'yes and maybe', that the workload is more with online classes. The calculated χ^2 values are quite lower than critical values, and it states that the workload is more on teachers and students with the online classes. The high *p*-values than α and smaller *C* and φ values support this. Therefore, H_0 cannot be rejected. So the null hypothesis is accepted. The reason for more workload may be the creation and study of PPTs, PDFs, video, assignments, online-questions-bank, etc.

6 Conclusion

The percentages of respondents, for the 'teaching–learning', are an effective tool and has better utility and uses, are on the higher side. 93% respondents are familiar with gadgets, 73% respondents are in the understanding mode, 78% respondents are able to communicate, 90% respondents are operating gadgets, 79% respondents are able to share PPT, video, etc., 81% respondents are able to resolve objections, 81% respondents are able to listen clearly, 84% respondents are able to see presentation clearly, and 76% respondents are able to handle the challenge of online classes, thus, it states that online teaching–learning is an effective tool. For these attributes, all the calculated χ^2 test values are smaller than the critical values of χ^2 tests, which is supported by high *P*-values (*p*-values are higher than the significant value of 0.05). Thus, the null hypothesis cannot be rejected. The smaller *C*-values and φ-values also support the acceptance of the null hypothesis. So, it is clear that the null hypothesis (H0E) is accepted.

H_{0E}: Students and teachers understand that online classes are effective tools.

The percentages of respondents for 'teaching–learning' and for 'academic advancements' have a better attitude for online classes and are on the higher side. 63% respondents wish to learn from online classes, 56% respondents says that teachers are happy, 66% respondents say that assignments, etc., are easy in online classes, 49% respondents are getting the better advantages with online classes, and 57% respondents say that interaction is easy in online classes, thus, it states that online teaching–learning is for academic advancements. 69% of respondents say that workload is more with online classes, but the overall view of most respondent states that the workload for learning new technological changes and technical smart classes is welcomed. For these attributes also, all the calculated χ^2 test values are smaller than the critical values of χ^2, which is supported by high *p*-values (*p*-values are higher than the significant value of 0.05). Thus, the null hypothesis cannot be rejected. The smaller *C*-values and φ-values also support the acceptance of the null hypothesis. Therefore, null hypothesis (H0A) is accepted.

H_{0A}: Students and teachers understand that online classes help in academic advancement.

On testing, both the hypothesis are accepted, concludes that in the present age of technical and technological updating, and the online classes are better and leading to academic advancements, and moreover teachers and students are happy and in acceptance mode, thus, the title "Is Online Teaching–Learning Process An Effective Tool For Academic Advancement" is justified. This effect is visualized especially in COVID-19 time, but the high level of acceptance and implementation signifies that online teaching–learning mode and online classes will remain to continue even after the COVID-19 period ends, and people start to live a normal and usual life.

Student's Perception:

1. Students are able to accommodate and learn the technology, gadgets, and process of online classes.
2. Students are happy with the computer subjects in the syllabus as it became helpful in the handling of gadgets.
3. Students have better chances to get a variety of desired courses from specialized institutions and experts.
4. Students who are willing to enhance their knowledge, have better exposure with online classes.

Teacher's Perception:

1. Teachers have to learn the handling of technology and the technicality of gadgets, which might be cumbersome.
2. Teachers are feeling workload in online classes because they have to prepare the PPTs, videos, presentation strategies, assignments, etc., in the team or meet.
3. Online examination paper preparation, online check of answer sheets, etc., increases workload on the teachers.
4. Management of the institution/universities should support the teachers in the handling of the gadgets, technology for the proper assessment for the online classes.

7 Future Scope

(1) Flexibility as you can access it from an institution or home.
(2) Wide range of educational program as technical and non-technical can be availed.
(3) Affordable to students and teachers both.
(4) Teaching–learning experience is customized as students and teachers may be specific.
(5) More cost-effectiveness than a regular course.
(6) Approach to distant universities/institution.
(7) Freedom to select the course of your choice.
(8) High chances to get the expert of your field/subject for your better clarity.
(9) Commuting time and energy may be utilized for the learning process in a better way.
(10) Mutual discussion and better understanding options are available.
(11) IIT, IIM, and specialized institutions are approachable to students while students are sitting at his/her place.

8 Suggestions

(1) After COVID-19, online classes should be continued in a ratio of 20 to 25% to the regular classes.
(2) Online classes should be in assistance to regular/offline classes.
(3) The proper workshop should be organized for teachers for better performance in online classes and for better handling of tools like Microsoft Team, Google Meet, etc.
(4) Webinars on related topics to the online teaching–learning process should be conducted.
(5) Training programs should be regularized for online classes for teachers.
(6) Presentation and group discussion should be conducted on related topics in institutions.
(7) A techno-friendly environment should be maintained, i.e., paper waste along with ink, electricity and printer-wear-n-tear should be minimized.
(8) In continuity, online classes should not be the substitute for offline classes.

References

Bao, W. (2000). *Covid-19 and online teaching in higher education: a case study of Peking University*. New York: Wiley, March 2000, https://doi.org/10.1002/hbe2.191.

Dhawan, S. (2020). Online learning: A Panacea in the time of Covid-19 Crisis. *Journal of Educational Technology System, 49*(1), 5–22.

Kaup, S., et al. (2020). Sustaining academics during COVID 19 pandemic: The role of online teaching learning. *Indian Journal of Ophthalmology, 68*(6).

Kim, J. (2020). Learning and teaching online during Covid-19: Experiences of student teachers in an early childhood education practicum. *International Journal of Early Childhood*. https://doi.org/10.1007/s13158-020-00272-6.

Rapanta, C., et al. (2020). Online University teaching during and after the Covid-19 crisis: Refocusing teacher presence and learning activity. *Postdigital Science and Education*. https://doi.org/10.1007/s42438-020-00155-y

Sindiani, A. M., et al. (2020). Distance education during the Covid-19 outbreak: A cross-sectional study among medical students in North of Jordan. *Annals of Medicine and Surgery*. https://doi.org/10.1016/j.amsu.2020.09.036

Sophia, E. (2018). Effective online teaching and learning practices for undergraduate health sciences students: An integrative review. *International Journal of Africa Nursing Sciences*, 73–80. www.elsevier.com/locate/ijans

A Comparative Analyzing of SMS Spam Using Topic Models

Er. Garima Jain

Abstract

Mobile phones or smart phones have changed or revolutionized the way we live. These days the short message service (SMS) is becoming fashionable. For spammers, the success of the mobile messaging channel has become a very attractive target to attack. To impose an additional level of security in the pervasive environment, we will create a system which is more authenticated for SMS. This system will have impact on user's usability from the point of view of user's safety. In modern era, the financial industries and other related agencies are seeing the SMS as an important aspect to communicate with their customers which somehow opens the easy flap for spammers, and customer's safety measures is at hazard. The digital encryption methodologies are useful to support the SMS formation which needs two nodes to swap over digital signed SMS message. These two nodes are protected by the public key cryptography and authentication is done with the help of the ECDSA signature scheme. These two nodes are recognized as sender and receiver, and when a sender sends an SMS to any receiver, the unencrypted text is sent means that there is possibility of loss of information. In this paper, we propose the technique called Gaussian Naive Bayes Classification (GNBC) for the filtering of spam by SMS that solves the message topic model (MTM) problems. It is believed that some pre-processing rules and background terms make it the most appropriate model to completely represent spam by SMS. Finally, we have concluded that GNBC is more accurate for the SMS spam filtering activity.

1 Introduction

There are a few different ways to make spam messages like email, SMS/MMS sent tumultuously to your PDA, short code, different remote numbers, and so on. As per the Text Retrieval Conference (TREC), the term "spam" is—a spontaneous, undesirable email that was sent aimlessly (Cormack, 2008). These undesirable and unnecessary spam messages are named as pervasive spam (Spam, 2015). A GSMA pilot spam reporting program, (GSMA Launches SMS Spam Reporting Service, 2011). The improvement of Open Mobile Alliance (OMA) (Efficient Support Vector Machines for Spam Detection: A Survey, 2015) morals for versatile spam revealing. The Internet is responsible for email spam though versatile organization is utilized for SMS spam (Kim et al., 2013; Torabi et al. 2015). The immense volume of spam sends moving through the PC networks effectively affect the memory space of email workers, correspondence transmission capacity, and CPU force and client time. To effectively handle the danger which is presented by email spams, fundamental essential email suppliers, for instance, Gmail, Yahoo mail and Outlook have chipped away at the gathering of various AI (ML) methods which are neural networks in its spam channels. The way that email is an extremely modest method for coming to a great many potential clients fills in as a solid inspiration for novice publicists and direct advertisers (Cranor & Lamacchia, 1998). One potential answer for improving spam characterization calculation is utilizing a spam channel named LingerIG actualized in 2003 out of an email arrangement framework named Linger (Chae et al., 2017).

Er. G. Jain (✉)
Swami Vivekanand Subharti University,
Meerut, UP 250005, India
e-mail: jaingarima2011@gmail.com

1.1 Market Inclinations Resultant in an Increase of SMS Attacks

The SMS takes remained used as dollar-making machine by mobile operators over the years. As per a survey, uncountable SMSs are sent on daily basis. Communication through SMS has its own benefits like all the GSM mobile companies use SMS communication. Nowadays, it is possible to send ringtones, animations, business cards, logos, and WAP configuration settings easily by a SMS which leads to increase the SMS attack by sending malicious malwares along with these setting SMS. The SMS market or mobile messaging market is an extremely beneficial production for mobile operator and is growing speedily (What YOU can do to control cell phone spam, 2012).

As per Fig. 1, people from developed countries like USA, UK, and Japan prefer communication through SMS instead of other mode of contact. Electronically sent messages are at higher risk and can easily be sensed by spammers. Spammers may use these messages to play with user's personal data or may impairment with the users by using theirs premium tariff facilities (Spam News, 2015; Sao & Prashanthi, 2015). In comparison of email spamming, SMS spam has an exponential growth measured up to more than 500% yearly (Benevenuto et al., 2010; GSMA, 2011; Guzella & Caminhas, 2009).

As per Table 1, Cloud mark report states that, in 2019, the SMS spam counting varies from region to region (Text Message (SMS) Spam Reporting, 2012). Asia has highest rate of SMS spam up to 30%, while North America reports the figure up to 1%. The volume of spam emails containing
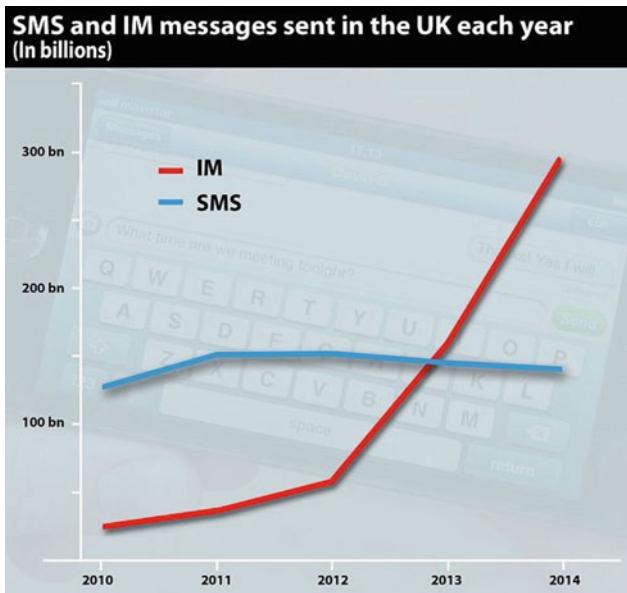
Fig. 1 SMS and IM messages sent in UK each year in billions (Delany et al., 2004)

malware and other malicious codes between the fourth quarter of 2019 and first quarter of 2020 is depicted in Fig. 2 (Dada et al., 2019; Fonseca et al., 2016).

2 Related Works

In recent approach, SMS spam is a serious security threat in lots of countries which badly destroy the individual privileges and still harm the public safety measures. Pervasive SMS spam filtering can be carried out using various approaches and methodologies on different programming framework. This section aims to analyze previous work which is related to spam detection filtering the spam messages in pervasive environment (Jaswal & Professor, 2013; Satish kumar, 2013; Malarvizhi & Saraswathi, 2013). This section also focused on the motivation and findings through the previous research papers.

2.1 Background
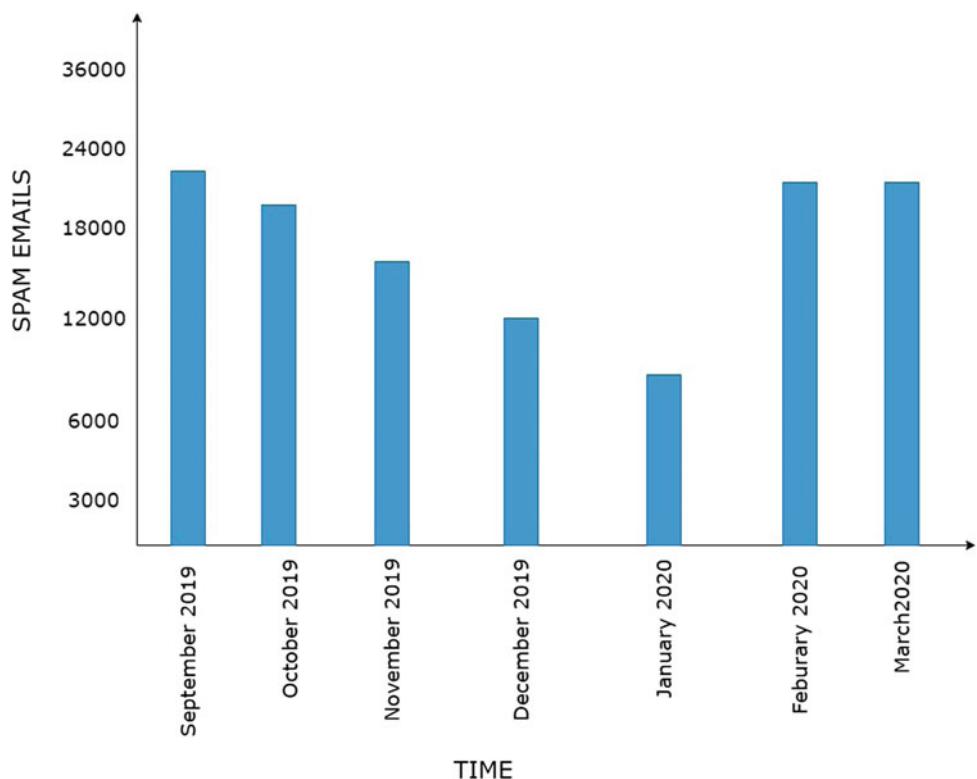
As we have go through the previous research work, we had treasure that mostly email spam clarifying was taken into consideration (Kim et al., 2013; GSMA, 2011; GSMA, 2011a; Sharma et al., 2012; Education & Science, 2013; Johnson et al. 2014) which can be defined as: Operator's server can catch the messages of any frequency triggered from phone numbers. This way has two defects related to pseudo-base stations and possible delay the mass SMS. Users can define black lists or fair lists or secure keywords in their mobile phone at the cost of their own negative impact.

Author (Kou et al., 2020) discuss another most effective method content-based SMS filtering, but it is cost-effective. Finally, MTM is compared with the SVM; the result shows that the MTM is more powerful tool to protect from SMS spam. Author examined about feature determination which is a significant segment in AI and an important advance for text and order. Author You et al. (2020) creator examine and depict a solo technique focusing on astutely distinguishing on the web survey spams. Their investigations on TripAdvisor exhibit the high adequacy and knowledge of the proposed model, which can possibly altogether help the online web business. Author Gopi et al. (2020) in their proposed thought of this paper is to improved RBF piece of SVM-performed with 98.8% of precision when contrasted and the current SVM-RBF classifier and different models. Author Barushka and Hajek (2020) the methodology followed in their paper is to utilize cost-touchy gathering learning strategies with regularized profound neural organizations as base students. Their methodology beats other well-known calculations utilized in interpersonal organization spam sifting, for example, arbitrary woods, Naïve Bayes

Table 1 Graph of mobile behavior shown in developed countries from September 2019 to March 2020 (age group 16+)

	USA	European countries	Japan	India
Messaging (Used)				
Send SMS	72	89.7	62.6	74
Direct messaging	31.2	25.2	6.6	19.9
Financial messaging services				
Bank financial messages	32.4	19	18	21
Share market financial messages	21.2	18	21.5	31

Fig. 2 Volume of spam emails 4th quarter 2019 to 1st quarter 2020

or backing vector machines. Gaurav et al. (2020) their paper proposed a novel, spam mail discovery strategy dependent on the archive naming idea which arranges the new ones into ham or spam. The experimental aftereffects of this paper delineate that RF has higher exactness when contrasted and different strategies. Author Cekik and Uysal (2020) experimental outcomes showed that the PRFS offers either better or serious execution regarding other component determination strategies as far as Macro-F1.

The Author Abayomi Alli et al. (2019) examined investigation that closes with fascinating discoveries which show that most of existing SMS spam separating arrangements are still between the "Proposed" status and "Proposed and Evaluated" status. Likewise, the scientific categorization of existing best in class techniques is created, and it is presumed that 8.23% of Android clients really use this current SMS against spam applications. Their investigation likewise presumes that there is a requirement for specialists to misuse all security strategies and calculation to make sure about SMS consequently improving further characterization in other short message stages. Author Bahassine et al. (2020) their paper give the blend fundamentally improves the presentation of Arabic content order model. The best f-measures got for this model are 90.50%, when the quantity of highlights is 900. Author Asghar et al. (2020) in their paper the work show that joining spam-related highlights with rule-based weighting plan can improve the presentation of even gauge spam location strategy. This improvement can be useful to Opinion Spam recognition frameworks, because of the developing enthusiasm of people and organizations in detaching counterfeit (spam) and certifiable (non-spam) surveys about items. Author Jain et al. (2020) this paper additionally presents a similar examination of various calculations on which the highlights are executed. Furthermore,

it presents the commitment of various highlights in spam identification. After execution and according to the arrangement of highlights chosen, artificial neural network algorithm utilizing back propagation strategy works in the most effective way. Author Bhat et al. (2020) explore and propose two profound neural organization variations (2NN DeepLDA and 3NN DeepLDA) of existing subject displaying method Latent Dirichlet Allocation (LDA) with explicit intend to deal with huge corpuses with less computational endeavors. Two proposed models (2NN DeepLDA and 3NN DeepLDA) are utilized to copy the measurable cycle of latent Dirichlet allocation. Reuters-21578 dataset has been utilized in the examination. Results registered from LDA are contrasted, and the proposed models (2NN DeepLDA and 3NN DeepLDA) utilize Support Vector Machine (SVM) classifier. Proposed models have demonstrated noteworthy exactness other than computational adequacy in contrast with conventional LDA.

3 Message Topic Model (MTM)

The MTM follows the latent semantic analysis enriched by probability. MTM can reduce sparsely problems up to higher extent in comparison to other filtering technologies. The multinomial distributions like document topic or topic-word distributions are governed by several parameters like α and β which show the hyperparameters prior to θ and φ obtained through a Gibbs sampling (Saxena and Payal 2011).

4 Problem Statement

Today, network security is more unpredictable contrasted with before. Huge increment in the quantity of spontaneous business notices being sent to client's cell phones has been watched by means of text informing. SMS spam is an eminent issue for the mobile phone customers. Among the network, the ongoing increments in the spam rate had caused an extraordinary concern. To manage this spam issue, there are numerous methods utilizing diverse sort of spam channels. Essentially, every one of these channels arrange the messages into the classification of spam and non-spam (Ham). The majority of the classifiers choose the destiny of an approaching message based on certain words in information part and sort it. There are two sections, known as test information and preparing information that function as the information base the spam classifier to characterize the messages. The issue of spam has been tended to be as a straightforward two-class record arrangement issue where primary point is to sift through or separate spam from non-spam (Ham). As archive grouping assignments are driven by enormous ineffective information, so choosing most

separating highlights for improving exactness is one of the fundamental destinations, and this theory work focuses on this undertaking. The essential point of this work is to focus on various arrangement strategies and to look at their exhibitions on the space of spam message discovery. To lookout, which one is more effective under which set of highlights, various pre-characterized messages are prepared with the strategies. Auxiliary point of the proposition is to progress in the direction of actualizing the strategy which spam can undoubtedly be distinguish with no information superseding and which additionally increment the prior exhibition by finding the best couple of included decrease procedure and characterization calculation. As a huge number of such couples as of now exists, however this work can be considered as a stage toward that objective.

5 Methodology

To achieve all the aims, objectives and overcome the problems as discussed in Sect. 3, various algorithms need to be used for clustering, classification, tokenization and more. In this section, we discussed some of the important algorithms need to be used in this paper or research work. Also the algorithm defines to form some of the associate correct prediction which is a key challenges for facing meteorologist at all planets (https://www.developershome.com/sms/smsIntro.asp; Jain & Mallick, 2016,2017; Failed, 2017). The security algorithm will provide a great level of security in which we have lesser key size as associated with other cryptographic techniques (Jain, 2018).

6 K-means

There are several algorithms for data clustering. To achieve simplification, we do clustering which is nothing but the partitioning of data into groups. Although clustering simplifies the dataset, it loses few details. Clustering is not suitable for infinite streams. Working of K-means algorithms can be described as K input parameter with n set of objects can be partitioned into K clusters in l iterations. The time complexity of K-means algorithm is $O(nkl)$.

6.1 Term Frequency-Inverse Document Frequency

Term frequency-inverse document frequency is also known as TF-IDF. To create tokens or categorize documents, text mining techniques like TF-IDF are used. Term frequency can be described as the occurrence of a particular word in an individual document (Bønes, et al. 2007; www.securelist.

com). There is possibility that the same word can be occurred in multiple documents many times TD-IDF uses inverse document frequency which is nothing but the balancing of the occurrence count a particular word.

$$\text{TF}(t) = (\text{Number of times term } t \text{ appears in a document})$$
$$/(\text{Total number of terms in the document})$$

$$\text{IDF}(t) = \log\_e(\text{Total number of documents}$$
$$/\text{Number of documents with term } t \text{ in it}).$$

$$\text{Value} = \text{TF} * \text{IDF}$$

6.2 GNBC (Gaussian Naive Bayes Classifier)

In our study, we present a classifier named as Gaussian Naive Bayes Classifier (GNBC) which is a combination of Naive Bayes algorithm and Gaussian distance function. The probability theory of semantic analysis has been used for GNBC, and research tells that it is more suitable algorithm for SMS spam filtering. The basic difference between GNBC and MTM is given as follows: The number of tokens is able to find the appropriate status class (SPAM or HAM) due to which identification of spam message is accurate. Number of tokens which are already fixed for spam filter would not cover for the sparse matrix due to which data does not over ride and spam and ham messages can easily be identified.

In Table 2, the Gaussian distribution shown is standardized so that the sum over all values of x gives a probability of 1. Within one standard deviation of the mean, the nature of the Gaussian gives a probability of 0.683. The Gaussian distribution is also termed as "normal distribution" and is often described as "bell-shaped curve." The mean value is $a = yz$, where

$$y = \text{number of events}$$
$$z = \text{probability of any integer value of } x$$

7 Experimental Results

GNBC classifier is applied on the dataset: the large corpus SMS Spam Collection Dataset created by T.A. Almeida et al. By applying classifier on the dataset, the best classifier can be judged as compared with MTM. From the statistics,

while applying GNBC and MTM on the dataset, GNBC classifier has the best accuracy than MTM and consumed less time without overriding the data. This paper has incorporated datasets which were specified by T.A. Almeida et al. can be downloaded from https://archive.ics.uci.edu/ml/datasets/SMS+Spam+Collection. This is accessible online for study sources and is used generally. For SMS Spam research, the SMS Spam collection v.1 (hereafter the corpus) is a set of SMS tagged messages which have been collected. It contains one set of SMS messages.

7.1 Evaluation Metrics

The metrics measured the percentage of spam detected by the system and how many misclassifications it makes. Few of the evaluation metrics are:

- True Positive (TP): When positive occurrences are effectively arranged, it is spoken to by a number called genuine positive.
- False Positive (FP): When positive occurrences are mistakenly characterized, it is spoken to by a number called bogus positive.
- False Negative (FN): When negative cases are inaccurately characterized, it is spoken to by a number called bogus negative.
- True Negative (TN): When negative occasions are effectively arranged, it is spoken to by a number called genuine negative.
- Accuracy (ACC): It very well may be characterized as the extent of effectively ordered classes to be specific True Positive and True Negative over the complete number of arrangements.

$$\frac{\text{True Negative} + \text{False Positive}}{\text{True Negative} + \text{False Positive} + \text{True Positive} + \text{False Positive}} * 100 \tag{1}$$

- Precision (P): It is the fraction of the messages retrieved that are related to the end client.

$$\frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}} \tag{2}$$

- Recall (R): It is the fraction of the positively retrieved messages that are related to the client (Figs. 3, 4, 5 and 6).

$$\frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}} \tag{3}$$

Table 2 Gaussian distribution function

Distribution	Functional form	Mean	Standard deviation
Gaussian	$f_g(x) = 1/\sqrt{2}\pi \ \sigma^2 e^{\frac{-(x-a)^2}{2\sigma^2}}$	a	ρ

```
        1        2        2        1        2        2        2

   Columns 460 through 486

        1        1        2        1        1        1        1

   Columns 487 through 500

        2        1        2        2        1        1        1


   err =

        0.0560

fx >>
```

Fig. 3 Snapshot showing error on command window
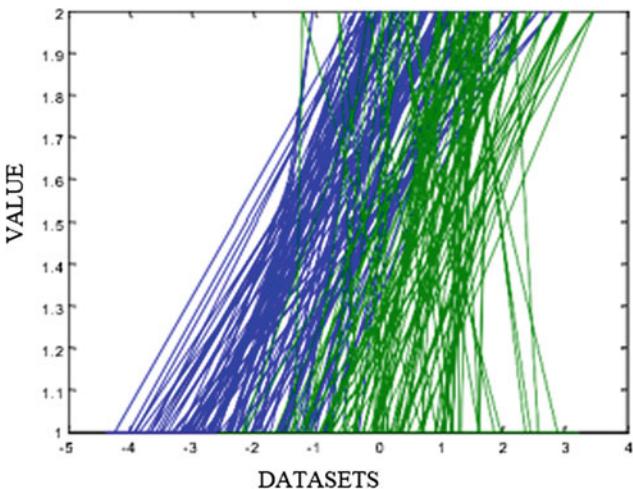
Fig. 4 Data without filtering of ham, spam and noisy data
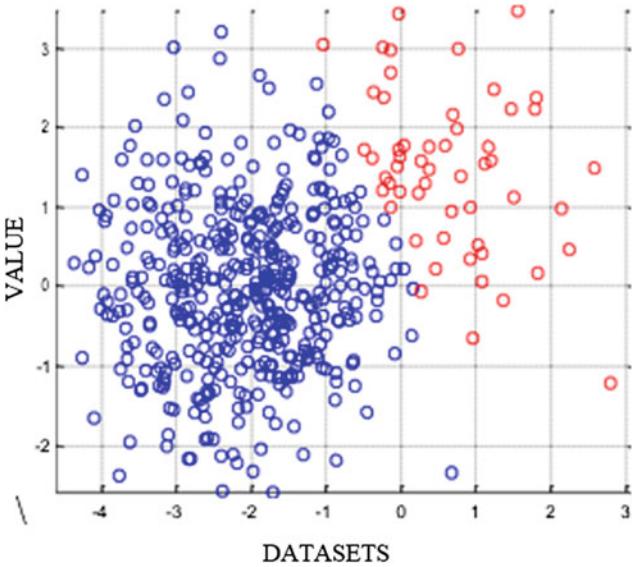
Fig. 5 Data after filtering in which blue color represents noisy data, red color represents spam data

7.2 Experiment 2

Again running a classifier on a separate dataset, it has been shown that Fig. 7 shows the data without filtering which consist of ham, spam and noisy data. Figure 8 shows the data in which red color represented as Spam data, green color represented as Ham data and blue color represented as noisy data. Figure 9 shows the accuracy in MTM and GNBC models, and it has shown that GNBC gives more accurate result when we compared with MTM. Figure 10 shows the error coming on command window.

And the error we had received is 0.0320.

7.3 Experiment 3

Again running a classifier on a separate dataset.

And the error we had received is 0.1340 (Fig. 11).
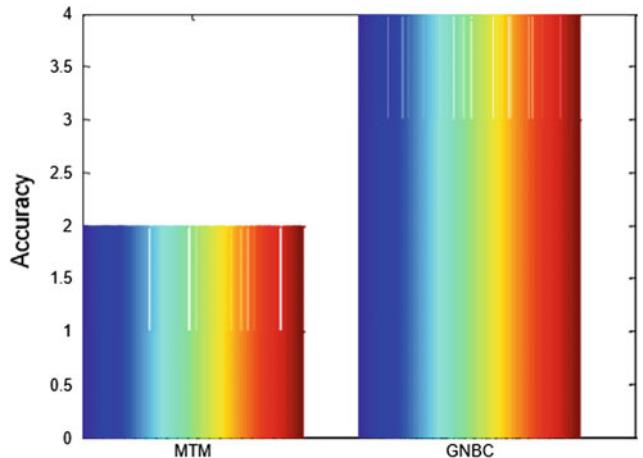
Fig. 6 Comparison between MTM and GNBC, i.e., accuracy

```
        1        2        1        1        2        1        2

   Columns 460 through 486

        2        2        2        1        2        2        2

   Columns 487 through 500

        2        2        2        2        2        2        2


   err =

        0.0320

fx >> |
```

**Fig. 7** Snapshot showing error on command window
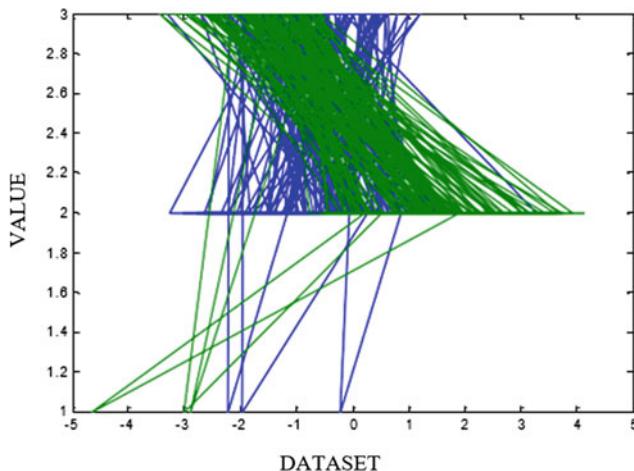
**Fig. 8** Data without filtering of ham, spam and noisy data
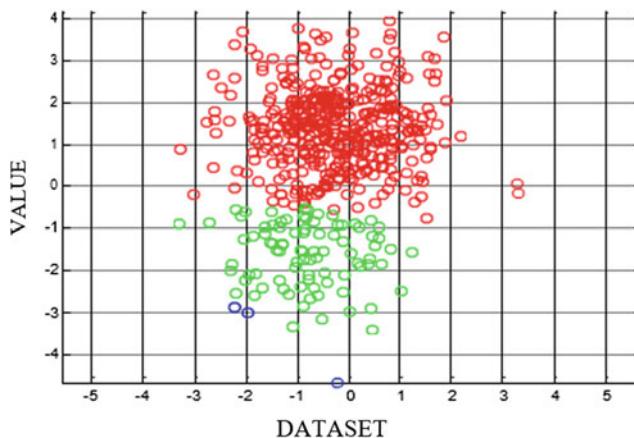
Fig. 9 Data after filtering which blue color represents noisy data, green color represents ham data, red color represents spam data
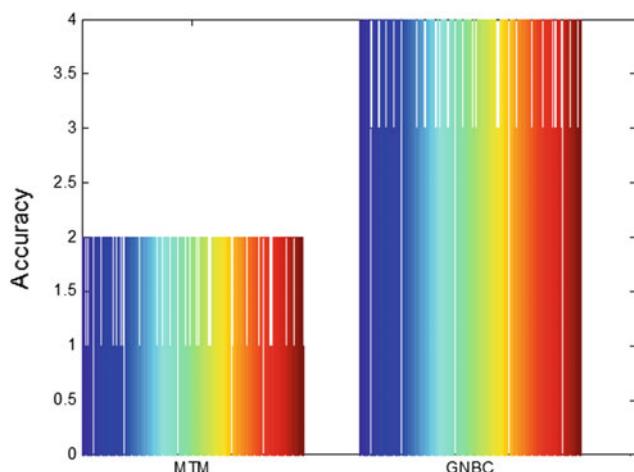
Fig. 10 Comparison between MTM and GNBC, i.e., accuracy


```
      1        2        2        1        1        1        2

Columns 460 through 486

      2        2        2        2        2        1        2

Columns 487 through 500

      1        1        2        1        2        1        1

err =

     0.1340

fx >> |
```

Fig. 11 Showing error on command window

8 Results and Discussion

On performing experiment on the dataset, trying to classify the data as spam or ham using GNBC and MTM classifier, we observe that GNBC is more accurate as compared with MTM. Also we had observed that when data is filtered by MTM, it is overriding, whereas when we filtered the same by GNBC, it is clearer. In the above experiment, data with red color represented as Spam data, green color represented as Ham data and blue color represented as noisy data. Also we had calculated the error which changes as per the dataset and spam messages.

9 Conclusion

Nowadays, the undertaking of automatic SMS spam clarifying in pervasive environment is stagnant a real task. The major problem handled in detection of spams in SMS is due the total character small in number in short text message and the usual practice of idioms and acronyms. The immediate conclusion from the results is that GNBC has the best performance considering accuracy and overriding of the data. It requires fewer input features to achieve the same results produced by other classifiers. The main aim of our research to refine spam token precisely as compared to existing technique which increase accuracy of the system. Furthermore, our aim will be using classifiers of Gaussian-based NBC to increase the efficiency of spam detection system.

10 Future Scope

The feature plot can increase the aspect of the future work which gives practice in numerous methods. If we are adding more significant features like in the given certain thresholds for the measurement and for the evaluation of the knowledge and the given arcs can also contribute to the development in results. In future, using this technique, we can make and application for smartphones (iPhone, android, Windows) for protecting them from spam message. This will also be compared like we did in DND (Do not disturb) in which we can also block numerous annoying communications, but in the given future we can also make an attempt to block all the communicated messages from given undesirable figures as well as junk bases.

References

Abayomi-Alli, O., Misra, S., Abayomi-Alli, A., & Odusami, M. (2019). A review of soft techniques for SMS spam classification: Methods, approaches and applications. *Engineering Applications of Artificial Intelligence, 1*(86), 197–212.

Asghar, M. Z., Ullah, A., Ahmad, S., & Khan, A. (2020). Opinion spam detection framework using hybrid classification scheme. *Soft Computing, 24*(5), 3475–3498.

Bahassine, S., Madani, A., Al-Sarem, M., & Kissi, M. (2020). Feature selection using an improved Chi-square for Arabic text classification. *Journal of King Saud University-Computer and Information Sciences, 32*(2), 225–231.

Barushka, A., & Hajek, P. (2020). Spam detection on social networks using cost-sensitive feature selection and ensemble-based regularized deep neural networks. *Neural Computing and Applications, 32* (9), 4239–4257.

F. Benevenuto, G. M., Rodriques, T., & Almeida, V. (2010). Detecting spammers on Twitter. In: *Proceedings of the 7th Annual Collaboration Electronic Messaging, Anti-Abuse and Spam Conference.*

Bhat, M. R., Kundroo, M. A., Tarray, T. A., & Agarwal, B. (2020). Deep LDA: A new way to topic model. *Journal of Information and Optimization Sciences, 41*(3), 823–834.

Bønes, E., et al. (2007). Risk analysis of information security in a mobile instant messaging and presence system for healthcare. *International Journal of Medical Informatics, 76*(9), 677–687.

Cekik, R., & Uysal, A. K. (2020). A novel filter feature selection method using rough set for short text data. *Expert Systems with Applications, 1*(160), 113691.

Chae, M. K., et al. (2017). Spam filtering email classification (SFECM) using gain and graph mining algorithm. In *2017 2nd International Conference on Anti-Cyber Crimes (ICACC)*. IEEE.

Dada, E. G., et al. (2019). Machine learning for email spam filtering: Review, approaches and open research problems. *Heliyon, 5*(6), e01802.

Delany, S. J., et al. (2004). A case-based technique for tracking concept drift in spam filtering. In *International Conference on Innovative Techniques and Applications of Artificial Intelligence*. London: Springer.

Torabi, Z. S., Nadimi-Shahraki, M. H., & Nabiollahi, A. (2015). Efficient support vector machines for spam detection: A survey. *International Journal of Computer Science and Information Security, IJCSIS, 13*(1).

Fonseca, O., et al. (2016). Measuring, characterizing, and avoiding spam traffic costs. *IEEE Internet Computing, 20*(4), 16–24.

Garima Jain, E., & Mallick, B. (2017). The weather forecasting using sliding window algorithm. *IJRCCT, 6*(4), 099–105.

Gaurav, D., Tiwari, S. M., Goyal, A., Gandhi, N., & Abraham, A. (2020). Machine intelligence-based algorithms for spam filtering on document labeling. *Soft Computing, 24*(13), 9625–9638.

Gopi, A. P., Jyothi, R. N., Narayana, V. L., & Sandeep, K. S. (2020). Classification of tweets data based on polarity using improved RBF kernel of SVM. *International Journal of Information Technology, 1,* 1–6.

GSMA. (2011a). Operator FAQs. GSMA Spam Reporting Service.

GSMA.(2011b). SMS spam and mobile messaging attacks—Introduction, trends and examples. *GSMA Spam Reporting Service.*

GSMA Launches SMS Spam Reporting Service—PC World Business Center. (2011). PC World. Retrieved January, 13 2011.

Guzella, T. S., & Caminhas, W. M. (2009). A review of machine learning approaches to spam filtering. *Expert Systems with Applications*, 10206–10222.

https://www.developershome.com/sms/smsIntro.asp

Jain, G. (2018). Time-series analysis for wind speed forecasting. *Malaya Journal of Matematik (MJM), 1*(2018), 55–61.

Jain, G., & Mallick, B. (2016). A review on weather forecasting. *IJARCCE.*

Jain, G., & Mallick, B. (2017). A study of time series models ARIMA and ETS. *IJMECS.*

Jain, A. K., Goel, D., Agarwal, S., Singh, Y., & Bajaj, G. (2020). Predicting spam messages using back propagation neural network. *Wireless Personal Communications, 110*(1), 403–422.

Jaswal, V., & Sood, N, (2013). Spam detection system using Hidden Markov model. *International Journal of Advanced Research in Computer Science and Software Engineering, 3*(7).

Johnson, D., Menezes, A., & Vanstone, S. (2014). The elliptic curve digital signature algorithm (ECDSA). *International Journal of Information Security, 1*, 36–63.

Kim, M., Kim, J., & Cheon, J. H. (2013). Compress multiple cipher texts using ElGamal encryption schemes. *Journal of Korean Mathematical Society, 50*, 361–377.

Kou, G., Yang, P., Peng, Y., Xiao, F., Chen, Y., & Alsaadi, F. E. (2020). Evaluation of feature selection methods for text classification with small datasets using multiple criteria decision-making methods. *Applied Soft Computing, 1*(86), 105836.

Kumar, S. (2013). *How to activate do not disturb (DND) India registration—All network*, May 26 2013.

Malarvizhi, R., & Saraswathi, K. (2013). Content-based spam filtering and detection algorithms—An efficient analysis & comparison. *International Journal of Engineering Trends and Technology (IJETT), 4*(9).

Nadimi-Shahraki, M. H., Torabi, Z. S., & Nabiollahi, A. (2015). Using J48 tree partitioning for scalable SVM in spam detection.*Computer and Information Science, 8*(2), 37.

Spam News. (2015). https://en.wikipedia.org/wiki/Acision,(2015)

Priyanka, S., & Prashanthi, K. (2015). E-mail spam classification using Naïve Bayesian classifier. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 4*(6).

Rathi, M., & Pareek, V. (2013). Spam mail detection through data mining—A comparative performance analysis. *International Journal of Modern Education and Computer Science, 12*, 31–39. Published Online December (2013) in MECS (https://www.mecs-press.org/). https://doi.org/10.5815/ijmecs.2013.12.05.

Saidani, N., Adi, K., & Allili, M. S. (2020). A semantic-based classification approach for an enhanced spam detection. *Computers & Security, 94*, 101716.

Saxena, N., & Payal, A. (2011). Enhancing security system of short message service for MCommerce in GSM. *International Journal of*

Computer Science & Engineering Technology (IJCSET), 2(4), 126–133. ISSN: 2229-3345.

Sharma, S., Yadav, J. S., & Sharma, P. (2012). Modified RSA public key cryptosystem using short range natural number algorithm. *International Journal, 2*.

Spam. (2015). https://www.kaspersky.com/about/news/spam.

Text message (SMS) spam reporting. *T-Mobile Support Community*. Retrieved December 8, 2012.

What YOU can do to control cell phone spam (PDF). *AT&T Consumer Guide*. Retrieved December 8, 2012.

www.securelist.com.

You, L., Peng, Q., Xiong, Z., He, D., Qiu, M., & Zhang, X. (2020). Integrating aspect analysis and local outlier factor for intelligent review spam detection. *Future Generation Computer Systems, 1* (102), 163–172.

IFME-Intelligent Filter for the Mathematical Expression

Andri Rai and Deepti Malhotra

Abstract

Mathematical expression extraction is one of the most important challenges for decades, and hence, there is an extreme need to counter the issue of mathematical expression and concept retrieval from scientific documents. While there have been many attempts for mathematical expression (ME) retrieval by using diverse approaches like Symbol Layout Tree (SLT), DenseNet, convolution neural network (CNN), support vector machine (SVM) and many more. As a result, they lead to new implication and restrictions in precise ME similarity retrieval and its specific mathematical semantic. In order to analyze the mathematical document, the automatic detection and retrieval of similar recognized ME is a key task. The research paper presents the existing mathematical plagiarism detection techniques and mathematical expression extraction techniques proposed by different researchers. The prime objective of this research work is to propose an intelligent tool to filter the standard mathematical expression and notation from the scientific document.

A. Rai (✉) · D. Malhotra
Department of Computer Science and IT, Central University of Jammu, Rahya Suchani, Samba District, Bagla, Jammu and Kashmir, India
e-mail: andri.cujammu@gmail.com

D. Malhotra
e-mail: deepti.csit@cujammu.ac.in

1 Introduction

Mathematical expression extraction from scientific documents is an onerous area of research in academic improvement. Mathematical expression extraction is a complex yet essential task for academic plagiarism detection and information retrieval. Various scholars have attempted to extract the mathematical notations and expressions from documents, but precision and recall of these are relatively low at par with simple text retrieval. The compelling and completion for detecting the mathematical plagiarism and retrieval of the source document depend on the detection of ME. With the advancement in the digitalization of documents, it is becoming more and more difficult to detect the ME from documents. Although many techniques for the OCR based detection of ME give better performance for simple text documents, retrieving the ME from source with exact name is not accurate and effective. Mainly, there are two types of ME detection that is inline and embedded detection process that is implemented Zanibbi and Blostein (Zanibbi and Blostein 2012a).

The recent research for the ME detection is based on online and offline handwritten MEs, which still lack fully solving the problem. OCR-based ME detection usually has difficulties for recognizing the larger no of character and different types of symbols from the image documents. Traditional methods for ME detection focused on the displayed and inline detection of MEs by using the rule-based methods for detection by Lee and Wang (Lee and Wang 1997), and they employ the n-gram model for recognizing the ME from a large corpus. However, many different methods were given by Phong et al. (2017, 2019) for classifying the inline and displayed ME detection like based on SVM. There are also DNN-based methods for mathematical ME detection OCR that recognize the symbols from PDFs, handwritten documents, printed documents by using much deep learning-based ME detection methods proposed by Gao et al. (Gao et al. 2017) and Chan (Chan and Yeung Aug. 2000).

Further, the mathematical expression extraction's formulas and symbols detection is an important subset of the academic plagiarism detection, which cannot be ignored, although it is a relatively small part of the plagiarism detection. It is accountable in mathematical plagiarism detection and in the lack of math information retrieval. The novel method for a possible feature selection and feature comparison strategies for developing the mathematical-based plagiarism detection approaches are designed by Norman Meuschke et.al. (Meuschke et al. 2017), and the result shows that the mathematical expressions are promising text-independent features to identify academic plagiarism. Later, they also presented a prototype that implements a hybrid approach to academic plagiarism detection by analyzing the similarity of mathematical expressions, images, citation patterns, and text, and shows a result visualization approach by using HyPlag to analyze the confirmed cases of content reuse. Norman Meuschuke et.al. (Meuschke et al. 2018) analyzed the concept of mathematical content similarity in different types of STEM documents and its implication in academic plagiarism detection. In their research paper, they presented a two-stage detection that combines the similarity assessments of mathematical content, academic content, and text. They also compared the effectiveness of math-based, citation-based, and text-based approaches using confirmed cases of academic plagiarism.

The rest of the paper is organized as follows. Section 2 presents the extent of work done in the research area. The proposed IFME framework has been illustrated and discussed in Sect. 3. The performance metrics that can be useful for our model results in future is discussed in the Sect. 5 and Finally, Sect. 6 finishes the research proposal by concluding and with some helpful future disclosures.

2 Background and Related Work

Mathematical Plagiarism Detection Techniques

Table 1 outlined the different methods of mathematical plagiarism detection techniques proposed by various researchers.

Mathematical Expression Extraction Techniques

Table 2 summarizes the various techniques of mathematical expression proposed by many researchers.

3 IFME-Intelligent Filter for Mathematical Expression

For the detection of standard mathematical expression and notation from the scientific document, the IFME framework is proposed which is presented in Fig. 1.

The description of the various components used in the IFME framework is discussed as follows:

Math Documents In this phase, the different mathematical documents are collected.

ME Extraction by Neural Network In this component, the mathematical expressions have been extracted from the mathematical document collected by the first component: using CNN and U-net framework for the extraction of in-line and embedding mathematical expressions.

Segmentation of ME Features The extracted ME features are then segmented in different sub-blocks for both the inline and embedded ME features.

Compute Cosine Similarity of ME The extracted features are created as vector for the computing the cosine similarity of MEs to identify the similarity between each detected MEs. It will use in improving the mathematical plagiarism detection.

ML Classification of ME After computing the similarity between the features of mathematical expressions, classification has been done by using the random forest algorithm to classify that whether the detected ME is a standard notations or it is identified as a new idea for detecting plagiarism. If it is new identified idea, then it will be manually validated.

Standard ME Database InftyProject databases called InftyCDB-1, InftyCDB-2 and the Marmot dataset, that contains characters, symbols and spatial features of mathematical documents, have been used as the standard mathematical expression databases.

Intelligent Filter for Mathematical Expression (IFME) Algorithm

This is the given pseudo-code of the algorithm for extraction of mathematical expression and detecting the plagiarism:

```
Input: Mathematical documents
Output: Standard Mathematical Notations
Step1: Take the mathematical document.
Step2: Extract the different mathematical expressions
from the document.
Step3: Store the extracted Mathematical expressions in
Vector A.
```
$[A] = A_{ME1} + A_{ME2} + A_{ME3} + \ldots A_{MEn}$

$$[A] = \sum_{i=1}^{n} A_{\mathbf{ME}}$$

Step4: Take the ME dataset and store the different mathematical expressions in vector B

$[B] = B_{ME1} + B_{ME2} + B_{ME3} + \dots B_{MEn}$

Step5: Calculate the Cosine Similarity between two Vectors A and B.

Step6::

$$Similarity = \cos \theta = \frac{A.B}{\Vdash A \Vdash \Vdash B \Vdash} \frac{\sum_{i=1}^{n} A_i \times B_i}{\sum_{i=1}^{n}(A_i)^2 \times \sum_{i=1}^{n}(B_i)^2}$$

Where, A_{MEi} and B_{MEi} are the components of vector A and B.
Step7:/*Classify the features of detected MEs*/
If " STANDARD NOTATION"
" NOT PLAGIARISM
Else
"MANUAL VALIDATION"
Step 8: END

4 Result and Discussion

To evaluate the proposed algorithms, simulation test bench for the IFME framework has been created with a Lenovo idea pad laptop, hardware configuration of 8 GB RAM, 2 TB Hard disk. The input for the proposed framework is mathematical document images that are collected from 400 different documents.

Mathematical Dataset

The training and testing of the model is done using the InftyMCCDB-2 which is the updated version of InftyCDB-2 dataset. It contains more than 30,000 expressions that are further grouped into 12,551 images for training and 6830 images for testing in the dataset (Fig. 2).

Evaluation of Framework

Recall R_{ME}, Precision P_{ME} and F-measures F_{ME} have been used as the performance matrices to validate the identified mathematical expression. For the F_{ME} it is the average weighted score of recall R_{ME} and precision P_{ME} which measures how good is the designed framework works.

Table 1 Analysis of mathematical plagiarism detection techniques

S. No.	Author and year	Problem handled	Input	Analysis	Dataset
1	Phong et al. (2019)	Similarity detection of mathematical, text content	102 k STEM documents	Detection of similarity assessments for mathematical, academic and text content	PDF of AP and NTCIR-11 MathIR task
2	Isele et al. (2018)	Mathematical information retrieval for plagiarism detection	MIR documents	Analyzed the various math plagiarism approaches	MIR documents corpus
3	Meuschke et al. (2018)	Similarity of mathematical expressions	Plagiarized document	Analyzed the similarity of mathematical expressions, images, citation patterns, and text	NTCIR-11 MathIR task dataset
4	Iwatsuki et al. (2017)	Detected in-line mathematical expressions	Mathematical PDF document	A conditional random field (CFR) applied for math identification in layout and linguistic features	Manual corpus
5	Meuschke et al. (2017)	Mathematical-based plagiarism detection	Mathematical documents	Feature selection and feature comparison of math document	NTCIR-11 MathIR task dataset

Table 2 Analysis of mathematical expression extraction techniques
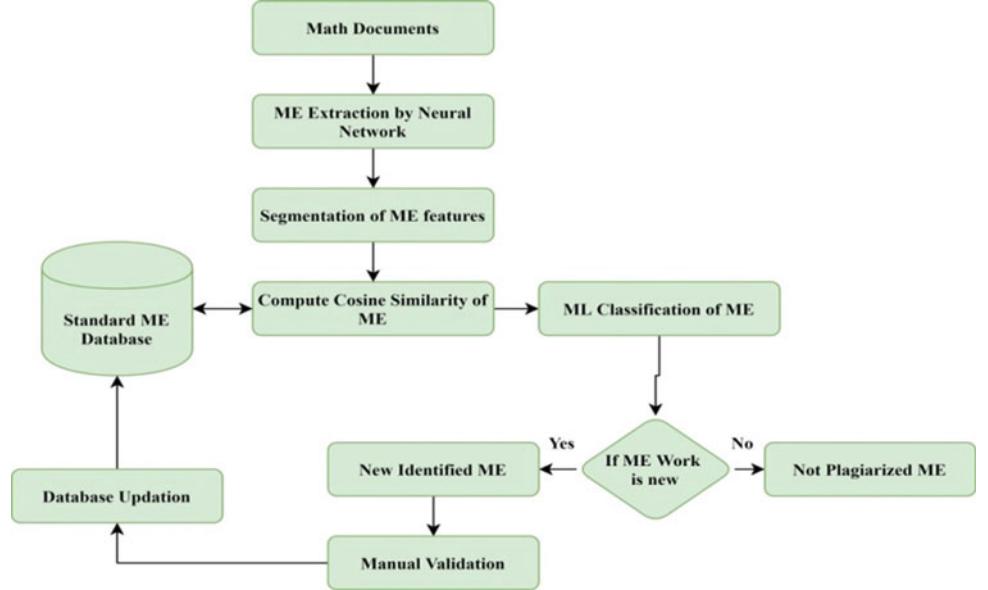
S. No.	Author and year	Problem handled	Input	Analysis	Dataset
1	Ohyama et al. (2019)	Expression detection from mathematical images	Document images	ME detection using U-NET framework	GTDB-1 and GTDB-2
2	Phong et al. (2019)	Variable detection using CNN and SVM	Math document image	CNN and SVM for analyzing image	Marmot dataset with 400 scientific document
3	Guangcun et al. (2019)	Recognize the 2-D structure existing in mathematical expressions	Image of expressions, symbols	A multi-scale CNN called DenseNet used for ME identification	CROHME 2014
4	Pathak et al. (2019)	LSTM-based math retrieval	LATEX document	LSTM neural network for detecting similarity in query search formula	NTCIR-12 MathIR task
5	Mahdavi et al. (2019)	Math formula recognition from document	Math image documents	ME extraction by weighted LOS graph using Edmond's algorithm	Infty MCCDB-2 and CROHME
6	Zhang et al. (2017)	Handwritten math expression recognition	Online Handwritten math document	GRU-RNN used for encoding and decoding of document	CROHME 2014 and CROHME 2013
7	Phong et al. (2017)	Displayed mathematical expression detection	Math document	ME detection using SVM and FFT	Harvard Mathematical Textbooks Dataset and InftyCDB-2
8	Gao et al. (2017)	Formula detection using deep learning	PDF Document	CNN and RNN for formula detection form features	Marmot and Created dataset from CiteSeer
9	Guidi and Coen (2016)	Study of math retrieval	MR retrieval documents	Identified several methods, dataset, systems designed for MR retrieval	ArXiv, DLMF, PlanetMath
10	Stathopoulos and Teufel (2016b)	Math information retrieval	Math Document	C-value algorithm for automatic extraction and detection of MR	18,730 math articles and MREC as a dictionary of 10,601 types
11	Asebriy et al. (2016)	Retrieval of expression	Math document	Encoding MathML and KNN for search algorithm	6925 ME using symbols from five languages
12	Zanibbi. et al. (2016)	Finding similarity for math formula	ME documents	Designed a tangent search engine for query search by expression that can be matched with the corpus	NTCIR-11 Wikipedia
13	Zanibbi et al. (2015b)	Math extraction from PDF	PDF Document	Glyph bounding box and syntax tree for converting and extraction of ME	MikTex and LATEX
14	Yu et al. (2014b)	Equation retrieval	MathML document	Feature retrieval form equations	2000 Math Equations
15	Kim et al. (2012b)	Retrieval of mathematical expression	Math document	Analyzed different ME recognition methods	ME research papers collection
16	Zanibbi and Blostein (2012c)	Formula identification from PDF	PDF document images	A combined rule-based (SVM) and learning-based methods for analyzing the features	Math textbooks in English and Chinese

Recall R_{ME} It is the ratio of correctly predicted positive mathematical expression from the actual class of mathematical expression, defined as:

$$R_{ME} = \frac{TP}{TP + FN} \tag{1}$$

Precision P_{ME} It is the ratio correctly predicted positive mathematical expression to the total predicted mathematical expression, defined as:
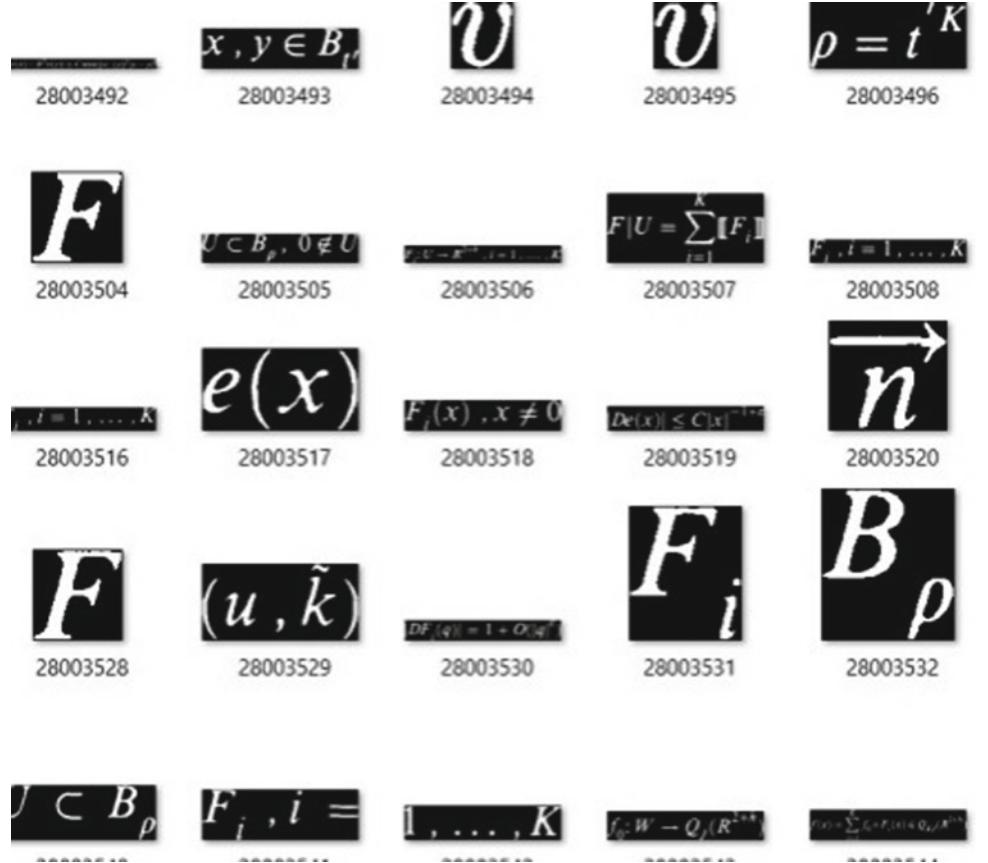
$$P_{ME} = \frac{TP}{TP + FP} \tag{2}$$

Fig. 1 IFME framework

F-measures F_{ME} The F-measure is the weighted average of recall and precision that is measured for predicted mathematical expression, because it takes both false negative and false positive values of predicted mathematical expression, it defined as:

$$F_{ME} = \frac{2 \times P_{ME}R_{ME}}{R_{ME} + P_{ME}} \qquad (3)$$

where the *TP* stands for True Positive; it is for the number of truly predicted values, *FN* stands for False Negative that

Fig. 2 InftyMCCDB-2 dataset

is the number of yes values predicted as false and *FP* represents the False Positive; it is the number of no values predicted as true.

The evaluation of classified class can be measured on by finding the accuracy (A_{ME}) of the model and A_{ME} is defined as

$$A_{ME} = \frac{TP + TN}{TP + TN + FP + FN} \qquad (4)$$

In this accuracy (A_{ME}) formula *TP*, *FN*, *FP* stand same as in the recall (R_{ME}), precision (P_{ME}) and F-measures (F_{ME}) and *TN* stands for the (True Negative); these are the number of values which original class is yes but predicted as the no value class. Accuracy (A_{ME}) shows the performance of framework on combining all the parameters taken in the system. Figure 3 shows achieved performance of each work carried out by the researchers based on some performance metrics:- recall, precision, F-measures and accuracy. By this we can conclude that some researcher achieved the best performance for the ME extraction that can be useful for using it to filtering out the ME for detecting the plagiarism in mathematical documents.

5 Conclusion and Future Work

This research paper presents the study of existing mathematical plagiarism detection techniques and mathematical expression extraction techniques proposed by different researchers. The proposed framework uses a convolution neural network and U-net framework for the extraction of in-line and embedding mathematical expressions. Cosine similarity algorithm has been used to find the similarity between the features of the mathematical expressions. After computing the similarity between the features of mathematical expressions, classification has been done by using the random forest algorithm to classify that whether the detected ME is a standard notations or it is identified as a new idea for detecting plagiarism. If it is newly identified idea, then it will be manually validated techniques. It has been analyzed that the convolution neural network and the U-net framework produce promising results in getting higher accuracy of (around 0.941, when compared to the machine learning-based framework). In the future, the framework can also be designed by using different kind of neural network for better performance, and it will also be useful for the information retrieval of the mathematical document.
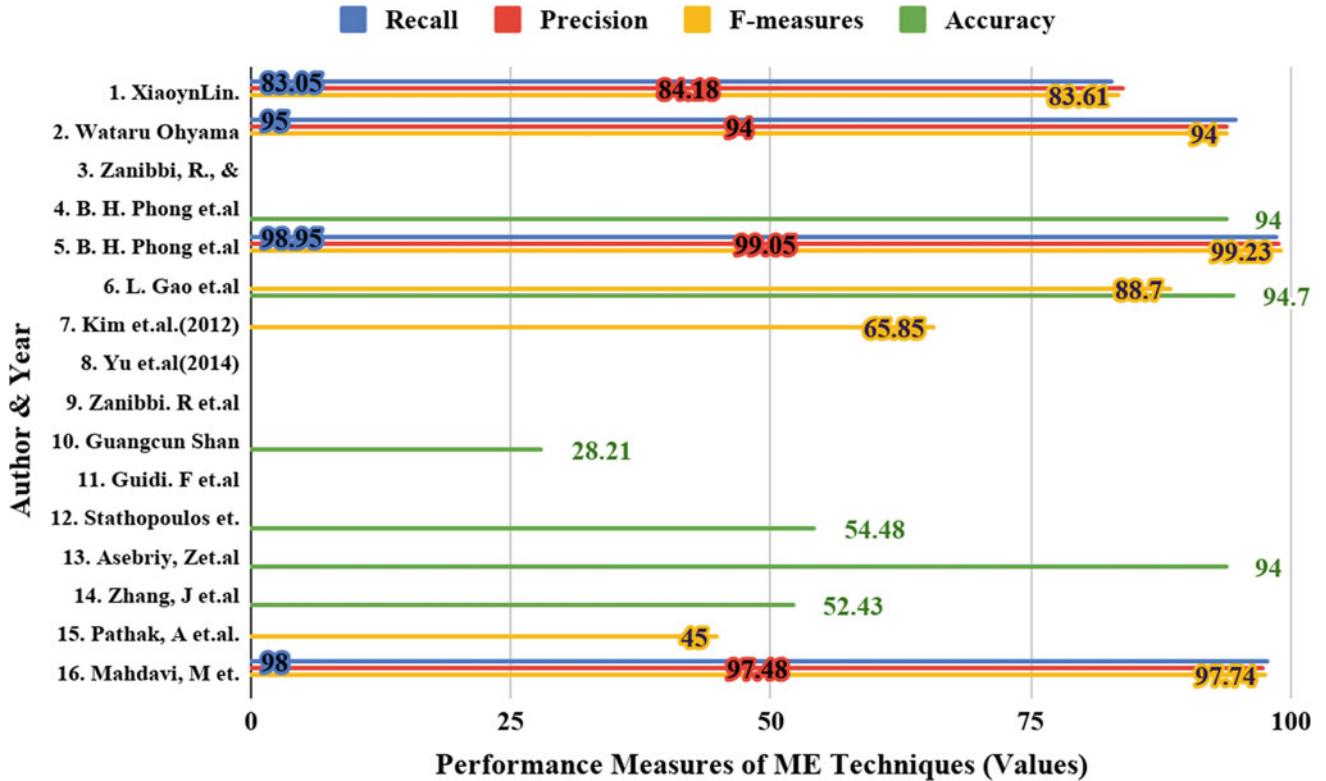
Fig. 3 Performance measures of ME techniques

References

Asebriy, Z., Raghay, S., Bencharef, O., & Kaloun, S. (2016). A semantic approach for mathematical expression retrieval. *IJACSA, 7,* 190–194.

Asebriy, Z., Raghay, S., Bencharef, O., & Kaloun. (2016). A semantic approach for mathematical expression retrieval. *IJACSA, 7,* 190–194.

Chan, K.-F., & Yeung, D.-Y. (2000). Mathematical expression recognition: A survey. *International Journal of Document Analysis and Recognition, 3*(1), 3–15.

Foltýnek, T, Meuschke, N., Gipp, B. (2019). Academic plagiarism detection: a systematic literature review. *ACM Computing Surveys (CSUR), 52*(6), 1–42.

Gao, L., Yi, X., Liao, Y., Jiang, Z., Yan, Z., & Tang, Z. (2017). A deep learning based formula detection method for PDF documents. In *Proceedings of 14th IAPR International Conference on Document Analysis Recognition (ICDAR)* (Vol. 1, pp. 553–558).

Guidi, F., & Coen, C. S. (2016). A survey on retrieval of mathematical knowledge. *Mathematics in Computer Science, 10*(4), 409–427.

Isele, M. R. (2018). Analyzing similarity in mathematical content to enhance the detection of academic plagiarism. ArXiv:1801.08439

Iwatsuki, K., Sagara, T., Hara, T., & Aizawa, A. (2017). Detecting in-line mathematical expressions in scientific documents. In *DOCENG 2017—Proceedings of the 2017 ACM Symposium on Document Engineering.* https://doi.org/10.1145/3103010.3121041

Kim, S., Yang, S., & Ko, Y. (2012a, October). Mathematical equation retrieval using plain words as a query. In Proceedings of the 21st ACM international conference on Information and knowledge management (pp. 2407–2410), (2012, October).

Kim, S., Yang, S., & Ko, Y. (2012, October). Mathematical equation retrieval using plain words as a query. In *Proceedings of the 21st ACM International Conference on Information and Knowledge Management* (pp. 2407–2410).

Kristianto, G. Y., Goran Topic, & Aizawa, A. (2016). MCAT Math retrieval system for NTCIR-12 mathir task. In *NTCIR.*

Lee, H.-J., & Wang, J.-S. (1997). Design of a mathematical expression understanding system. *Pattern Recognition Letters, 18*(3), 289–298.

Lin, X., Gao, L., Tang, Z., Lin, X., & Hu, X. (2011a, September). Mathematical formula identification in PDF documents. In *2011 International Conference on Document Analysis and Recognition* (pp. 1419–1423). IEEE.

Lin, X., Gao, L., Tang, Z., Lin, X., & Hu, X. (2011b, September). Mathematical formula identification in PDF documents. In *2011 International Conference on Document Analysis and Recognition* (pp. 1419–1423). IEEE.

Mahdavi, M., Condon, M., Davila, K., & Zanibbi, R. (2019, September). LPGA: Line-of-sight parsing with graph-based attention for math formula recognition. In *2019 International Conference on Document Analysis and Recognition (ICDAR)* (pp. 647–654). IEEE.

Meuschke, N., Schubotz, M., Hamborg, F., Skopal, T., & Gipp, B. (2017). Analyzing mathematical content to detect academic plagiarism. In *International Conference on Information and Knowledge Management, Proceedings.* https://doi.org/10.1145/3132847.3133144

Meuschke, N., Stange, V., Schubotz, M., & Gipp, B., Hyplag, A. (2018). hybrid approach to academic plagiarism detection. In *41st International ACM SIGIR Conference on Research and Development in Information Retrieval, SIGIR2018.* https://doi.org/10.1145/3209978.3210177

Meuschke, N., Stange, V., Schubotz, M., Kramer, M., & Gipp, B. (2019). Improving academic plagiarism detection for STEM documents by analyzing mathematical content and citations. In *Proceedings of the ACM/IEEE Joint Conference on Digital Libraries.* https://doi.org/10.1109/JCDL.2019.00026

Nishizawa, G., Liu, J., Diaz, Y., Dmello, A., Zhong, W., & Zanibbi, R. (2020, April) Mathseer: A math-aware search interface with intuitive formula editing, reuse, and lookup. In *European Conference on Information Retrieval* (pp. 470–475). Cham: Springer.

Ohyama, W., Suzuki, M., & Uchida, S. (2019). Detecting mathematical expressions in scientific document images using a u-net trained on a diverse dataset. *IEEE Access, 7,* 144030–144042.

Pathak, A., Pakray, P., & Das, R. (2019, February). LSTM neural network based math information retrieval. In *2019 Second International Conference on Advanced Computational and Communication Paradigms (ICACCP)* (pp. 1–6). IEEE.

Phong, B. H., Hoang, T. M., & Le, T.-L. (2017). A new method for displayed mathematical expression detection based on FFT and SVM. In: *Proceedings of 4th NAFOSTED Conference on Information and Computer Science* (pp. 90–95).

Phong, B. H., Hoang, T. M., & Le, T.-L. (2019). Mathematical variable detection based on convolutional neural network and support vector machine. In *Proceedings of International Conference Multimedia Analysis and Pattern Recognition (MAPR)* (pp. 1–5).

Phong, B. H., Hoang, T. M., & Le, T. L. (2019, May). Mathematical variable detection based on convolutional neural network and support vector machine. In *2019 International Conference on Multimedia Analysis and Pattern Recognition (MAPR)* (pp. 1–5). IEEE.

Stathopoulos, Y., Teufel, S. (2016, December). Mathematical information retrieval based on type embeddings and query expansion. In *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers* (pp. 2344–2355).

Stathopoulos, Y., Teufel, S. (2016a). Mathematical information retrieval based on type embeddings and query expansion. In *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers* (pp. 2344–2355).

Yu, B., Tian, X., & Luo, W. (2014a). Extracting mathematical components directly from PDF documents for mathematical expression recognition and retrieval. In *International Conference in Swarm Intelligence* (pp. 170–179). Cham: Springer.

Yu, B., Tian, X., & Luo, W. (2014, October). Extracting mathematical components directly from PDF documents for mathematical expression recognition and retrieval. In *International Conference in Swarm Intelligence* (pp. 170–179). Cham: Springer.

Zanibbi, R., & Blostein, D. (2012a). Recognition and retrieval of mathematical expressions. *International Journal on Document Analysis and Recognition (IJDAR), 15*(4), 331–357. https://doi.org/10.1007/s10032-011-0174-4

Zanibbi, R., & Blostein, D. (2012b). Recognition and retrieval of mathematical expressions. *International Journal on Document Analysis and Recognition (IJDAR), 15*(4), 331–357.

Zanibbi, R., & Blostein, D. (2012c). Recognition and retrieval of mathematical expressions. *International Journal on Document Analysis and Recognition (IJDAR), 15*(4), 331–357. https://doi.org/10.1007/s10032-011-0174-4

Zanibbi, R., Davila, K., Kane, A., & Tompa, F. (2015). The tangent search engine: Improved similarity metrics and scalability for math formula search. arxiv:1507.06235

Zanibbi, R., Davila, K., Kane, A., & Tompa, F. The tangent search engine: Improved similarity metrics and scalability for math formula search. arXiv:1507.06235

Zhang, J., Du, J., & Dai, L. (2017, November). A GRU-based encoder-decoder approach with attention for online handwritten mathematical expression recognition. In *2017 14th IAPR International Conference on Document Analysis and Recognition (ICDAR)* (Vol. 1, pp. 902–907). IEEE.

Implementation of Muscle Testing for Lie Detection

Rahul Angral and Deepti Malhotra

Abstract

Detecting lies is a challenging and necessary pursuit, with widespread implications in many scenarios, including police investigations, court decisions, and military circumstances. There are wide variety of techniques available for detecting deception. The most commonly being used is polygraph which is the oldest and traditional method for lie detection. Traditional-based lie detection methods require subjects to be tested which sometimes generate false positives when subject is anxious or aroused emotionally. Less work has been done to computationally and statistically predict lies. Hence, detection of lies is a prominent area that requires deliberations from the end of researchers, academicians and scientists to develop more automated systems based on subject's emotions that not only offer reliability and accuracy but are also convenient for common man. This article aims to provide a comprehensive review of existing lie detection techniques and also proposes a novel approach based on subject's emotion for lie detection.

Keywords

Lie detection • Signal processing • Feature extraction • Classification

R. Angral (✉) · D. Malhotra
Department of Computer Science and IT,
Central University of Jammu, RahyaSuchani,
Samba District, Bagla, Jammu and Kashmir, India
e-mail: rahulangral7@gmail.com

D. Malhotra
e-mail: deepti.csit@cujammu.ac.in

1 Introduction

Signal processing can be described as a simple process of manipulating the features of particular signal for getting a signal with more pleasing features. These features include amplitude, phase, or frequency spectrum. The approach of signal processing can change these features to satisfy a particular need. In the past, electronic engineers made use of different hardware tools for signal processing. These tools are resistors, capacitors, inductors, transistors, diodes, and other semiconductor devices. In this scenario, a time continuous signal variable was given as input to hardware components. This component generated a novel adaptation of the signal variable. The new adaptation had change in some features. The digital image processing approach uses software tools instead of hardware tools to perform different tasks (Bageley, 1979). Software is used for the processing of time-continuous signal variables. It is essential to convert variables into the right layout. In general, variables are converted into a sequence of numbers. The conversion is done using analog-to-digital (A/D) converters. Afterward, a processor or computer manipulates the signal in some preferred manner. The sequence of numbers obtained through processors should be transformed back to the analog signal with the help of digital-to-analog (D/A) converter. Initially, the digital image processing had limited applications and low-speed processors. However, in current scenario, digital signal processing has extremely quick and energy competent computers (processors). DSP or digital signal processing is different from other fields in CSE as it uses data of other types, known as signals. In DSP, a signal is generally sampled in the time domain at a series of limited intervals through time during which the amplitude is also determined separately like the term quantization defines. These signals generate as sensory data from various real-world signals including visual images, sound waves, and seismic vibrations in almost all cases (Bauer et al., 1987). Digital signal processing refers to the mathematics, the algorithmic

approaches, and the technologies using which these signals are firstly converted into digital form and then manipulated. This technology is used to serve a number of purposes including improving the quality of visual images, recognition, speech generation, and compression of data to store and transmit. The high-speed advancements in computer technology and Integrated Circuit (IC) fabrication has led to the significant expansion in the arena of digital signal processing in the past few years. The role of digital signal processing is highly important in a number of fields relevant to science and technology. Research and development in digital signal processing are leading enrichments in numerous hi-tech fields, such as human-to-machine communication, clinical and scientific image acquisition, multimedia, telecommunication.

For detecting the deception, a concern-based lie detection approach is promoted by police manuals. An increment in likelihood of displaying nervous behavior when someone is lying is possible since this approach assumes that people are highly concerned in case when they are lying as compared to when they are speaking the truth. Polygraph is another name for lie detection method. Different kinds of body parameters are used as indices to estimate a lie by the polygraph device. When the subject being tested is anxious or aroused emotionally, false positives are generated by polygraph which is its major drawback. To determine the lies and overcome the difficulties being posed by traditional polygraph, a new approach is designed in which the emotions play a very important role. Further, the wired systems that induce panic in the subject under test are used as base for traditional lie detection approaches. For overcoming the limitations of traditional polygraph and helping in the investigation of detecting lies such that no physical contact with the subject is involved, the new approach is designed. In our daily lives, emotions play a very important role. The true feelings of an individual at any given instant can be revealed directly by emotions. To decipher the current emotional state of a person when at ease, this study acts as an important tool. Since the emotions are universal and do not change based on some external factors of people, they play an important role in lie detection techniques. Using an expression put up by any person at any time, the emotion felt by that person can be deciphered. There are thousands of expressions created by the 80 facial muscular contractions and their combinations in any individual (Polatsek, 2013). Fear, happy, surprise, anger, disgust, contempt, and sadness are few of the basic expressions commonly found in humans.

The rest of the paper is structured as follows. Section 2 elucidates various lie detection methods being discussed by various researchers. The proposed approach for lie detection based on signal processing is given in Sect. 3. Results of the proposed approach has been discussed in Sect. 4. Finally, Sect. 5 summarizes the research paper by mentioning some

considerable statements as a conclusion with the prospect of extending the research work in the future.

2 Literature Review

Duran et al. (2018) suggested a study which focused on a predicator which had potential for detecting the lies. The suggested predicator was known as RHR whose recording was done for about 1 min for the person under test. Following this, the participants judged 24 videos of individuals explaining a real scenario which was also known as deception detection task (Duran et al., 2018). The ability to differentiate truth and lies was predicted only by RHR as per the multiple regression analysis performed among different individual characteristics. The prediction was seen to be negative here. The outcomes showed that the detection of lies was worse when the RHR was high. Limited selection and usage of cues was suggested because of the restricted attention since the RHR approach was known to be a physiological attribute which indexed the independent arousal and because restricted attention resources could be caused due to high-arousal states. Thus, poor deception detection was achieved due to higher RHR.

Jensena et al. (2018) presented a research where the deceit was detected by using dynamometric muscle testing (DMT) method (Jensena et al., 2018). This research focused on investing if differentiating the lies from truth was possible by grip strength through DMT. This research performed a probable study of test accuracy through this paper. The authors recruited 20 participants which were aged between 18 to 65 years and had healthy hands. A visual stimulation after which an auditory instruction was applied to find the person was telling lie or not related to the stimulation prior to record the grip became stronger had performed here. The results showed that to detect the lies, the accuracy of grip strength was better.

Singh et al. (2015) presented a research in which the different human behaviors were identified using eye blink pattern (Singh et al., 2015). To detect lie and truth of an alibi with the help of image processing techniques, a new method was proposed in this research. An experimentally proven hypothesis that was generated from presented approach that the persons who told lies experienced more cognitive demand instead of persons who spoke truth, were a base for this lie detection method. MATLAB was used to perform the blink detection with the deployment of HAAR cascade algorithm. The algorithm of skin detection was implemented on histogram back projections included in the detected eye images to make a decision for the open or closed position of eyes.

Immanuel et al. (2018) studied that when any individual lie, their blink rate decreases drastically, and then moments
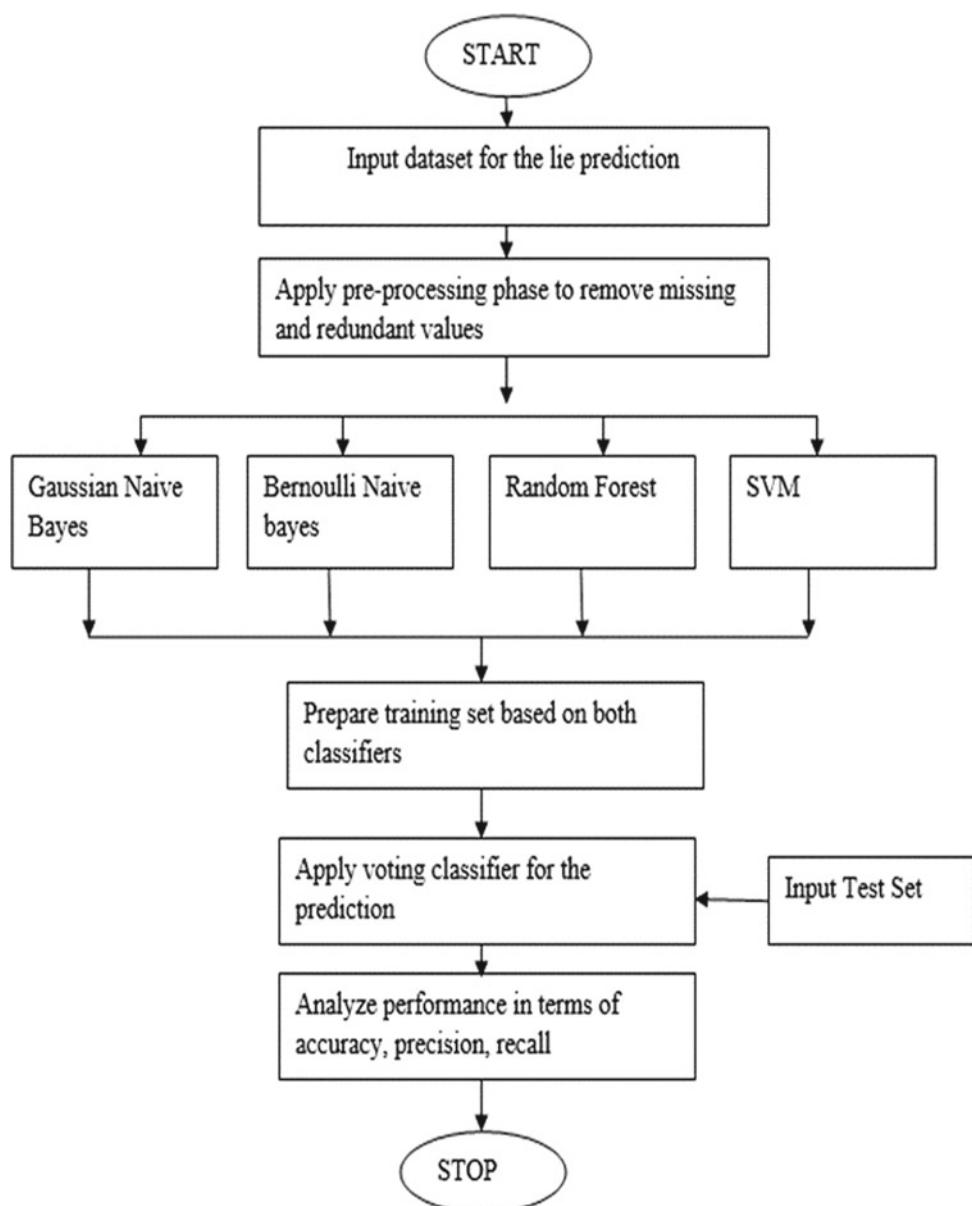
after, there is a rapid increase in those eye moments (Immanuel et al., 2018). For checking if the reaction to the question is true or not, this property can be helpful. The data from 10 subjects which included 10 readings each was taken in this research. During and after a person told a lie, the number of blinks were studied. For checking the accuracy of proposed method, results were then used. With around 95.12% accuracy, there was a reduction in the blink rate as per the studied outcomes. For detecting the lies in a subject, the blink characteristics extracted from EEG datasets provided to be highly effectives. Thus, for lie detection, this approach provided highly efficient outcomes.

Anwar et al. (2019) proposed a new method through which a highly robust information detection system could be generated which was high speed and highly accurate (Anwar

et al., 2019). To ensure that the reduced numbers of EEG channels were used without compromising the accuracy of system, the classification algorithm for lie detection was designed. EMOTIV headset was established to design an improved system to detect deception with the help of mobile EEG recording system. Further, a specialized training sequence was used to present improvements by adjusting the cost of SVM parameters.

Veena and Visu (2016) studied that there has been a huge increase in cyber-crime according to the data gathered from the last decades (Veena & Visu, 2016). This technology is being used smartly by individuals committing the crime. Any kind of information being used by individuals on internet is easy to be cracked. For committing any crime, there is no need of much training and intelligence. It is easy to target a weak

Fig. 1 Ensemble 1 classifier

person with little technical knowledge along with some smartness. To know how general their principles were, the fMRI and micro-expressions were examined in the most recent technologies. Based on the research studies, it was seen that this designed approach was highly effective lie detection.
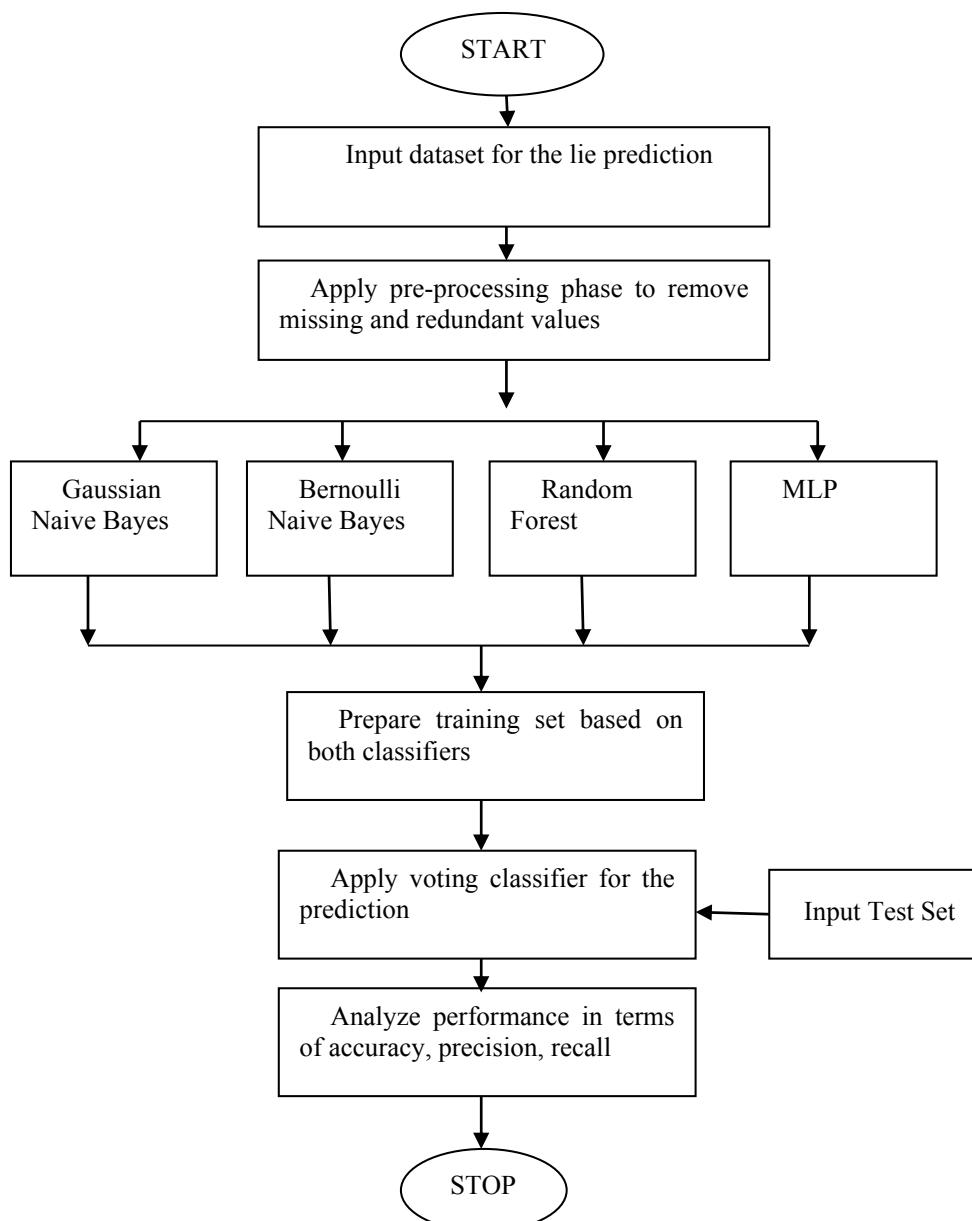
Owayjan et al. (2012) suggested a novel lie detection technique that had used the facial micro-expressions (Owayjan et al., 2012). The LabVIEW was used to design this automated vision system. The interview of subject was captured using the embedded vision system (EVS). Further, in four stages, an embedded vision system (EVS) was utilized so that the video was transformed in series of frames and procedures. The color conversion and filtering were performed on the initial two stages. To particular key features of

facial structure, geometric-based dynamic templates were applied in the third stage. For determining if the subject was lying or not, the facial micro-expressions were detected in the fourth stage with the help of required measurements. Based on the outcomes, it was seen that the applications responding to spontaneous facial expressions in real time provided high precision when applied with proposed approach.

3 Proposed Methodology

The first ensemble classification method of the Gaussian naive Bayes, Bernoulli naive Bayes, random forest, and C4.5. The four algorithms are given as input to the voting

Fig. 2 Ensemble 2 classifier
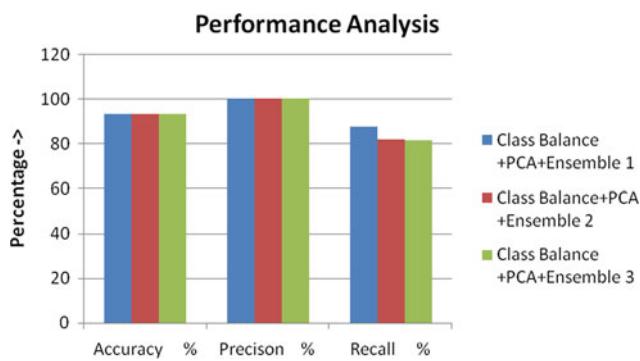
Fig. 3 Performance of class balance with PCA and ensemble classifiers

classifier for the further prediction. The second ensemble classification method of the Gaussian naive Bayes, Bernoulli naive Bayes, random forest, SVM. The four algorithms are given as input to the voting classifier for the further prediction. The third ensemble classification method of the Gaussian naive Bayes, Bernoulli naive Bayes, RF, MLP. The four algorithms are given as input to the voting classifier for the further prediction (Figs. 1 and 2).

4 Result and Discussion

Data is collected from McCabe and Halstead features extractors of source code. The description of features had been given in the 70 s for accurately characterizing code features related to the quality of software. The association character is quite disruptive. The McCabe and Halstead measures are "module" -based in which a "module" is the smallest unit of functionality. In C or Smalltalk, "modules" is known as "function" or "method" correspondingly (Fig. 3).

5 Conclusion and Future Work

This research work is related to lie detection from the signal processing. The feature extraction approach is enforced for the lie detection. The technique of feature extraction will

check the variation between the input signals. The input is separated into the training and test ratio. The training set will be the 60% of the whole data set and 40% will be the 40%t. The technique of voting classifier will be applied which can classify the signal into two class means weather it is lie or not lie. The voting classifier will be the combination of the multiple classifiers which prepares the training set. The test set will be taken as input which classify signal into certain classes. It is expected that proposed method will accurately classify signal into certain classes.

References

Anwar, S., Batool, T., & Majid, M. (2019). Event Related Potential (ERP) based lie detection using a wearable EEG headset. In *2019 16th International Bhurban Conference on Applied Sciences and Technology (IBCAST)*.

Bageley, J., & Manelis, L. (1979). Effect of awareness on an indicator of cognitive load. *Perceptual and Motor Skills, 49,* 591–594.

Bauer, L. O., Goldstein, R., & Stern, J. A. (1987). Effects of information processing demands on physiological response patterns. *Human Factors, 29,* 213–234.

Duran, G., Tapiero, I., & Michael, G. A. (2018). Resting heart rate: a physiological predicator of lie detection ability. *Physiology & Behavior*.

Immanuel, J., Joshua, A., & Thomas George, S. (2018). A study on using blink parameters from EEG data for lie detection. In *2018 International Conference on Computer Communication and Informatics (ICCCI)*.

Jensena, A. M., Stevensb, R. J., & Burls, A. J. (2018). Muscle testing for lie detection: Grip strength dynamometry is inadequate. *European Journal of Integrative Medicine, 17,* 16–21.

Owayjan, M., Kashour, A., Al Haddad, N., Fadel, M., & Al Souki, G. (2012). The design and development of a Lie Detection System using facial micro-expressions. In *2012 2nd International Conference on Advances in Computational Tools for Engineering Applications (ACTEA)*.

Polatsek, P. (2013). Eye blink detection. In *IIT.SRC 2013* (pp. 1–8). Bratislava.

Singh, B., Rajiv, P., & Chandra, M. (2015). Lie detection using image processing. *2015 International Conference on Advanced Computing and Communication Systems*.

Veena, K., & Visu, P. (2016). Detection of cyber crime: An approach using the lie detection technique and methods to solve it. In *2016 International Conference on Information Communication and Embedded Systems (ICICES)*.

Prediction of Loan Scoring Strategies Using Deep Learning Algorithm for Banking System

Ashwani Kumar, Raman Dugyala, and Pronaya Bhattacharya

Abstract

There has been a tremendous growth in banking and finance sectors. With this growth, the ease to access of sanction loan has increased because many people are applying for loans. The problem here is that bank has only limited number of resources and capital, which the bank can distribute among the customers. The whole task of categorizing to whom the bank should sanction loan and to whom it should not has become a difficult task for the bankers. Generally, bank undergoes a rigorous procedure for verifying the customer to sanction loan. This procedure may take a week's time or two. The drawback here is that the customer needs to wait for two whole weeks to know whether he/she is deserving or not. In this paper, we have reduced the risking factor of banks behind finding the appropriate person for loan approval by the bank. We even reduce the time of loan approval analysis. We first use data mining techniques to analyze previous records to which the bank has already sanctioned loan based on the analysis made out of these records we train the deep learning model. The new data is treated as testing data, and the output of the customer is calculated accordingly.

Keywords

Deep learning algorithm • Data mining • Training & testing • Loan approval analysis

1 Introduction

Nowadays, distributing loans has been the integral business sector of almost every bank. The important aspect of assets used in banking directly comes from the profit earned from the loans. The best step of any banking system is to identify the worthy stakeholders from which they can get maximum profit from the investment in the assets. The field of banking is affecting the lives of the loan holder by its services. Financial companies grant loan after a rigorous process of verification and validation, but still there is no surety that the loan being granted to the deserving candidates out of all the applicants. Through in our proposed approach, we can predict whether that particular applicant is provided loan sanction service or not. The entire process of validation of features is calculated automatically by deep learning algorithms.

Our paper prediction of loan scoring strategies using deep learning classifier for banking system provides a solution for the bank employees as well as for the applicant who is seeking for a loan. In this paper, we provide a simple and fast way to the bank employees to choose the deserving applicant from the number of applications. The proposed approach can calculate the values of every parameter taking part in loan scoring strategies on new test data same parameter are processed with respect to their related values. We also used time constraint which can be set for all loan application to check whether the loan can be approved or not for a person. In the current situation, the success and failure of banking system directly depend the analysis of credit risk. If the bank could not collect the amount back from the loan person properly, this will lead a loss to bank. Hence, calculating credit risk plays a vital role to be managed by the bank (Sudhamathy & Jothi Venkateswaran, 2016). Loan scoring strategies are two types: First is application scoring and the second one is behavioral scoring. In application scoring, classifiers are identified from the loan applications to calculate score. The classifiers are 'good', 'bad', 'risk',

A. Kumar (✉) · R. Dugyala
Sreyas Institute of Engineering and Technology, Hyderabad, India
e-mail: ashwani.kumarcse@gmail.com

P. Bhattacharya
Institute of Technology, Nirma University, Ahmedabad, India

'high risk' group. In the behavioral scoring, the classifier depends on the customer payment history and personal information (Babu & Satish, 2013; Laha, 2007). The important part of the banking industry is to measure and minimize the risk associated with a financial loss. For calculating the risk, our model uses risk evaluation model (Arutjothi & Senthamarai, 2016, 2017). The use of classification and prediction is the important key points for the proposed approach. In the current scenario, deep learning-based methods provide a very good accuracy for prediction models. In our proposed work, we will be using the decision tree techniques of deep learning to build this prediction model to predict loan scoring analysis because decision tree gives very good accuracy in the prediction.

The prime objective of this paper is we have to use data mining techniques to analyze previous records to which the bank has already sanctioned loan. Based on this analysis, we trained our deep learning-based model to predict the loan for a decision. The main objective of this paper is to predict whether the loan can be sanctioned to a person or not. To support the proposed approach, we are using data collection, deep learning models, training of the proposed model, logistic regression and testing. We have also compared different machine learning classification models based on the data collected and selected the best model, which gives a good accuracy. In this paper, the proposed deep learning algorithm is used to check whether the person can avail the facility of loan or not by calculating the data with the help of logistic regression classifiers which gives the accurate result for the prediction. Our proposed approach gives benefit to both parties for customer; it reduces the time period of loan approval and for bank employees it reduced the risking factor of bank in behind finding the appropriate person for loan approval by the bank.

This research paper is organized as follows: Sect. 1 shows the introduction of the loan prediction and deep learning algorithm. The Sect. 2 provides the literature review of deep learning and prediction models. In the Sect. 3, we have shown the proposed work. Section 4 gives result analysis and scope of the research in the fields of loan prediction. Finally, the Sect. 5 concludes the research article.

2   Literature Survey

In the literature review, we have gone through various research papers for prediction of loan. We find many data mining algorithms for the prediction of loan using different tools. We also read the research papers in which the minimum required parameter explained for the prediction. We have identified risk assessment and entropy the important issues in the financial institutions such as banking system. Prediction of loan scoring strategies is widely analyzed using classification methods. It uses feature selection technique to remove the irregularity of the attributes. Abddmoula applied K-NN classifier on the Tunisian commercial loan dataset which gives about 88.63% of classification rate. Bach (Abdelmoula, 2015) in his paper highlights on loan decision-making systems with several feature selection techniques and classifiers in which evaluator-based system provides highest accuracy than other feature selection techniques. Arutjothi proposed a new credit scoring model, which uses the hybrid feature selection method which has a strong mathematical basis, but also has higher accuracy and effectiveness. Nikhil Madane et al. proposed a paper loan prediction using decision tree they make use of decision tree induction algorithm for implementing a model and review credit scoring of mortgage loans for the applicants. This credit score helps in sanctioning of the loan; hence, its assessment is mandatory. The model is used to predict a safe for loan sanctioning using Kaggle dataset. Om Prakash Yadav et al. proposed a paper on loan prediction in which they have tried to evaluate the credit risks and to identify the loan repayment prediction using decision tree algorithm (Bach et al., 1997; Kumar & Goel, 2020). Arun et al. (2016) focus to reduce the efforts of bank employees by generating a model by various machine learning algorithms and explained which of the methods can be accurate. To sum up in one line, all research articles explained in literature review use different algorithms such as min-max normalization, KNN algorithm for the prediction of loan which gives 75.08% accuracy result.

Logistic regression is used to predict the probability of an outcome that can only have two values (Madane1 & Nanda, 2019). The prediction is based on the use of one or several predictors. It produces a logistic curve, which is limited to values between 0 and 1. Logistic regression is a classification algorithm used to assign observations to a discrete set of classes. For data cleaning process, various methods are used; one of the important method is Bayesian technique. In this method, missing values can be filled by calculating nearest neighbor values and can be identified by regression. Regression is a technique which uses Bayesian classification along with decision tree. This method is the first choice of the researcher for predicting the missing values. By making a good decision, it results in finding out more accurate data entry for missing values (Nisbet et al., 2009; North, 2012; Pujari, 2001). To convert large volume of dataset into smaller volume, data reduction methods are used which preserve data integrity (Han et al., 2012). The dataset may contain various repeated attributes so there is a need for removing the redundant attributes. The selection of necessary attribute is done by a mechanism known as feature selection which is used to decrease the dataset by discarding the irrelevant attributes (Gupta, 2014; Raudenbush & Anthony, 2002; Whitney 1971; Witten et al. 2016). In our
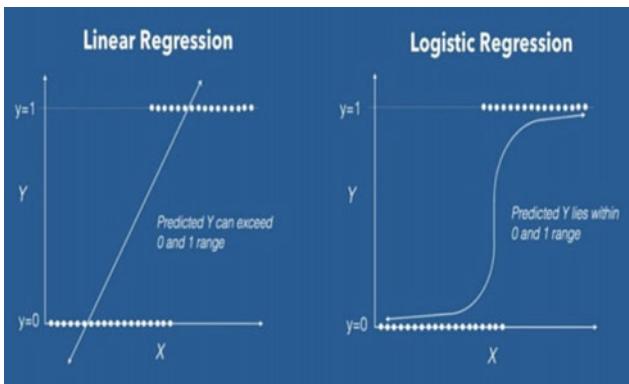
Fig. 1 Linear regression versus logistic regression

country India, the number of loan application drastically increased in recent years. The major problem experienced by the bank employees is they are not able to take decision about loan approval or analysis whether the customer can pay back the amount or not. Currently, all commercial banks are trying to find out effective way to motivate customers for applying their loans. The other problem is with the sanctioned loan, there are some customers who did not shows a positive response once their loan application gets approved. Our proposed approach gives a solution to prevent these situations; banks must find some models to predict customer's behaviors. Machine learning-based techniques give a good performance for this purpose. Figure 1 shows the comparison difference between linear regression and logistic regression.

There is a need for increasing the accuracy in prediction of loan approval in banking sector. Therefore, this paper presents a deep learning-based algorithm by using logistic regression along with minimizing the risk factor for the prediction of loan in commercial banks. We cannot say which model is best because model has its own specification and accuracy depends on data provided to it. Kumar et al. (Kumar & Srivastava, 2020; Kumar et al., 2019) proposed an object detection method for blind people to locate objects from a scene. They have used machine learning-based methods along with single SSMD detector algorithm to develop the model (Raman & Krishna, 2013; Dugyala et al. 2016).

3 Loan Scoring Strategies Using Deep Learning

The model used in our research work focuses on predicting the credibility of user for loan repayment by analyzing their behavior. Customer behavior is the input provided into the model, and the output is a decision whether to sanction or reject loan using data analytics tools. The process of predict loan approval required to train the data using deep learning algorithms and then compare past customer data with trained data for making a decision. The collected datasets may contain missing values, corrupted data and anomalies in the data, which needs to be properly managed or discarded. The collected dataset uses many attributes that define the behavior of the customers. In this section, we have provided the prediction of loan scoring strategies using deep learning algorithm for banking system for that we have used important parameter such as risk analysis, entropy and logistic regression. Figure 2 shows the system model used for prediction.

In this approach, we are using data collection, deep learning models, training of the model, logistic regression, dataset, validation and testing. Our model will help the bank employees to predict the trustworthy persons who have applied for a loan, thus increasing the chances of retaining their loans in time by using decision tree. The process includes first the bank manager will verify the customer's eligibility for loan using proposed model while giving some basic information of the customer. Second the customer can also check loan eligibility by providing required information, and in response, he will receive email whether he is eligible for loan or not. Hence, there is no need for the customer to visit bank many times leads in time saving for the customers. The entire process of loan prediction can be understood form the system model shown in Fig. 3.

Figure 3 shows a model used for prediction of loan scoring strategies using deep learning algorithm. First, data collection is performed for training and testing purpose for loan prediction. Second, after data collection the trained model is prepared using the k-means algorithm. Lastly, we have provided the test datasets for the model to make a
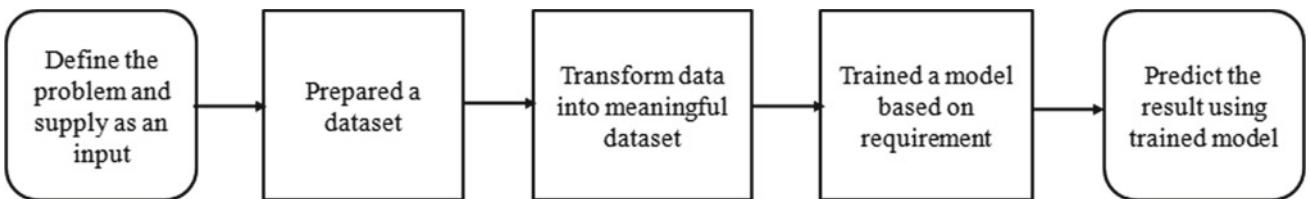
**Fig. 2** System model used prediction
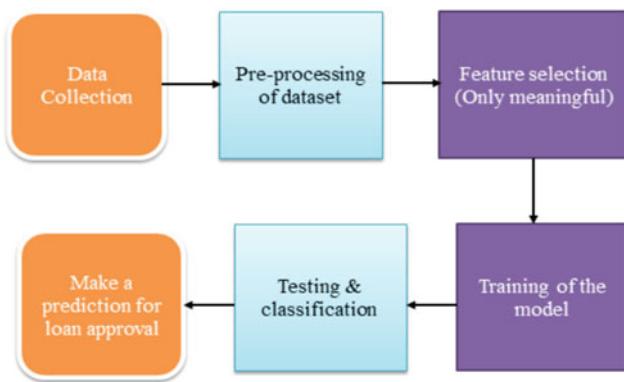
Fig. 3 Model used for prediction of loan scoring strategies using deep learning algorithm

prediction. The scheme is used to identify the defaulters who did not pay loan on time. K-means algorithm helps in the process of classification of dataset.

3.1 Data Collection

Data collection refers to the previous data records of the customers to whom the loan was sanctioned collected.

3.2 Training of Model

The collected data given to deep learning model as input is termed as training data. In this, we analyzed various fields of collected data and find out the attributes used in the records. We first trace out the missing data and fill them with appropriate values.

3.3 Testing

We supply the new records to deep learning model and fetch output for the same. The output obtained would be based on the conclusions made out of previous data.

3.4 Dataset

The dataset includes different types of training dataset, validation dataset and test dataset. In the training dataset, sample of data is used to fit the model. This is the actual dataset that we use to train the model. The validation dataset is sample of data used to provide an unbiased evaluation of a model. The test dataset is the gold standard used to evaluate the model.

3.5 Validation

In validation dataset, we consider various parameters such as loan status as Yes or No. For testing, we consider some sample data and test the data to check the desired output.

3.6 K-Means Algorithm

Applying of k-means yields k which supports the original n data points. These are more similar to each other that belong to the other clusters. This technique is used for dynamic clustering.

$$J(v) = \sum_{i=1}^{c} \sum_{j=1}^{c_i} \left(\| x_i - v_j \| \right)^2 \qquad (1)$$

The following are steps used in the process of loan prediction.

Step 1	We have to load dataset into the classification model
Step 2	Perform the pre-processing on the dataset. The data sets may contain missing values, corrupted data and anomalies in the data
Step 3	Classify the customer into different cluster classes based on customer behavior
Step 4	Feature selection performed on the dataset while considering certain important attributes
Step 5	Build a prediction model using deep learning algorithm
Step 6	Make a prediction for loan approval.

In loan scoring strategies using deep learning, a data mining technique is used for identifying the classifier. This classifier can make a good decision from the input set to correctly predict an accurate class based on trained dataset and should be able to learn complex patterns. The proposed scheme consists of data collections, pre-processing, feature selection and prediction phases. Deep learning-based algorithms are one of the mostly used methods for loan prediction (e.g., worthy, not worthy, cannot say and risky) (Kumar et al. 2020; Yadav & Soni, 2019). We had developed deep learning-based model which uses K-means algorithm for decision making for making a prediction. The main aim of the proposed model is to predict loan approval with high accuracy.

4 Result Analysis

In this section, we have discussed the result of our proposed approach. We can predict the status of a loan application for the customer applied for the loan by providing all the
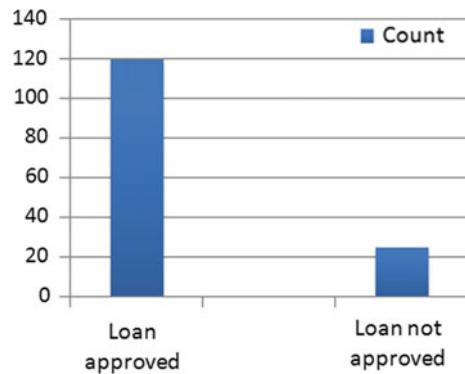
Fig. 4 Status of loan to approve or not using training dataset
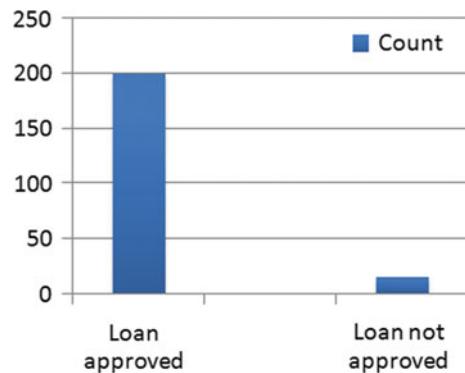
Fig. 5 Status of loan to approve or not using actual dataset

attributes into our model. We also have test cases in which we predict the number of customer deserving for loan sanction by supplying the testing data to our model. Since we have used the logistic regression algorithm, the output of the data would be binary, i.e., yes or no or 1 or 0. The testing data is stored in a variable called prediction variable.

Figures 4 and 5 demonstrate the performance of the proposed model using test dataset and actual dataset. The model uses k-means algorithm to take decision and logistic regression to detect accurate result. The model also tells us whether to approve or reject a loan application applied by a customer. This model stores a table of trustworthy and defaulter customer from the previous datasets. The bank employees can use this model to reduce the risk of investment failure by providing loan services to the defaulters and even reduce the time period of loan approval analysis. Our model gives correctly 81.3% performance while applying on test dataset.

Figure 6 represents histogram graphs for the various attributes for the loan approval. These histogram graphs contain number of people on the y-axis and loan approval attribute on the x-axis. These graphs give us a rough idea that how the customer details are directly or indirectly related to loan sanction. These graphs are plotted using Matplotlib library. Table 1 represents the description of each features used in the dataset. These feature selection is very crucial and used to judge the behavior of the customer applied for loan approval. The proposed model can predict whether to approve or reject the loan application. Heap map is used which describes the attributes of customer for loan prediction, and they are correlated with each other. The graph describes attributes like credit history, loan amount term, loan amount, etc.

5 Conclusion

In this paper, we have provided a solution for bank employees to predict loan approval for a particular customer using the trained model. The prime aim of prediction of loan scoring strategies is to classify and analyze the nature of the loan applicants. The graphs generated during data visualization phase give more clarity about the prediction. These graphs also provide the information about short-term loan identified, as most preferred by majority of the loan applicants. Prediction of loan scoring strategies helps banking sector for predicting the future of loan and its status. This enables bank employees to take action in the initial days for loan approval. The proposed approach would be very useful to the banking system for better targeting and acquiring new customers. The said model gives vital information to avoid a big financial loss for the banking institutions. The use of deep learning-based technique in the proposal model gives a very good accuracy. In future, efficient machine learning algorithms can be used to further increase the accuracy and retrieved precise results of the model.
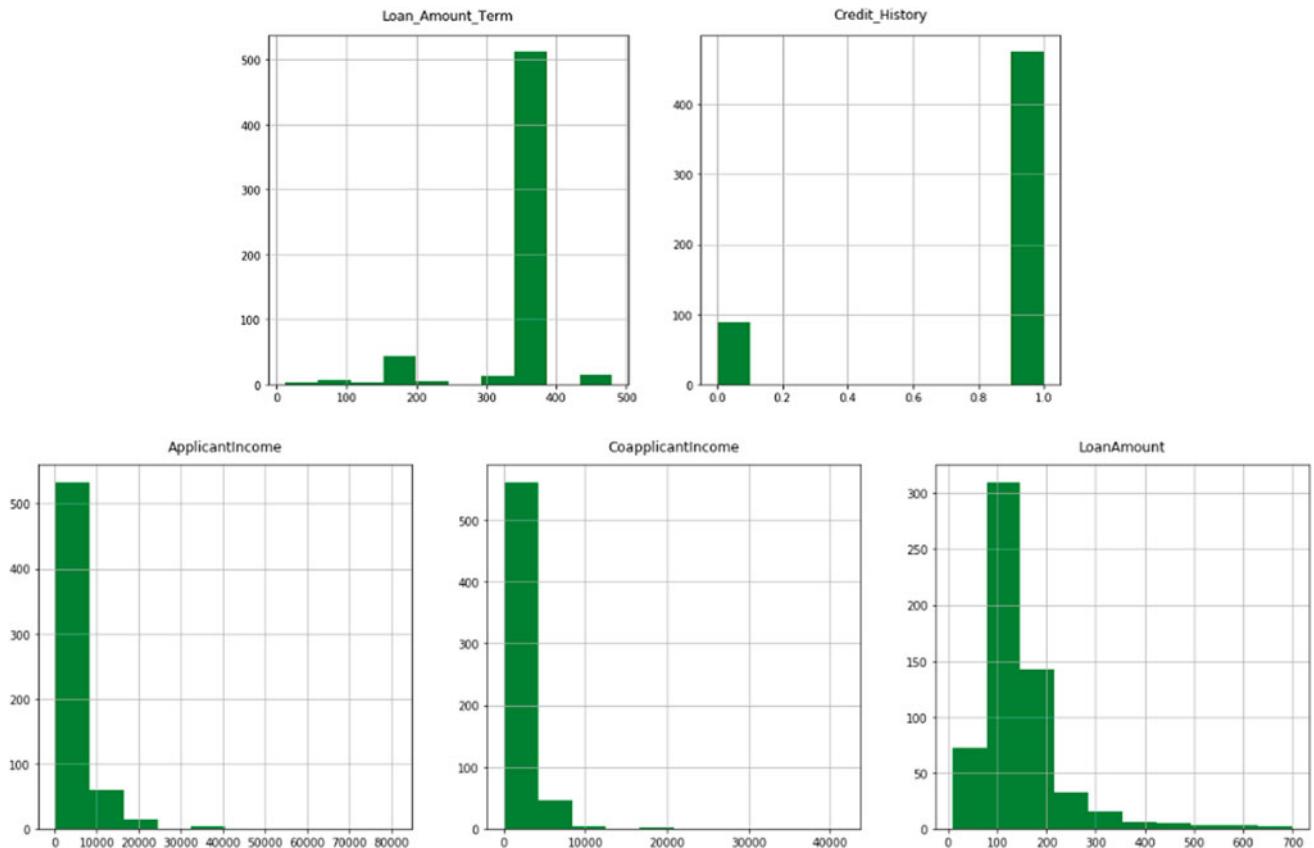
Fig. 6 Histogram graphs of various attributes of loan approval

Table 1 Description n of each features used in the dataset

S.R.	Feature selection based on customer behavior	Description of features
1	loan_policy	1 If the customer meets the loan underwriting criteria, and 0 otherwise
2	type_of_purpose	This refers to the purpose of the loan
3	int_rate	The interest rate of the loan
4	days_	The no. of days to loan sanctioned
5	inq_	The loan holder inquiries
6	no_of_installment	The monthly installments owed by loan holder if the loan is sanctioned
7	loan_fully_paid_or_not	This indicates whether the loan was fully paid *r* or not

References

Abdelmoula, A. K. (2015). Bank credit risk analysis with k-nearest-neighbor classifier: Case of Tunisian banks *Accounting and Management Information Systems*, *14*(1).

Arun, K., Ishan, G., & Sanmeet, K. (2016). Loan approval prediction based on machine learning approach. In *National Conference on Recent Trends in Computer Science and Information Technology (NCRTCSIT-2016)*.

Arutjothi, G., & Dr. Senthamarai, C. (2017). Comparison of feature selection methods for credit risk assessment. *International Journal of Computer Science*, *5*(I), No 5.

Arutjothi, G., & Senthamarai, C. (2016). Effective analysis of financial data using knowledge discovery database. *International Journal of Computational Intelligence and Informatics, 6*(2).

Babu R., & Rama Satish, A. (2013). Improved of K-nearest neighbor techniques in credit scoring. *International Journal For Development of Computer Science & Technology* I.

Bach, M. P., et al. (1997). Selection of variables for credit risk data mining models preliminary research. *MIPRO 2017—40th Jubilee International Convention*. Aldonado, M., Chang, C.-C. K., Gravano, L., & Paepcke, A. (1997). The stanford digital library metadata architecture. *International Journal Digital Library*, *1*, 108–121

Dugyala, R., Bezawada, B., Thatiparthi, R. K. V., & Sathyanarayan S. (2016). Static program behavior tracing for program similarity quantification. In *Proceedings of the First International Conference on Computational Intelligence and Informatics Vol. 507 of the series Advances in Intelligent Systems and Computing* (pp 321–330).

Gupta, G. K. (2014). *Introduction to data mining with case studies*. Delhi, India: PHI Learning Pvt. Ltd.

Han, J., Kamber, M., & Pei, J. (2012). *Data mining concepts and techniques*. USA: The Morgan Kaufmann Series in Data Management Systems, Elsevier.

Kumar, A., Reddy, S. S. S. S., & Kulkarni, V. (2019). An object detection technique for blind people in real-time using deep neural network. In *2019 Fifth International Conference on Image Information Processing (ICIIP)*, Shimla, India (pp. 292–297). https://doi.org/10.1109/ICIIP47207.2019.8985965.

Kumar, A., & Srivastava, S. (2020). Object detection system based on convolution neural networks using single shot multi-box detector. *Procedia Computer Science, 171,* 2610–2617.

Kumar, A., Zhang, Z. J., & Lyu, H. (2020). Object detection in real time based on improved single shot multi-box detector algorithm. *EURASIP Journal on Wireless Communications and Networking, 2020*(1), 1–18.

Kumar, S., & Goel, A. K. (2020). Prediction of loan approval using machine learning technique. *International Journal of Advanced Science and Technology*, 29(9s).

Laha, A. (2007). Building contextual classifiers by integrating fuzzy rule based classification technique and k-NN method for credit scoring. *Advanced Engineering Informatics, 21*(3), 281–291.

Madane1, N., & Nanda, S. (2019). Loan prediction analysis using decision tree. *Journal of The Gujrat Research Society, 21*(14s).

Nisbet, R., Elder, J., & Miner, G. (2009). *Handbook of statistical analysis and data mining applications*. Canada, UK: Academic Press Publications, Elsevier.

North M. (2012). *Data mining for the masses*. Global Text Project.

Pujari, A. K. (2001). *Data mining techniques*. UK: Universities Press, Sangam Books Ltd.

Raman, D., & Krishna, B. V. (2013). Ensuring security services for data storing and data sharing in cloud computing. *International Journal of Science and Research (IJSR), 2*(2). ISSN 2319-7064.

Raudenbush, S. W., & Anthony, S. B. (2002). *Hierarchical linear models: Applications and data analysis methods*. USA: Sage Publications.

Sudhamathy, G., & Jothi Venkateswaran, C. (2016). Analytics using R for predicting credit defaulters. In *IEEE International Conference on Advances in Computer Applications (ICACA)*. IEEE.

Whitney, A. W. (1971). A direct method of nonparametric measurement selection. *IEEE Transactions on Computers, 100*(9), 1100–1103.

Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J. (2016). *Data mining: Practical machine learning tools and techniques*. USA: Morgan Kaufmann Series in Data Management Systems, Elsevier.

Yadav, O. P., Soni, C., Kandakatla, S. K., & Sswanth, S. (2019). Loan prediction using decision tree. *International Journal of Information and computer Science, 6*(5).

Smart Home Load Analysis and LSTM-Based Short-Term Load Forecasting

Semawit Araya, Nitin Rakesh, and Mandeep Kaur

Abstract

Load forecasting is the main exploration field in the smart grid technologies. The classification of load forecasting depends on its target forecasting that ranges from minutes to years. Residential smart home load forecasting focuses on forecasting energy consumption of smart homes which is crucial when it comes to energy conservation and load management issues. This paper focuses on application and implementation of deep learning algorithm known as long short-term memory (LSTM) that predicts the load of residence hours or days ahead and the time series load analysis of the houses will be presented.

1 Introduction

Electricity usage at the individual household level shows high variance, since it relies on users' lifestyle, occupancy behavior, building characteristics, weather and calendar information. With the development of smart electricity metering technologies, huge amount of consumption data can be retrieved on daily and hourly basis. Energy consumption forecasting facilitates electricity demand management and utilities load planning. Most of the prior researches are focused on commercial customers or residential building-level energy consumption, course behavioral and occupancy sensor data to experiment on individual household's electrical consumption (Zhang et al., 2019). The extensive acceptance of smart meters enables a huge amount of fine-grained electricity consumption data to be collected. Temporarily, the deregulation of the power industry, particularly on the delivery side, has continuously been moving forward worldwide. How to analyze or handle massive smart meter data to promote and enhance the efficiency and sustainability of the power grid is a demanding issue. Till now, considerable works have been directed on smart meter data analytics (Wang et al., 2017). This paper divides the application of residential smart meter data analysis into four categories as load analysis, load forecasting, load management and load verification. Based on the authors review by performing load analysis, we can generate load profile of customers and detect bad data and non-technical losses (energy theft detection). Also, smart meter data can be used to forecast load and manage loads of consumers. Consumers load can be managed using different customer characterization techniques. Implementation of demand response marketing programs is also part of load management. Connection verification based on smart meter loads can be used for outrage management programs for data compression and data privacy and security purposes. In order to achieve this, we can use different analysis techniques like time series analysis, dimension reduction, outlier detection, classification, clustering, deep learning, low rank matrix… etc. (Wang et al., 2017). Smart meters can record household and appliance electricity consumption that utilized by several analysis methods and techniques under forecasting, clustering, classification and optimization objectives. Disaggregation is also additional technique that incorporates smart meter data (Yildiz et al., 2017). Load forecasting is a technique that has been used by utilities in the past and a technique that is still being performed. Load forecasting bay itself has several classes and categories based in the paper (Joshi & Singh, 2017). The author has explained the various forecasting horizons based on distinct time duration to

S. Araya · N. Rakesh · M. Kaur (✉)
Department of Computer Science & Engineering, School of Engineering and Technology, Sharda University, Greater Noida, Uttar Pradesh, India
e-mail: drmandeepkaur10@gmail.com

S. Araya
e-mail: semawitaraya@gmail.com

forecast the electric load of residences. The paper expresses and classifies the electric load forecasting techniques into five main categories or classes as shown in Table 1.

The different types of load forecasting types and techniques have been noticed for this research. The main focus will be on short-term load forecasting (STLF). The short-term load forecasting started at early 1960s. The first study of STLF was done by Heinemann et al. and continued his studies with exploring the relationship between load and temperature in 1966 (Joshi & Singh, 2017). This section of the paper deals with a review and categorization of different short-term load forecasting approaches. The main emphasis is to provide a review of different approaches for STLF and to present a complete study of load forecasting that focuses on STLF.

Based on this paper, different short-term forecasting approaches are presented:

1. Statistical (Traditional) approach
2. Modern or AI approach and
3. Hybrid approach.

Statistical approach needs a mathematical model which represents a relationship between load and several input factors. There are many statistical approaches such as exponential smoothing approach, adaptive filtering, regression-based approach, simple moving average, time series analysis, similar day lookup approach, etc. AI-based approaches for short-term load forecasting were not able to forecast highly nonlinear load. Therefore, soft computing or modern approaches were suggested. There are many AI-based approaches such as support vector machines (SVM), fuzzy logic, artificial neural network (ANN), genetic algorithm (GA), knowledge-based expert systems, etc. Hybrid approaches generally the combination of two or more different approaches. These approaches are introduced to overcome some drawbacks of the existing methods. There are many hybrid approaches to be used for load forecasting such as neural network, fuzzy expert, fuzzy expert system, neural expert systems, neural-genetic algorithm, fuzzy neural network, etc (Agana et al. 2018).

2 LSTM (Long Short-Term Memory)

Deep learning is a subset of machine learning. Deep learning algorithms are concerned with stimulating the structure, behavior and function of the brain (Shrestha 2019). This topic has received a great success in the last couple of years. Many researchers have produced state-of-the-art results successfully in many fields like image classification, market predictions, automatic speech and face recognitions, natural language processing, etc (Hosein and Hosein 2017). Deep learning is a part of machine learning that not only instructs computers to do the task but also helps in improving the accuracy of systems (Kong et al. 2017). Long short-term memory (LSTM) is an execution of the recurrent neural network (RNN). It was first proposed in 1997 by Hoch Reiter et al. LSTM can remember and store the information of earlier states. And then can be trained for task that requires memory or state awareness. LSTM partly discourses a major limitation of recurrent neural network (Zhang et al., 2019).

3 Proposed Methodology

In order to build a system that can predict electric load consumption of household from the load recorded from smart homes, we will be using the methodology showed in diagram below. Here we have planned electric load history recorded on smart meter. The data will be preprocessed since it contains outliners and missing values. Consumption load profile will be analyzed for the house old using time series analysis, and based on that, best features will be selected based on their impact on the inputs. Here, deep learning-based technique, known as long short-term memory (LSTM), a day ahead load will be predicted (Fig. 1).

Dataset description: The dataset used for this paper is collected from the UMASS smart home project repository. The main objective of the Smart project is to reduce and optimize home energy consumption. It consists of a high-resolution dataset from three homes and a lower resolution dataset from 400 homes the exact location of the

Table 1 Types of load forecasting

| Class type	Type	Forecasting Time frequency
Class I	Very Short-Term Load Forecasting (VSTLF)	>one minute
Class II	Short-Term Load Forecasting (STLF)	>one hour to one day, one weak ahead
Class III	Medium-Term Load Forecasting (MTLF)	One month- one year ahead
Class IV	Long-Term Load Forecasting (LTLF)	From one year–four or five years ahead
Class V	Very Long-Term Load Forecasting (VLTLF)	>five years

Fig. 1 Overall system architecture

homes. All these homes are in western Massachusetts. The data are collected from three smart meters located in the smart homes. The three meters consist of three different information about the houses. For this paper, we will use only the data of 1 smart home containing weather dataset and electric load dataset of the year 2014.

Data preprocessing: The data collected from this smart meter contains a lot of missing values which should be cleaned before the data processing step starts. Data cleaning plays a great role in increasing the performance of prediction. In this research, we have cleaned all the null values by replacing it with sum values. And while merging the two datasets, the weather and meter data, there was left out values since the size of the two data frames was different in time frequency; therefore, we have cleaned out all the left-out rows.

Time series load analysis of smart home A: The electric consumption of residences analysis can help us in identifying the appliances or the time where high energy consumption happens from the smart meter data recorded the meter have recorded the consumption of 15 elements found in the residence (Dishwasher [kW]) including the overall consumption and the overall generated electricity in kW are recorded in every 30 min of the year 2014. Below is a graph showing the plot of all the smart energy meters data (Fig. 2).

From this, for better understanding of the energy consumption pattern in the year 2014, we have plotted the overall energy consumption in KW in monthly frequency (Fig. 3).

From this plot, we can understand that there was high energy consumption during the months from 7 to 9 (July, august, September). We have also observed the generated energy in KW throughout the months which seem increasing energy generation on the months of April, May, June, July. Energy generation on the remaining of the months continues to be the same. In Fig. 4, we have compared the mean values of different features sampled over day. Of the residential

smart meter data used, generated and house overall energy consumption in kw.

The weather data of western Massachusetts used for this research contains 14 attributes of weather measured in 1-h frequency of the year 2014. The overall attributes of weather forecast dataset of the year 2014 every 2 month are plotted below. From the analysis, temperature, humidity and precipitation are constant throughout the year (Fig. 5).

The distribution of temperature over the whole year of 2014 I each month's been plotted and presented (Fig. 6).

The effect of temperature plays a great role in energy consumption during winter times, and high energy consumption has been observed based on the analysis shown in Fig. 7. Figure 8 shows the correlation analysis plot of between the used energy in kw versus the generated energy in kw. Relationship of the clustered weather with other variables like temperature, humidity and wind speed was also plotted and presented in Fig. 9.

LSTM Architecture: The main objective is to predict values for a time series where the history and data of more than 525,600 of minutes of a household's power consumption are given. İn order to predict the last value of a sequence of values, a multi-layered LSTM recurrent neural network has been implemented (Mohammad and Lee 2013). The users can resample the data over an hour to reduce the computation time and a faster response to test the model. Before implementing LSTM model, the data preprocessing and normalizing the features is a must. This approach works best if the dataset is very large. The supervised learning can be used to predict the house overall [kilo-watt] at any current time (t) with the temperature measurement, etc. The proposed LSTM model considers the following:

- Define the model with 100 neurons in the first hidden layer.
- Only one neuron in the output layer to predict house overall [in kilo-watts].
- 30 features as input (with shape 1-time step)
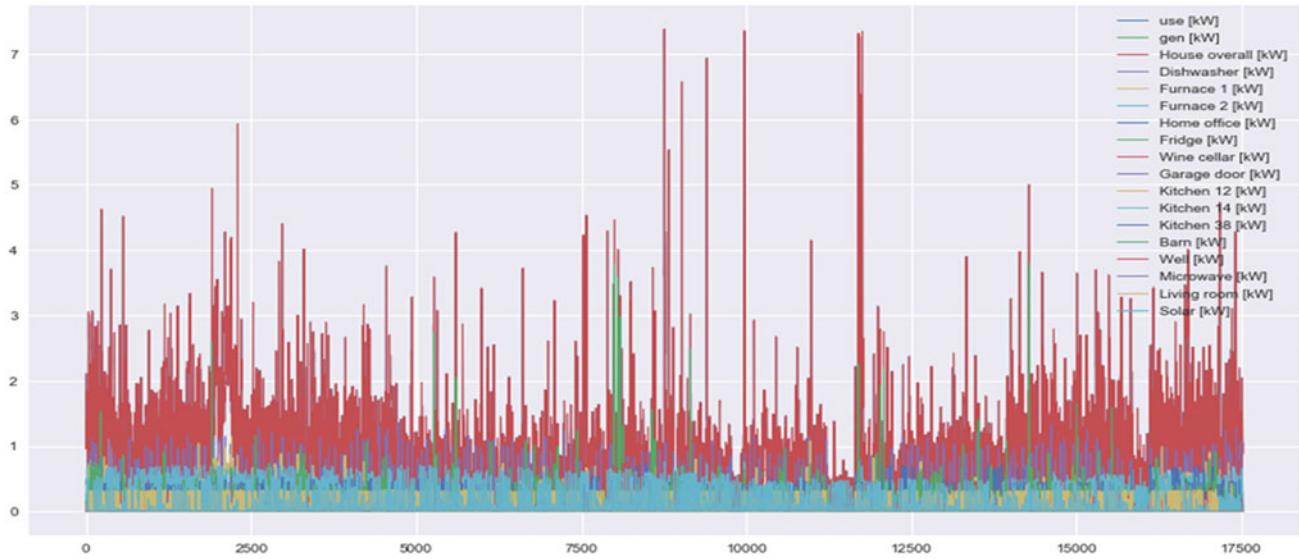
Fig. 2 Overall energy consumption of house A
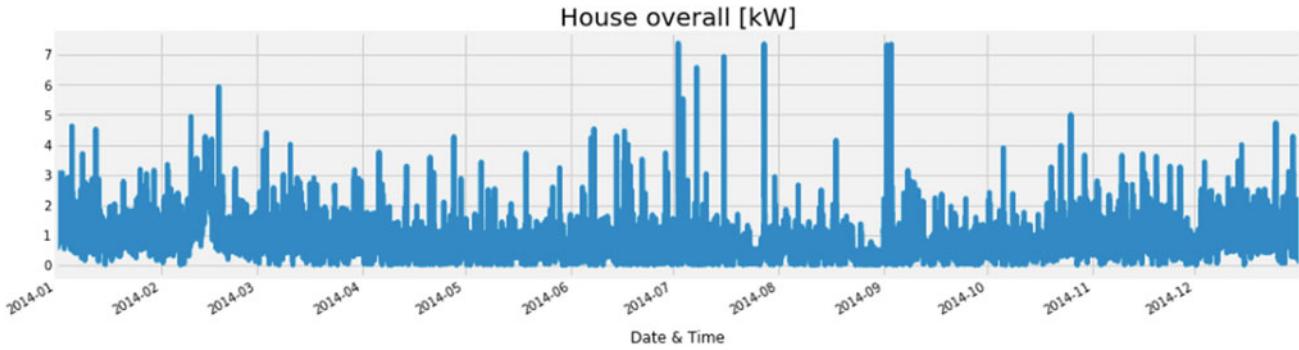
Fig. 3 Overall electricity consumption in the months in kw in 2014

- 20% dropout
- Use the RMSE loss function
- Use Adam version optimizer (a stochastic gradient descent)
- 20 Training epochs required to fit the model
- With a batch size of 70.

The LSTM model will output scaled output of forecasted value which we should change it to actual output using the scaler inverse function of phyton in order to see the difference between the actual and forecasted values. After the LSTM predicts, it will give us the predicted value and have to be changed to actual value; from this, we can understand that there is a gap between the actual and predicted values. Therefore, we need to tune the parameters of the LSTM in order to get the list of errors between the actual and predicted systems (Fig. 10).

This experiment has been done and will be shown and discussed in the result and evaluation section for the above

LSTM model, and we have chosen the RMSE to evaluate the performance of our model. Root mean square error (RMSE) is the standard deviation of the residuals, i.e., prediction errors.

4 Result and Evaluation

In this paper, we have used Jupiter notebook in order to analyze the dataset we have separated the input of the model in two cases: The first is to predict only using the meter data and observed the effect of resampling based on day and hourly mean. The second is using the combined dataset which is the data that came from the weather and the data from the meter only by selecting the best of both and analyze the effect of resampling and sample size.

A. Based on hourly mean resampled data: In this experiment, we evaluated the effect of resampling on hourly based. Therefore, we resample the data based on mean in

Fig. 4 Overall sampled mean daily
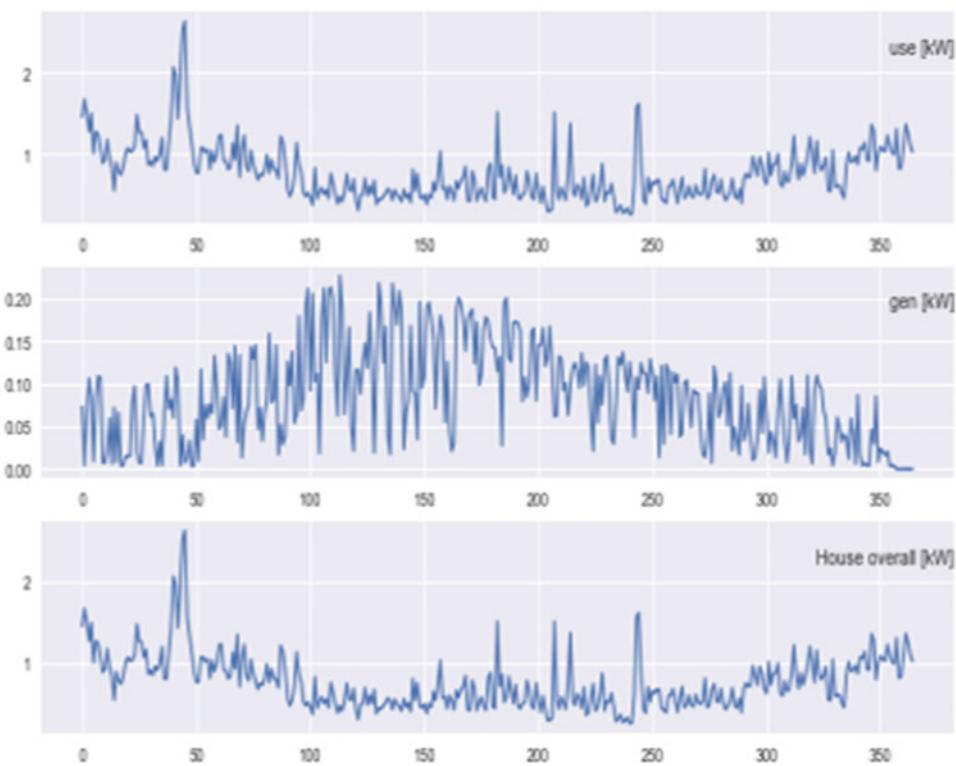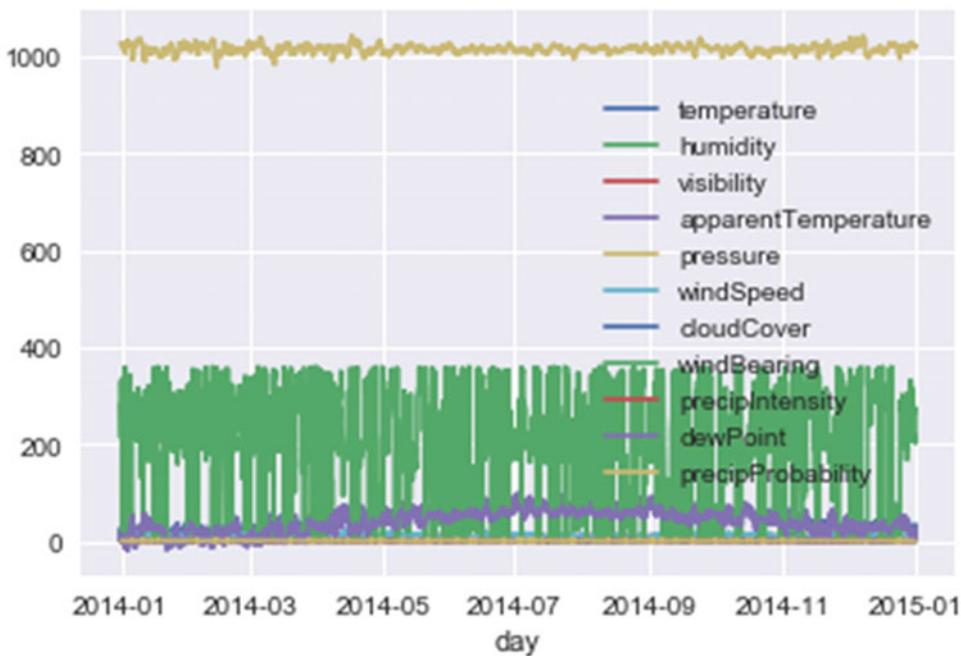
Fig. 5 Weather dataset plot
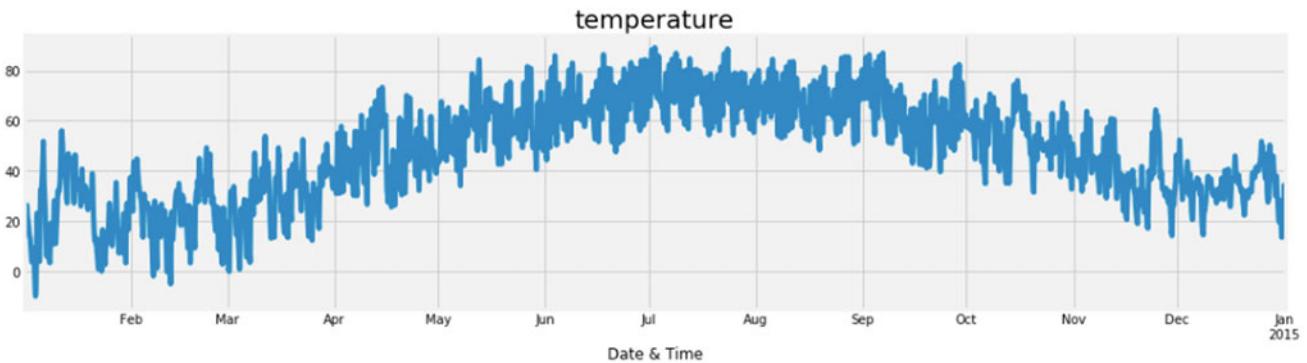
Fig. 6 Temperature dataset plot
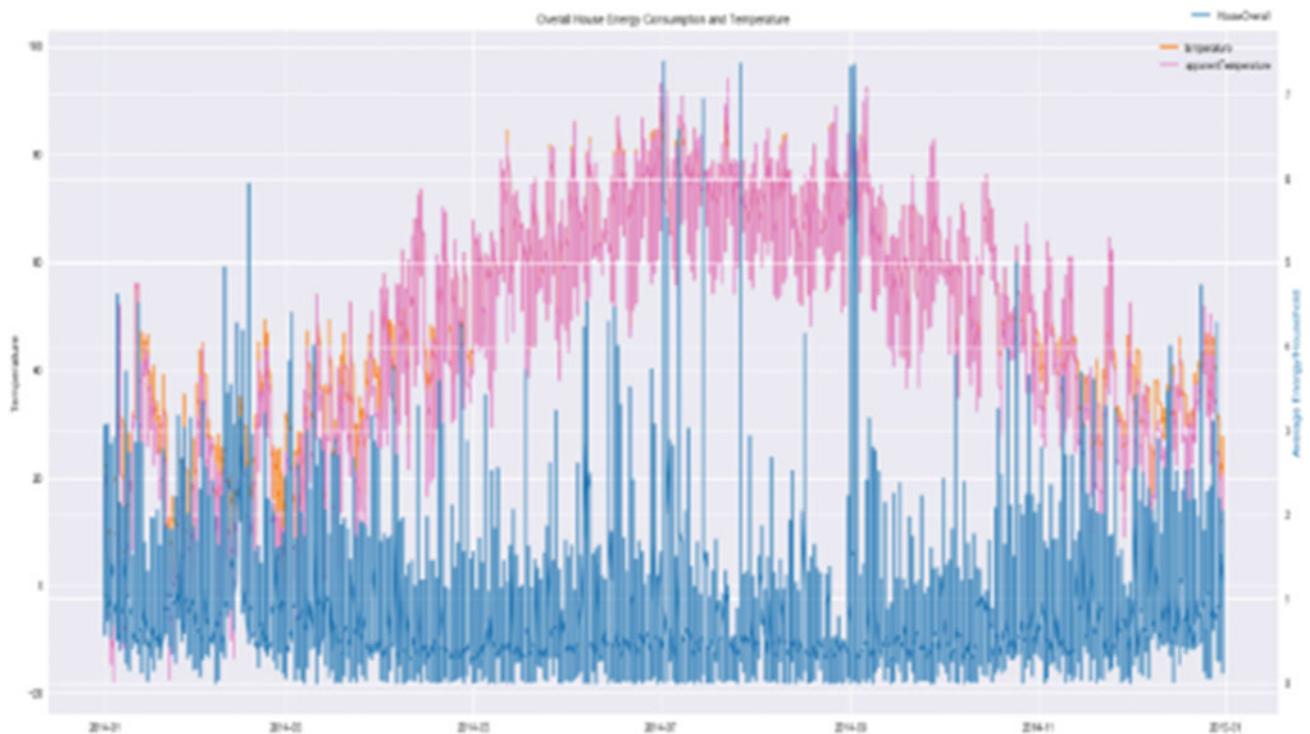
Fig. 7 Effect of temperature on energy consumption

hourly shape of the resampled (8760, 18). After resampling, we normalize the features based on min-max scaler, and then we reframing the scaled data to the supervised function after that we split the data to test and training datasets. We get the output (8760, 1, 2) (8760) (8759, 1, 2) (8759). This sample has training samples of 8760 and validation samples of 8759; for this experiment, we used input layer of LSTM 100 with 20 epochs, 70 batch size and 0.2 dropouts. The model

fitting of the sample with training samples 8760 is executed, and output is shown in Table 2.

From the above output, we have analyzed the losses on every epoch and modeled it, which will be shown in Figs. 11 and 12.

The LSTM model test RMSE has been calculated as: test RMSE = 0.376-time steps, every step is one hour (you can easily convert the time step to the actual time index); for a
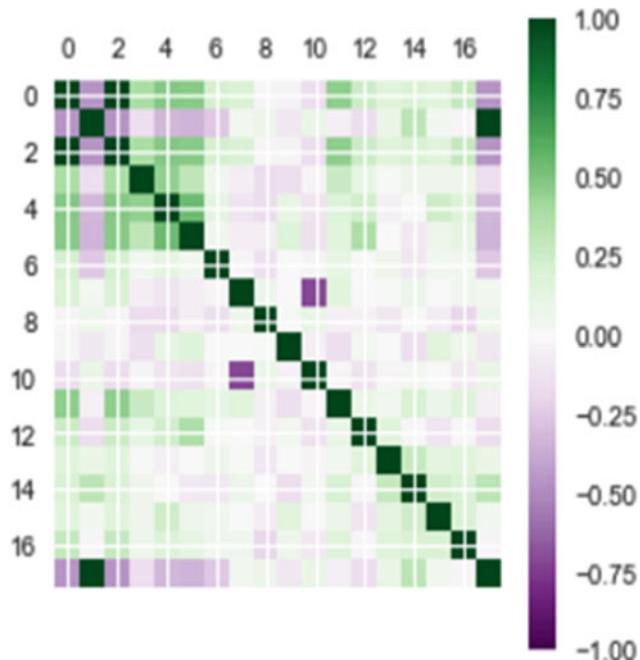
Fig. 8 Correlation matrix of meter data

demonstration purpose, we only compare the predictions in 200 h. We have conducted this experiment n 2 bases with 3 reframed attributes and with 5 reframed attributes (Table 3).

B. Based on un-resampled data: In this experiment, we will observe the effect of using the merged daily meter and weather data unmerged. Therefore, we will use the daily recorded dataset as it is daily data. Shape of the input is (1,187,765, 34) as we can see the input data size is very huge in comparison to the resampled datasets which makes the computation time slower. After that we normalize the features based on min–max scaler, and then, we reframe the scaled data to the supervised function; after that we split the data to test and training datasets. We get the output (8760, 1, 2) (8760) (1,179,004, 1, 2) (1,179,004,). This sample is having training samples of 8760 and validation samples of 1,179,004; for this experiment, we used input layer of LSTM 100 with 100 epochs, 70 batch size and 0.2 dropouts. The model fitting of the sample with training samples 8760 is executed, and output is below the RMSE value **Test RMSE = 0.546**. Based on the values predicted, we have done comparison of 200 sample data of actually recorded
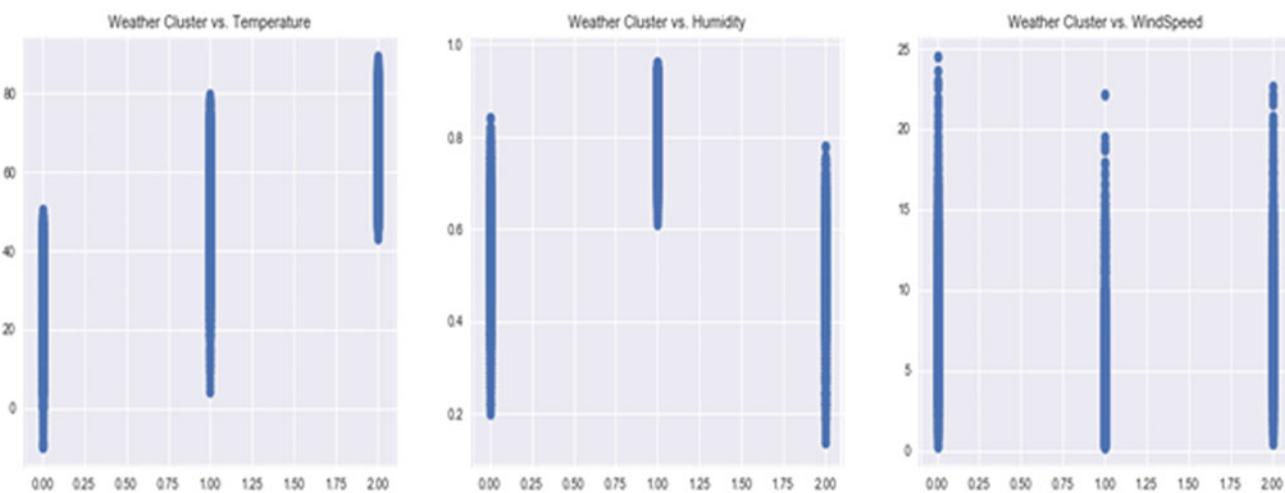
Fig. 9 Weather cluster versus temperature, humidity and wind speed

Fig. 10 LSTM input feature engineering
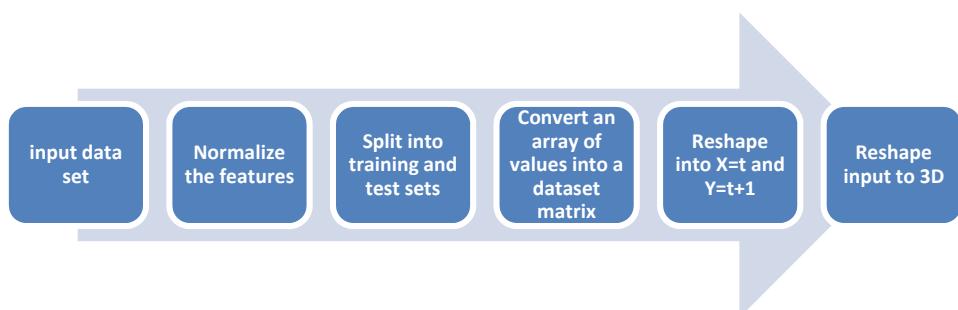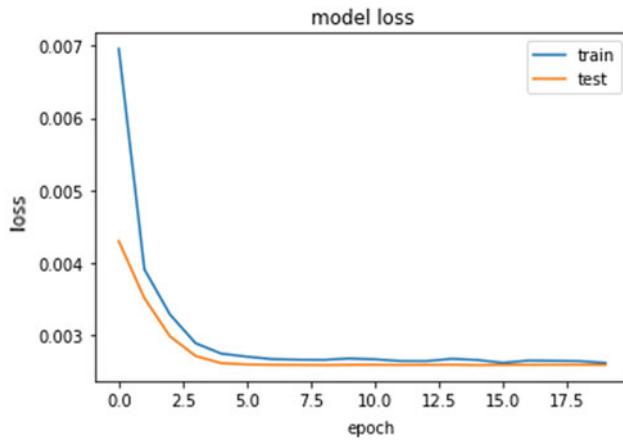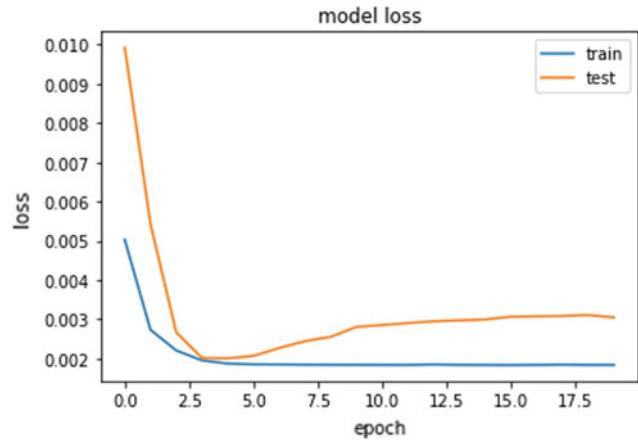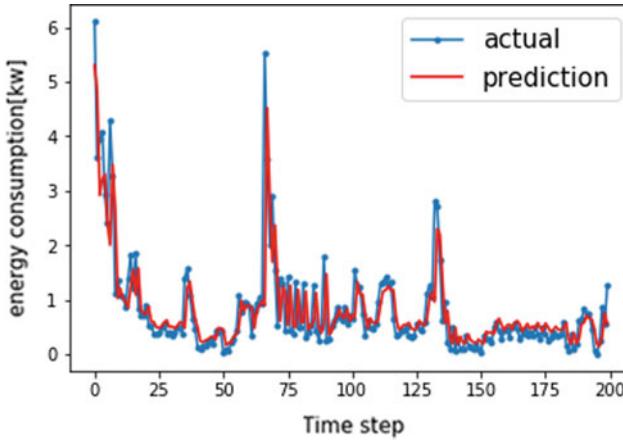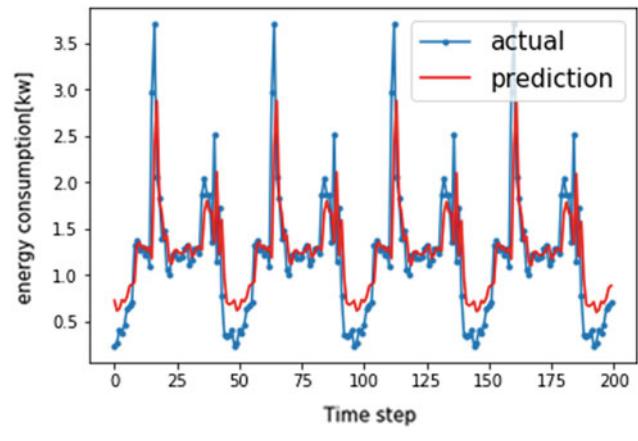
Table 2 Input parameters

Shape	Input	Training	Testing	Validation	Epoch	Dropout	Batch size	RMSE
(8760, 18)	100	8760	1	8759	100	0.2	70	0.376

Fig. 11 Loss model of case1

Fig. 13 Loss model of merged unsampled

Fig. 12 Actual versus prediction compared the predictions in 200 h

Fig. 14 Actual versus predicted value compared

Table 3 RMSE values for different attributes

No. of reframed attributes	RMSE
3	0.376
5	0.711

versus predicted energy consumption value in kw (Figs. 13 and 14).

5 Conclusion

The paper proposed time series analysis of smart home data with the short-term load and electricity load forecasting using the deep neural network-based model. Based on a dataset of smart home collected from the UMASS smart home project located in western Massachusetts. From the

experiments, we concluded that data resampling based on hourly or daily mean increases the performance of LSTM models and also increases the computational time of LSTMs for short-term load forecasting of smart homes. Also we have observed weather dataset plays a great roll in increasing performance of LSTM model but decreases the systems computational performance since we will be having too many features.

References

Agana, N. A., Oleka, E., Awogbami, G., & Homaifar, A. (2018). Short-term load forecasting based on a hybrid deep learning model. In: *Conference on Proceedings—IEEE SOUTHEASTCON* (Vol. 2018-April, pp. 1–6).

Hosein, s., & Hosein, P. (2017). Load forecasting using deep neural networks. In *Conference on Innovative Smart Grid Technologies*. IEEE Power & Energy Society, ISGT 2017.

Joshi, M., & Singh, R. (2017). Short-term load forecasting approaches : A review. *01*, 9–17.

Kong, K., et al. (2017). Short-term residential load forecasting based on LSTM recurrent neural network (Vol. 3053, No. c, pp. 1–11).

Mohammad, Y.-C. K. F., & Lee, K.-B. (2013). *Short term load forecasting using deep neural networks* (Vol. 3, No. 2, pp. 1–9).

Shrestha, A. (2019). Review of deep learning algorithms and architectures. *IEEE Access, 7*, 53040–53065. *Smart—UMass trace repository*. https://traces.cs.umass.edu/index.php/Smart/Smart. Accessed July 31, 2019.

Wang, Y., Chen, Q., Hong, T., Kang, C., & Mar, C. Y. (2017). Review of smart meter data analytics : Applications, methodologies, and challenges, no. June (pp. 1–24).

What is deep learning? How it works, techniques & applications—MATLAB & Simulink. https://in.mathworks.com/discovery/deep-learning.html. Accessed: Jul 21, 2019.

Yildiz, B., Bilbao, J. I., Dore, J., & Sproul, A. B. (2017). Recent advances in the analysis of residential electricity consumption and applications of smart meter data. *Applied Energy*, 1–25.

Zhang, X. M., Grolinger, K., & Capretz, M. A. M. (2018). Forecasting residential energy consumption using support vector regressions, no. January 2019 (pp. 2006–2007).

IoT-Based Smart Waste Management System

Sandeep Kumar, Mandeep Kaur, and Nitin Rakesh

Abstract

In today's world, the growth of population is increasing rapidly. As population increases the new problems are also generated. Advanced technology can solve these problems. Waste management is a big concern of today's world. Traditional methods are failing now. Therefore, the problem of waste management also can be solved with the help of new technologies. This waste management can be done smartly with the help of a technology IoT. The main objective of this system is to create a solution for smart waste management which is smart dustbin. As waste is collected by municipal employees from the dustbins, but tracking the waste level manually in dustbin is very difficult and costly. In this case, when bin is filled, waste comes out from the bin and becomes the reason of serious health hazard to the surrounding environment. Smart dustbin provides the facility to track the status of bin waste. It is connected to the Internet; therefore, real-time information of dustbin can be received.

Keywords

Android • Internet of things • Smart waste • Ultrasonic sensors • Node MCU • Smart dustbin

1 Introduction

Waste management is the important concerns of modern world. As nations of the world are developing, their problems and responsibilities for a health sector and sustainable environment are also increasing. While developed countries like USA, China, UK, etc., are inventing smart solutions for waste management, this makes huge positive impacts. But in other developing countries like India and Bangladesh, the condition of waste management is too harsh. According to a report capital of Bangladesh, Dhaka is the most polluted city in the world. The reason is that there are many issues with the management of municipal waste. Waste management is the most essential requirement of today's world. This system presents a solution of waste management using IoT technology (Medvedev and Fedchenkov 2012). A smart dustbin is the main product of this system. This dustbin is interfaced with Arduino, ultrasonic sensors and node MCU. The ultrasonic sensor will detect the level of the garbage available in dustbin. Then the data will be sent to Arduino. The same signal is encoded by Arduino, and it is shown on the LED screen and application screen.

The key issue of waste management is that the dustbin which is placed at public places gets overflowed (the bin is full) before the initiation of the next cleaning step. Hence, there is a need to design and implement a system that at least minimizes this problem to some extent. Today's world is filled with advancement of technology. The smart dustbin gives the potential solution for solving the problems of waste management. The waste management system will inform the status of waste level in dustbin to authorized person through mobile application using Wi-Fi and also provide the information about the status of garbage level of dustbin on LED screen attached with dustbin. This level of garbage in the dustbins is detected using the ultrasonic sensor which is placed in the upper part of dustbin called lid. When there is a garbage in hands and needs to trash that in dustbin, the lid of the dustbin will automatically open and close automatically after some defined particular time. The hardware which is required for this system is some electronic components such as an Arduino, Node MCU, 4 ultrasonic sensors, LED and an SG90 Tower Pro Servo Motor and the main dustbin.

S. Kumar · M. Kaur (✉) · N. Rakesh
Department of Computer Science & Engineering, SET, Sharda University, Greater Noida, India
e-mail: drmandeepkaur10@gmail.com

S. Kumar
e-mail: sandeepkumar07770@gmail.com

N. Rakesh
e-mail: nitin.rakesh@gmail.com

2 Related Work

The waste management in our cities has to be done effectively. There are many proposals for this, and some of them are already implemented. But every proposal cannot be considered as the best one. In this world, everything required improvements. The discussion about the idea of smart dustbin for main object smart waste management is present for quite a long period. In this discussion, the role of new technology which is IoT has important place. There are multiple ideas, and they appear similar to each other but these are slightly different. By using IoT technology, designing a smart dustbin which is able to make some impact on waste management in our society is the main purpose of the proposed work. This system provides the facility of better decision making by the authorized person.

It is observed during survey of maximum solutions, at hardware side, there is smart dustbin with Arduino (microcontroller) and Wi-Fi module (Node MCU). Therefore, a survey was done among different proposals and here it presents a survey which is done among different methods or solutions for smart waste management.

Smith and Waterman (1981) proposed a smart waste management using IoT that provided a solution given as a system that has multiple dustbins. These dustbins are fully accomplished with new technology devices. The level of garbage can be detected by attaching ultrasonic sensors to these dustbins. In this system, a communication is established between this system of dustbin and authorized control room with the help of GSM system. A mobile application which runs on android is also developed which monitors the data collected from smart dustbins from different locations. This will help to manage the waste efficiently. IR sensors are used to detect the level of the dustbins. For this detection, four IR sensors are used in each dustbin. These four sensors indicate the level of dustbin. When the dustbin is full, the output of fourth IR sensor becomes low. This data is sent to Arduino and microcontroller, and it encodes that data to send the message to the control room via GSM module. Control room is that place where all information is received, and after analyzing that information, right decision has taken. This whole system assures that the dustbins are cleaned as soon as possible when the garbage reaches at maximum level of dustbin.

Mahajan (2014) implemented model based on GIS Information System in the city of Asansol in India. This is a GIS transportation model for solid waste collection, its storage and disposal (Li et al. 2008). This model is proposed for the Eastern Finland to enhance the routing of vehicles which collect garbage from dustbins and scheduling waste collection. The main aim of the research was to develop an optimal schedule for waste carrier trucks on known routes. This data is received by DSS from the dustbins, and it is sent to organizers of waste collection in the particular place and to the road police who manage the traffic on roads. The benefit of this system is that now the truck driver does not waste time for waiting because he/she is able to go to the next point, and the route is dynamically recounted (Ghose et al. 2006).

Al-Maaded et al. (2012) is presented a review that was done on waste collection in developing countries like Bangladesh, India and Pakistan from 2005 to 2011, and this survey considers the challenges for developing countries in waste management system. This research focuses on finding the stakeholder's behavior and also evaluates different influential factors which define the roles of stakeholder in waste management processes. In this survey, the methods were tested on real data and considering system approaches for solid waste management in developing countries (Guerrero et al. 2013).

Prakash (2016) proposed a model of waste management using IoT for smart cities in organizing the waste collection system of commercial areas of the cities. This proposed system is similar to other systems as the level of the garbage in dustbin has been detected with the help of ultrasonic sensors, and a communication is established between the system and the authorized control room through GSM module. GSM module is used for tracking the location of dustbin. Microcontroller which is Arduino is used to interface the sensor system with GSM system (Singh et al. 2016). An application having GUI is also developed to supervise the required information related to the garbage present in dustbins for different already known locations. The main difference between the proposed system from other existing systems is the use of MATLAB-based GUI. This system is based on master and slave phenomenon. In this system, slave unit consists of smart dustbins and master unit consists of control room where all information of dustbins is present. Dustbins which come under slave unit consists of Arduino Uno board which has Atmega328 IC, ultrasonic sensor and GSM module for providing locations.

The survey is motivated to introduce and formulate a problem statement to find the solution for waste management using modern technology which can help in collecting the garbage from the dustbin on right time before overflowing the wastes. In other words, try to make a system which is helpful in tracking the level of dustbin and work smartly by open or close the door of dustbin automatically. The facility of opening the lid of dustbin automatically when our hand which having garbage reaches to near the dustbin, make easy for human's daily activities (Navghane et al. 2016).

3   System Design

3.1   Basic Modules and Structure

In this system, work can be divided into small units. These small work units are called modules. Some modules are independent to other modules but some are dependent to each other. Basically, these six modules are.

1. Attaching different components to the dustbin for example sensors, LED screen, Arduino, Node MCU, etc.
2. Connections of sensors to Arduino, the microcontroller with the help of jumper wires.
3. Connection of Node MCU and LED screen to the Arduino.
4. Load the Arduino to the laptop and develop a program for sensors working.
5. Write a program for connectivity of mobile application to the dustbin through Wi-Fi which is inbuilt in Node MCU.
6. Install the android application in the mobile from the play store and login to connect with the system

Abovementioned six basic modules are the main phases of the work process. After implementing each individual module, the process of collaboration between modules takes place. This integration process provides a working system as output of the work. The conceptual modules in a system are defined as shown in Figs. 1 and 2.

3.2   Procedure Design

The block diagram of the system that describes the details of how the components of the system are connected to each other is shown in Fig. 3. Use case diagrams are used for the visualization of functional requirements of the system. It makes it easy for choosing design options and development

Fig. 2 Data flow diagram
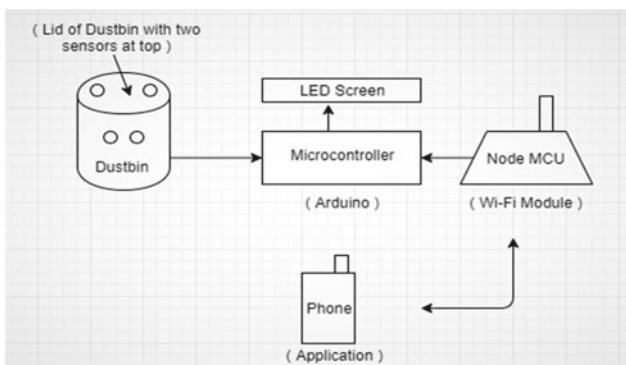
Fig. 1 Conceptual modules
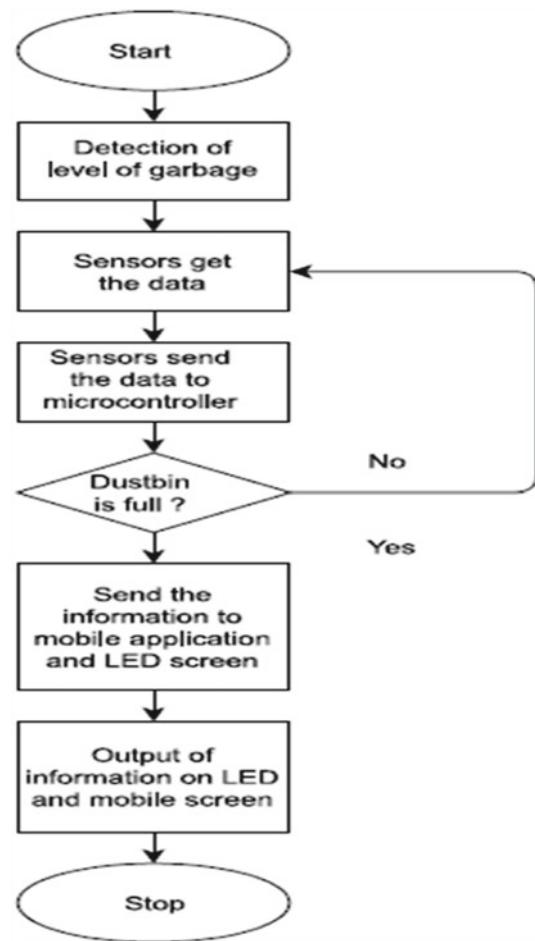
priorities. These diagrams describe the set of actions between system and one or more external user called Actors. Actors are referred to users who use the system or who will collaborate with the system. Figure 4 depicts the use case diagram User, Authorized Person and System are the actors.

The data flow diagram for the system is shown in Fig. 2.

Figure 5 presents a sequence diagram that provides the information about the interaction between different objects in sequence order. The order is in which interaction between objects takes place. These are used to model the system work. It helps in visualizing the logic or idea behind the sophisticated functions, operations or procedures.

3.3   Test Case Design

The strategies for testing are designed as test cases. These test cases describe the different functions and also provide the information about functions that what will be they provide the outcome. Here, a design of test cases is built in the form of table which consists of the details of required input,
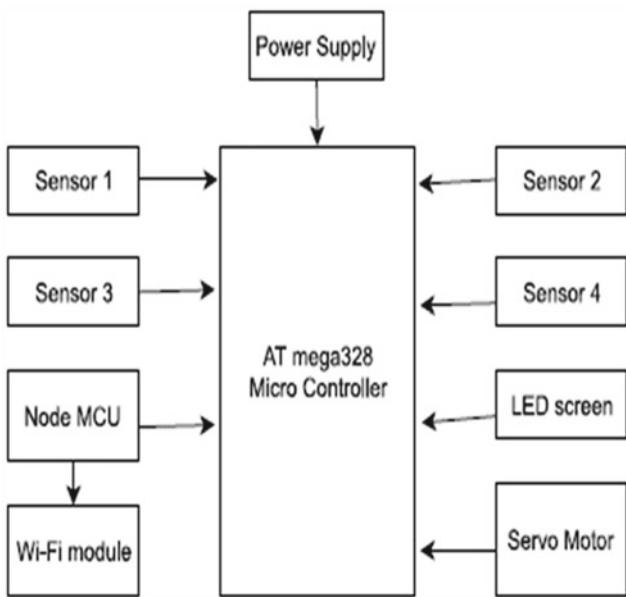
Fig. 3 Block diagram
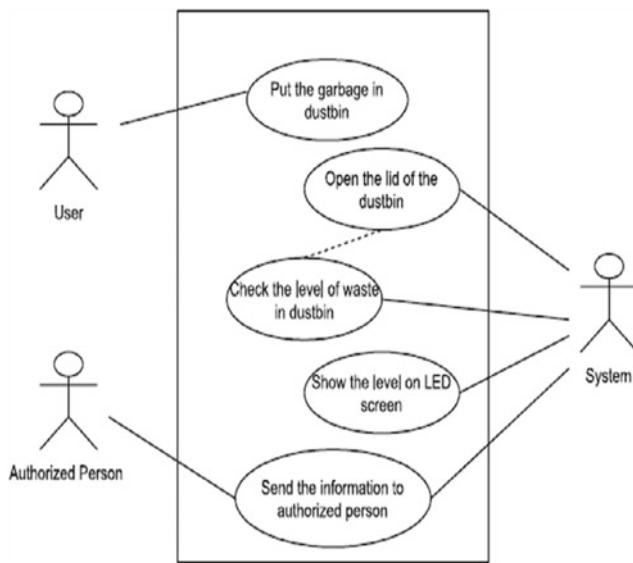
Fig. 4 Use case diagram

actions, expected outcomes, conditions, etc. The different test case scenarios are as follows in Table 1.

4   Implementation

Implementation is the process of converting the designed system into working system. Implementation process is the very crucial phase for any system. Here, implementation work can be divided into two ways. First one is implementation of hardware part and another software part. In this
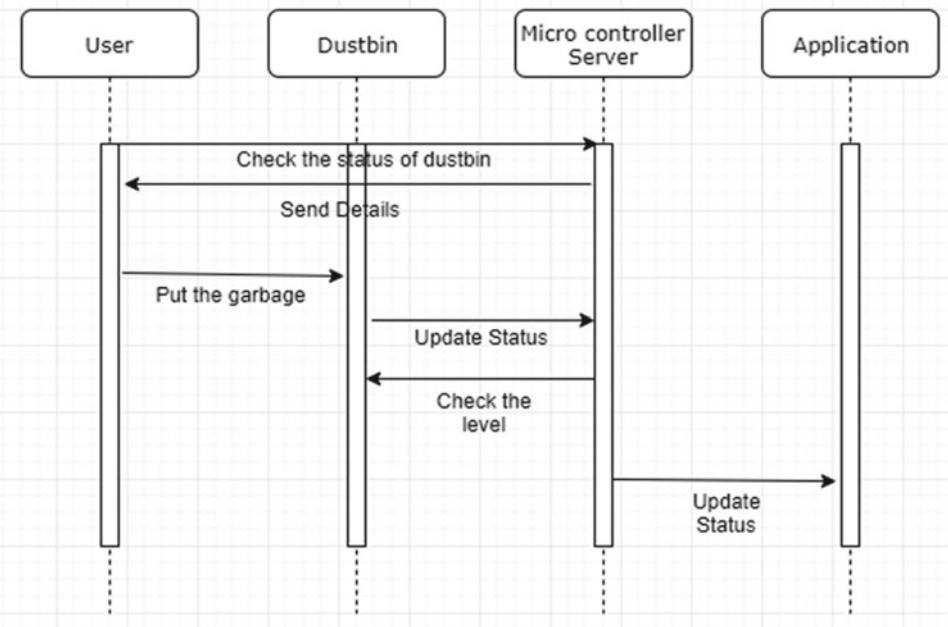
system, maximum implementation is the work of attaching hardware components to the dustbin and making connections between them with the help of jumper wires. This work follows the system designing work and takes the help of different type of diagrams such as data flow diagram (DFD), block diagram of system, use cases diagram and sequence diagram, etc. These diagrams will help in implementation of hardware part.

According to the planning, the sensors are connected to a medium-sized dustbin. For this, a thin plyboard is used and cut it in a circle in the size of open-top area of the dustbin. This plyboard is cut into equal two parts and stick them to each other with the help of the tape and make two holes in the center of that board. These two holes are used for fitting two sensors. These two sensors will detect the level of garbage present in the dustbin. Now, this board has to be attached with dustbin on the top with small screws. This will be the lid of the dustbin.

Other two sensors are attached to the vertical surface of the dustbin. These sensors are used for detecting the object. When user puts the garbage in dustbin via hands, these two sensors will detect the hands and send a signal to microcontroller. Microcontroller will open the lid of dustbin with the help of servomotor. This lid will close after some fixed amount of time. A servomotor is also attached to the dustbin in the bottom of the lid in the center, where the lid is cut in two parts. This servomotor is used for opening the lid of dustbin automatically when front two sensors detect any object. Now, another plyboard is cut in the shape of rectangle. This plyboard is used for attaching other components such as Arduino, Node MCU and LED screen. This also attached to the dustbin with the help of screws. LED display shows the real-time status of the garbage in the dustbin. All components are connected with the help of jumper wires. All components such as sensors, node MCU, servomotor and LED display are connected to microcontroller and Arduino.

Here are some figures which show the work of hardware implementation. In Fig. 6, two sensors are attached in vertical surface of the dustbin. These sensors will detect the object when user tries to put garbage in dustbin. As objects appear, sensors send the message to microcontroller and microcontroller opens the lid of dustbin with the help of servomotor. Figure 7 shows the connections of microcontroller, sensors, Node MCU and LED display. These all components are attached to the rectangle shape board. Node MCU is used because it provides inbuilt Wi-Fi module. It will help in making connection of system with mobile application. After completion of hardware implementation, coding part takes place.

Arduino software is used to load microcontroller with the help of USB cable. A port is given in the Arduino microcontroller for connecting USB cable. Arduino software is an

Fig. 5 Sequence diagram

Table 1 Test case scenarios

Sr. No.	Test case description	Input	Requirements	Test case status
T1	All the components work properly in synchronous manner	Power supply	All connections should be ok	Pass
T2	Connect mobile application to the system with the help of Wi-Fi by turning on the hotspot of mobile in which application is installed	Null	Wi-Fi module of Node MCU should be work properly	Pass
T3	Show the status of 'empty' dustbin on mobile application and also on LED display	Null	Dustbin should be empty	Pass
T4	Show the status of 'partial filled' dustbin with garbage on mobile application and also on LED display	Garbage filling	Dustbin should be filled partial	Pass
T5	Show the status of 'completely filled' dustbin with garbage on mobile application and also on LED display	Filled	Dustbin should be completely filled	Pass
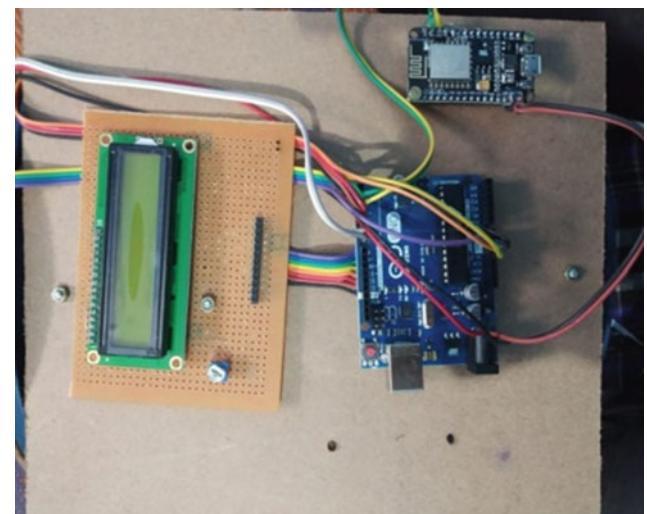
Fig. 6 Two sensors attached to dustbin

Fig. 7 Connections of different components

Fig. 8 Status of dustbin in mobile application 'Blynk'
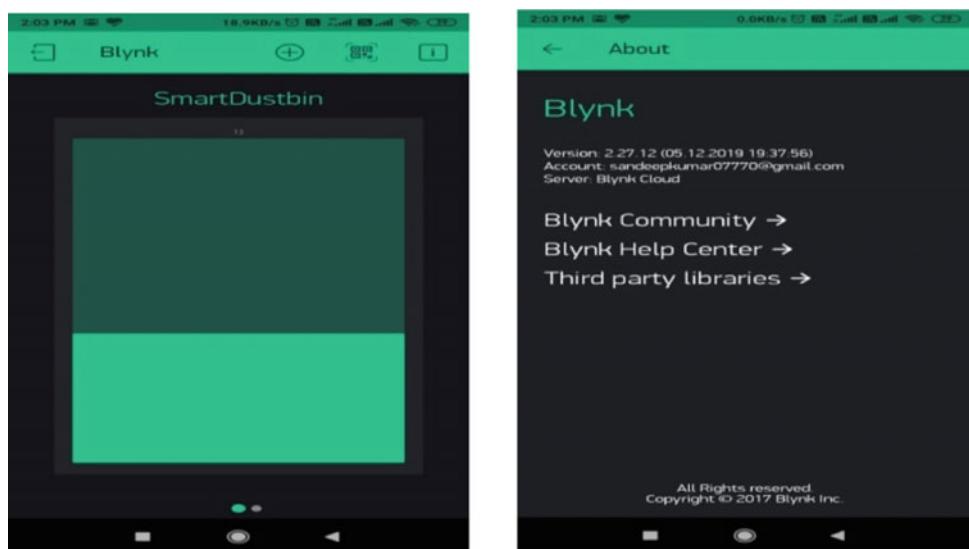
Fig. 9 First message displayed on LCD

Fig. 10 When dustbin is full

4.1 Test Reports

An Android mobile application 'Blynk' is used in this system. It is a popular Internet of things platform which provides free cloud, web dashboard and Android mobile applications. The output of the system is to show the status of dustbin in real time in mobile application as well as in LED display. This section discusses some screenshots of system's output. Figure 8 represents the outcome of the system.

Figures 9 and 10 depict the LCD display which also show the status of dustbin.

5 Conclusion

With the use of smart dustbin, the level of garbage can be checked whether the dustbin is full or partial full. The information regarding fill level of dustbins can be known from anywhere by the authorized person with the help of android mobile application, and the user can take a decision according this. This proposed system can reduce the cost which is spent on collection of garbage from dustbin. This system also helps in resource optimization.

integrated development environment (IDE) which provides the facility to write and upload programs to Arduino board.

First a new file is created to write the program and then by clicking on file option, a new file is generated. It contains two functions already without any inner code. These are setup() and loop(). Now, a program is written with these two functions to achieve desired outcome. After loading the microcontroller to the laptop, there are two programs need to write in C/C++ language. One of these program is written for the working of sensors, servomotor to open–close the lid of dustbin and LED screen to display the level of dustbin. Second program is written for establishing the connection of mobile application to the system. This is possible with the help of logging in to the mobile application with the help of Wi-Fi connection.

References

Al-Maaded, M., Madi, N. K., Kahraman, R., Hodzic, A., & Ozerkan, N. G. (2012). An overview of solid waste management and plastic recycling in Qatar. *Springer Journal of Polymers and the Environment*.

Ghose, M. K., Dikshit, A. K., & Sharma, S. K. (2006). A GIS based transportation model for solid waste disposal—A case study on Asansol municipality. *Journal of Waste Management, 26*(11), 1287–1293.

Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Journal of Waste Management, 33*(1), 220–232.

Li, J. Q., Borenstein, D., & Mirchandani, P. B. (2008). Truck scheduling for solid waste collection in the City of Porto Alegre, Brazil. *Journal of Omega, 36*(6), 1133–1149.

Mahajan, K. (2014). Waste bin monitoring system using integrated technologies. *International Journal of Innovative Research in Science, Engineering and Technology, 3*(7).

Medvedev, A., Fedchenkov, P., Zaslavsky, A. (2012). Waste management as an IoT enabled service in smart cities. Springer.

Navghane, S. S., Killedar, M. S., Dr. & Rohokale, V. M. (2016). IoT based smart garbage and waste collection bin. *IJARECE, 5*(5).

Prabu, P. (2016). IoT based waste management for smart city. *IJRCCE, 4*(2).

Singh, T., Mahajan, R., & Bagai, D. (2016). Smart Waste management using wireless sensor network. *IJRCCE, 4*(6).

Site named "repositorio.uniceub.br"

Smith, T. F., & Waterman, M. S. (1981). Identification of common molecular subsequences. *Journal of Molecular Biology, 147,* 195–197.

Website—www.ijircce.com

Website—www.nipsedu.co.in

Website—www.vjer.in

Website—www.futurecities.mes.ac.in

Website—www.jetir.org

An Analysis of Brain Tumor Segmentation Using Modified U-Net Architecture

Harshal Trivedi, Kishan Thumar, Karan Ghelani, and Dhyani Gandhi

Abstract

In the process of diagnosing a brain tumor, the most prominent task is the analysis of the MRI images, and so it is important to precisely assess the images. Despite advancements in the field of medical science and research, there are very few methodologies that provide us with accurate brain tumor segmentation. The segmentation of the images, which is done manually becomes a laborious, tedious task; moreover, the 3D nature of the data imposes several challenges in the segmentation of images, which is done in an automatic manner. Our research focuses on the approach for tackling the task of the segmentation by training a network architecture encouraged by U-Net. Worked on 2018 dataset of brain tumor segmentation challenge (BraTS), we got better results with our projected system than other state-of-the-art architectures like native U-Net architecture.

Keywords

U-net architecture • Computer vision • Brain tumor segmentation • Dice coefficient

H. Trivedi
Softvan Pvt. Ltd, Ahmedabad, India
e-mail: harshal@softvan.in

K. Thumar
Gandhinagar Institute of Technology, Ahmedabad, India
e-mail: kishanthumar97@gmail.com

K. Ghelani
Silver Oak College of Engineering and Technology, Ahmedabad, India
e-mail: karanghelani2910@gmail.com

D. Gandhi (✉)
LD Engineering College, Ahmedabad, India
e-mail: gandhidhyani@gmail.com

1 Introduction

Artificial intelligence (AI) is the training of machines to enable them to perform tasks that are performed by humans. AI is significant since it can help comprehend troublesome issues in different ventures, for example, entertainment, education, health, commerce, transport, and utilities. The utilization of computerized reasoning and, specifically, AI is getting progressively prominent in the field of research. These frameworks exceed expectations at rapid analysis of data, interpretation, and in certain research tasks such as image assessment and segmentation. Presently, researchers have started to utilize AI for brain tumor analysis. AI strategies are applied in the field of medication to improve the precision of analytic and diagnostic techniques.

Computer vision takes a shot at empowering computers to examine, distinguish and analyze pictures just like humans visualize and then provide acceptable output. The field is linked with artificial intelligence, as the computer must examine or act like humans. This interdisciplinary subject simulates and automates those elements of human imaginative and prescient structures with the usage of sensors, computer systems, and machine learning algorithms. Recently, deep learning algorithms perform a significant role in the computer vision discipline. Its application is that it is presently utilized in comfort stores, driverless car testing, every day therapeutic diagnostics, and in observing the well-being of crops and livestock.

Identifying with computer vision, ongoing journals show wide utilization of one of the sorts of deep artificial neural network, which is known as convolutional neural networks (CNN), especially for division and grouping of brain tumors. Brain tumor is a genuine infection wherein an irregular development of tissue inside the mind can upset appropriate cerebrum work and it has also been recorded as a major cause for increase in death rate cases. This paper (Menze et al., 2015) proposes that the main aim of BraTS challenge is empowering the improvement of present day strategies

and methodologies for tumor segmentation by giving an enormous dataset of clarified low-grade gliomas (LGG) and high-grade glioblastomas (HGG). In general, tumor developed in the brain is analyzed using magnetic resonance imaging (MRI). After confirmed brain tumor detection using MRI, a biopsy or surgical operation is undertaken to decide the brain tumor type and to examine the outcomes from a pattern of tissue. Brain tumor detection helps in preliminary clinical trials. Use of the advanced technology can be extended for the educational purpose giving the new generation medical students as well as high school students, better understanding and insights of the assessment of brain tumors, its patterns and diagnosis.

2 Related Work

Brain tumor detection has received significant attention from the researchers due to the discovery of a few detection techniques during recent decades. Initially, CNN was used to feature image into a vector which can be further utilized in classification. With CNN, we learned such feature mapping, but the same feature maps can be used to extend the vector to a segmented image. This is the main idea behind U-Net, and this reverse process would reduce the resulting distortions in the image considerably. A fusion intelligent machine learning technique which engages computational methods such as segmentation of images using feedback pulse coupled neural network, extricating specifications utilizing discrete wavelet transform method, lessening the dimensionality of the wavelet coefficients utilizing principal component analysis, and the feedforward backpropagation neural network to classify inputs into typical or irregular, and for computer-aided detection system for brain tumor detection through magnetic resonance images is proposed by El-Dahshan et al. (2014). Abd-Ellah et al. (2016) anticipated a method in which classification of magnetic resonance images (MRIs) was done into normal and abnormal by using combination of morphological filters, extraction of features utilizing the discrete wavelet transform (DWT) approach, and dimensionality decrease of the parameters by applying the principal component analysis (PCA) technique. For the usage of the order of MRI pictures, a kernel support vector machine (KSVM) was utilized.

Mahmoud Khaled Abd-Ellah et al. (2018) proposed a two-phase multi-model automatic diagnosis system. This research addresses the development of computer-aided diagnosis (CAD) system for tumor detection and magnetic resonance images (MRIs) were used for locating the tumor. The first phase is of tumor detection where the system consolidates a CNN for include extraction and feature classification is finished with an error correcting output codes support vector machine (ECOC-SVM). In the second phase,

a five-layer completely developed region-based convolutional neural network (RCNN) is employed to locate the position of the tumor. Rączkowski et al. (2019) implemented accurate, reliable, and active (ARA) framework with CNN, which is a Bayesian deep learning model, called ARA-CNN for histopathological image classification.

Isensee et al. (2017) present a modified algorithm of segmentation in the form of CNN, to obtain best results of segmentation of brain tumor. The system design is based on the popular U-Net which is trained on the BraTS 2017 validation set and modifications are done with caution. This network architecture presented potential scores. The resulting mean dice coefficients were 0.858 for whole tumor (WT), 0.775 for tumor core (TC), and 0.647 for the contrast enhancing tumor (ET). Dong et al. (2017) proposed a completely programmed technique using U-Net-based deep convolutional networks for performing brain tumor segmentation. The creators evaluated their technique utilizing multimodal brain tumor image segmentation (BraTS 2015) datasets which involved information of various numbers of cases for high-grade brain tumor and low-grade tumor. This method provided with promising segmentation of brain tumor proficiently. Clinical data was utilized to develop a way to segment three sub-regions of glioma by Tuan (2018). Their proposed strategy aims at producing more images using bit-plane which assembles the most and least significant bits. Thereafter, U-Net is implemented with numerous kernels, to section the entirety of glioma areas which provides progressively precise outcomes. They assessed this method with the BraTS challenge database of 2018 (Menze et al., 2015), and the same process accomplishes efficacy of 82, 68, and 70% dice scores on validation data.

For the purpose of performing easy automatic tumor detection and segmentation, Rajan and Sundar (2019) proposed a fresh hybrid energy-efficient technique called K-means clustering, unified with fuzzy C-means (KMFCM) and active contour by level set, for effectively performing tumor segmentation, detection of edges, and intensity improvement.

The BraTS Dataset 2018 provided by The Center for Biomedical Image Computing and Analytics (CBICA) essentially is the MRI scans of Glioblastoma (HGG) and Lower Grade Glioma (LGG), with a clinically affirmed prognosis. The CBICA provides a separate set of 66 MRI scans without ground truth, which was used for testing by Menze et al. (2015); 2017), Bakas et al. (2018).

Zikic et al. (2014) utilized max-pooling and separated two convolutional layers of a shallow CNN with stride 3, and in this way utilized one fully connected (FC) layer and a softmax layer. This research shows that CNNs are more promising than machine learning algorithms such as randomized forests (RF). For the brain segmentation task, Urban et al. (2014) used the 3D CNN. Voxel-wise classifier

is used on the data, and the cubes of voxels are fed into the classifier, which helps in the prediction of voxel(s) in the center of the cube. Pereira et al. (2016) explored small 3×3 kernels while using automatic segmentation method on CNN. On stacking up multiple convolutional layers, the author examined that as the depth increased, the extracted features became abstract. The authors also experimented with the use of the larger kernels/filter and concluded that even after using a larger number of feature maps, shallow architectures exhibited lower performance. Cireşan et al. (2012) made use of the deep neural network as the pixel classifier to perform the segmentation of neuronal structures shown as electron microscopy (EM) images automatically. The author uses two-dimensional CNN as a pixel classifier on every slice in the sliding window fashion to segment an entire stack of $512 \times 512 \times 30$ electron microscopy images. This approach causes redundancy in the computation leading to time inefficiency and the neural network cannot learn the global features in it.

The design of the U-Net is inspired from the fully connected layers mentioned in Long et al. (2015). A fully connected layer learns features from all the combinations of the features of the yield of the previous convolution or pooling layer. This fully connected layer flattens this output into a single vector of values, each representing a probability of a class. Image Segmentation involves classification of each image pixel of the input and later creating a map of all identified object areas on the image. Long et al. (2015) later projected the replacement of these detected areas with convolutions using 1×1 sized filter. Converting the fully connected layer into an equivalent convolution layer facilitates the usage of the neural net as a convolution to image larger than the original training image and spatially dense output can be obtained. With the purpose of increasing the receptive field and avoiding the input size reduction and information loss from the boundaries of the image, they used padding in the CNN.

Build upon the "fully convolution network" anticipated by Long et al. (2015), Ronneberger et al. (2015) attempts using a 2D completely convolutional neural network for segmentation of stacks of EM pictures. The network consists of a "contracting" or convolution stage, where the input size decreases, and the count of feature maps increases and an "expansive" or deconvolution stage in which the reverse process of the convolution happens. In the up-sampling part, the architecture gains U shape because of numerous feature channels, which allow the propagation of background information to higher resolution layers through the network, due to which the expansive path is to some extent conforming to the contracting path, altogether the network has 23 convolutional layers. In the last layer, the desired number of classes were achieved mapping the feature vector and is performed using a 1X1 convolution. The extension of the 2D network to 3D network is done in paper (Çiçek et al. 2016; Milletari et al. 2016).

3 Proposed Method

3.1 Architecture

Our architecture consists of the contracting and growing stages found in different works utilizing similar networks (Çiçek et al. 2016; Milletari et al. 2016; Ronneberger et al. 2015), where long skip connections are made between feature maps from the principle stage and feature maps from the consequent stage. Concatenation is the method that has been used frequently for concatenating feature maps in many different works. Inspired by Long et al. (2015), where the authors perform combination of layers of the feature hierarchy and enhance the spatial precision of the output to connect coarseness of final segmentation, segmentations created at different stages in the network are combined in our approach. Normalizing over every channel in every training sample, for instance, normalization is put in practice at test time unlike batch normalization which normalizes across input features and does not apply due to interdependency of small batches at the time of testing. We have implemented multi-class adaptation of dice-loss (Milletari et al. 2016) (Fig. 1).
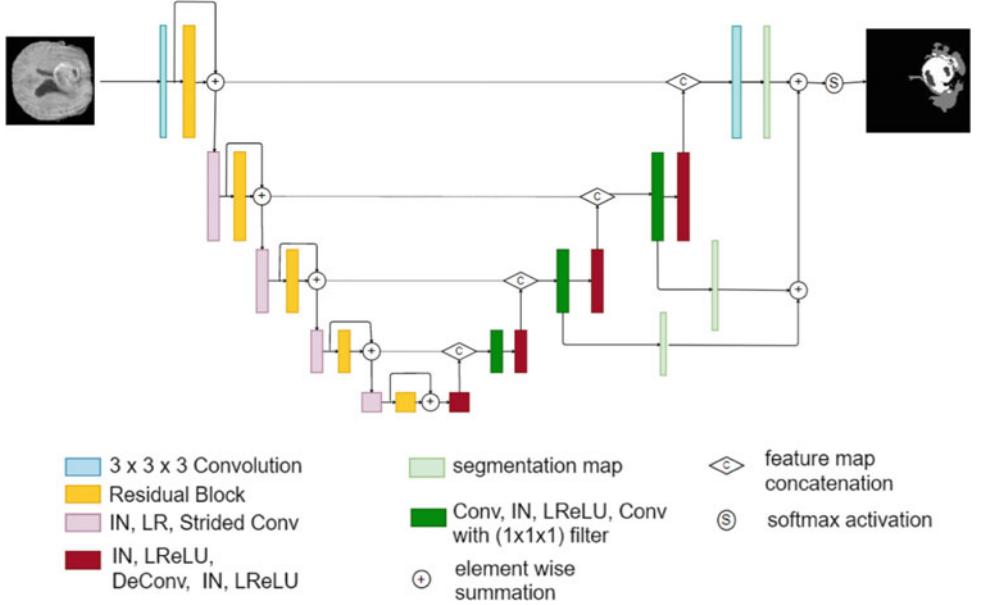
3.2 Data

In this paper, our emphasis is on brain tumor segmentation task with DNN. For the same task, we are utilizing the BraTS 2018 dataset for the purpose of training and assessment. The dataset includes multimodal MRI sweeps of HGG and LGG obtained in differing organization with distinct conventions. These MRI scans contain native T1, post-contrast T1-weighted, T2-weighted, and T2 fluid attenuated inversion recovery (FLAIR) volumes and are co-enrolled to a similar structural format interjected to a similar resolution (1 mm) and are skull stripped. One to four raters performed manual annotation on these MRI scans and even acceptance was achieved from veteran radiologists. Various segmentation labels were used to designate different glioma sub-regions such as TC, ET, and WT. Altogether, the dataset incorporates 285 MRIs for training (210 HGG and 75 LGG images), 67 validations and 192 testing MRIs.

3.3 Preprocessing

The BraTS challenge dataset is now given preprocessed which included skull stripping, and the data were co-enlisted

Fig. 1 Network Architecture. Our architecture, which is U-Net influenced, consists of the contracting pathways (on the left-hand side), where the features are extracted and input size reduces, and an expanding pathway (on the right-hand side) where the up-sampling is performed so as to scale up the activation size to the same image size. The skip connections connect feature maps from the principal stage to feature maps in the consequent stage

and re-sampled to a resolution of 1 mm × 1 mm × 1 mm. The dimensions of every volume were 240 × 240 × 155. The data is first preprocessed by image-wise normalization, and correction is performed on it. Bias field correction is performed to reduce the signal of certain modalities, caused by the magnetic fields while collecting the data. Then, all the nonzero-pixel, foreground locations from all the images are combined. The resultant image still has blank space background in every direction. To tackle this, the image is cropped and the smallest image that still contains foreground is obtained. Then using the same cropping values all the images in the input data are cropped. Later, those images are re-sliced to match the input shape of (128, 128, 128).

3.4 Training

The architecture was trained with the patches of the input data due to computational limitations. After mining 3D voxels with size 64 × 64 × 64 from the training data, they are provided as an input to the model, with the batch size of 2. The model was trained for 300 training steps, with each step involving iterating over 100 batches on NVIDIA GTX 1080ti GPU. The preliminary rate of learning was set to 5×10^{-4}, and ADAM optimizer was used. We made use of the dice-loss function to cope up with the issue of class imbalance,

$$L_{dc} = \frac{-2}{|I|} \sum_{i \in I} \frac{\sum_j a_j^i b_j^i}{\sum_j a_j^i + \sum_j b_j^i} \qquad (1)$$

where a is the prediction, i.e., network's softmax output and b being the ground truth. Both a and b have shape j by

c where j is the training patch's pixel quantity and $i \in I$, being the classes, so the scoring is repeated over all the classes and averaged (Fig. 2).

We additionally use augmentation techniques, for example, gamma correction augmentation and mirroring with random notations, scaling, elastic deformations, to avoid overfitting for images (Fig. 3).

4 Result Analysis

Our network is trained and assessed on the dataset of BraTS 2018 via fivefold cross-validation. Utilizing the BraTS 2018 validation set, we accomplished dice scores for WT = 0.89, TC = 0.79, and ET = 0.73 (Fig. 4).

It was observed that the revised approach introduced by an amalgamation of several segmentation maps generated at diverse scales implied in this paper gave better results than the native U-Net architecture and other conventional neural network approaches such as deep neural networks (DNN), fully convolution neural network (FCNN), and 3D CNN combined with random fields (Table 1).

All T1, T1C, T2, FLAIR images are skull stripped. Results in the T1 images highlight fat tissue within the brain and fat and fluid within the brain is highlighted in T2 images. FLAIR images appear like T2 weighted images where gray matter appears brighter than white matter. The abnormal glioblastoma in FLAIR weighted image are represented by a high signal (brighter/ white portion in the image) and similarly in T1 weighted image is represented by a low signal (darker portion in image). The ground truth is manually segmented, and the output through model is segmented with large and fine-grained regions accurately (Figs. 5, 6, 7, 8, 9 and 10).

Fig. 2 Block diagram of proposed method
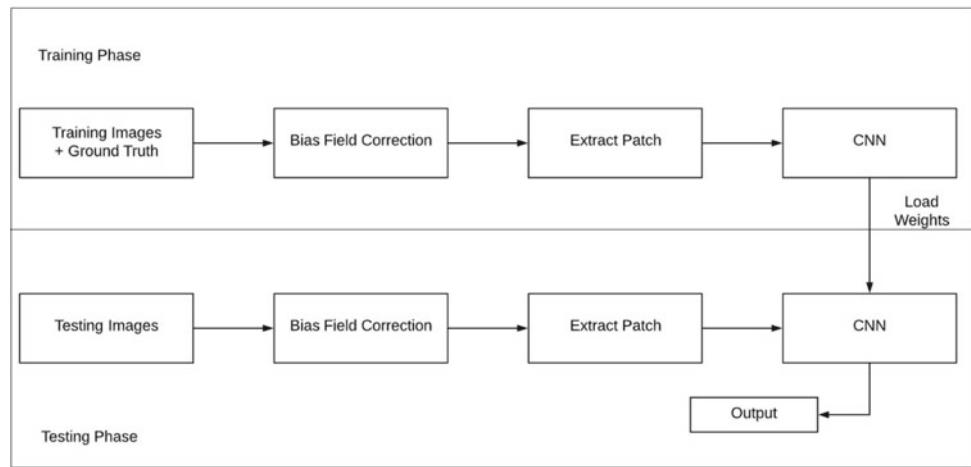
Fig. 3 Loss graph
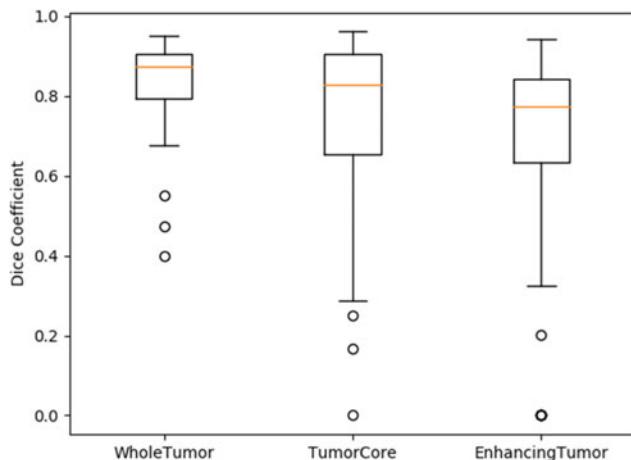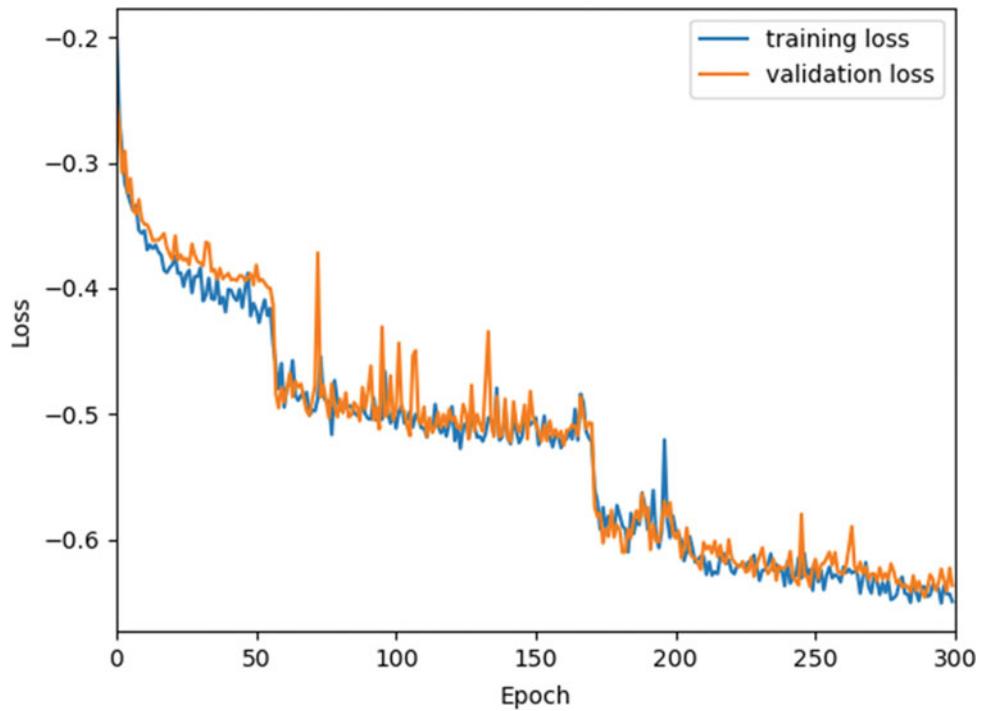
Fig. 4 Dice Coefficient for brain tumor segmentation

5 Discussion

Thus, to putting everything in a nutshell, our paper centers around the segmentation task and post going through different model approaches to the segmentation of the medical images, we trained the BraTS 2018 data on the Modified U-Net Architecture (Tuan 2018) which includes residual weights, deep supervision, and equally weighted dice coefficient. Using this architecture, we were able to achieve more accuracy than the original U-Net Architecture. We first normalized the image to rule out bias fields/gain fields, after which the data is alienated into 85% of training and 25% validation. The training data was fed into the architecture.

Table 1 Comparison of dice coefficients among various brain tumor segmentation methodologies

	Dice coefficient			
	Whole	Tumor core	Tumor enhancing	BraTS dataset
Modified U-Net	**0.89**	**0.79**	**0.73**	**2018**
S3D-UNet (Chen et al. 2018)	0.88	0.80	0.73	2018
NVDLMED (Myronenko 2018)	0.88	0.81	0.76	2018
EMMA (Kamnitsas et al. 2017b)	0.90	0.79	0.73	2017
U-Net (Dong et al. 2017)	0.86	0.86	0.65	2015

Note: The headings of the table and the results of our proposed architecture are specified in bold.
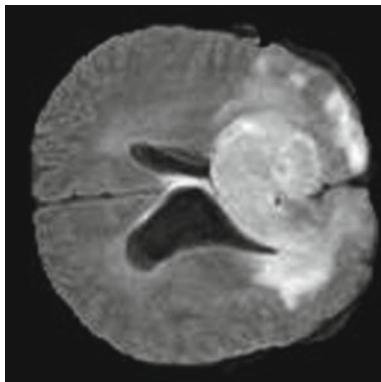
Fig. 5 FLAIR
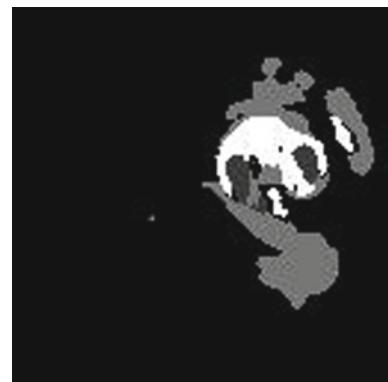
Fig. 8 Prediction
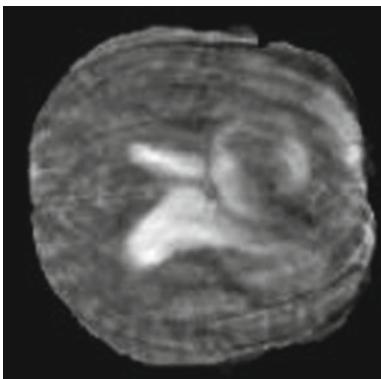
Fig. 6 T2
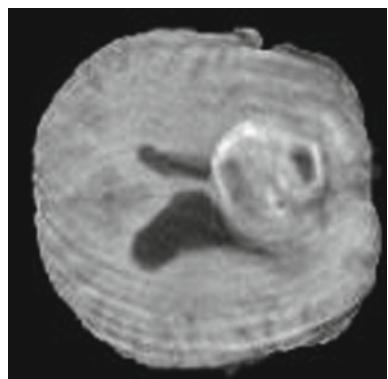
Fig. 9 T1CE
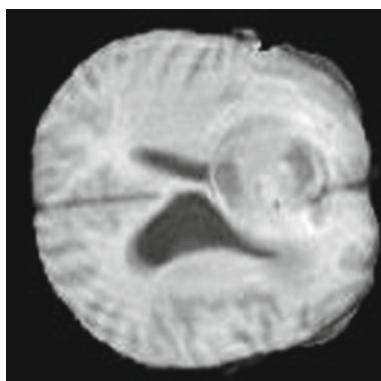
Fig. 7 T1
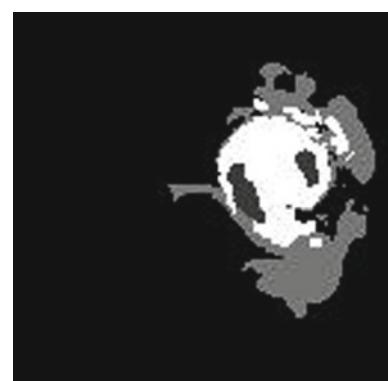
Fig. 10 Ground truth

We applied various data augmentation methods, for example, random notations, random scaling, and random mirroring. With the above-mentioned methods, we achieved a dice coefficient of 0.89 (80.3% average).

In order to make the model more accurate, we wish to train the model on more data with more variation in the architecture and data augmentation for better results. We can also append the pipeline with classifiers such as efficient net to make the result more accurate and robust.

References

Abd-Ellah, M. K., Awad, A. I., Khalaf, A. A., & Hamed, H. F. (2016, September). Classification of brain tumor MRIs using a kernel support vector machine. In *International Conference on Well-Being in the Information Society* (pp. 151–160). Cham: Springer.

Abd-Ellah, M. K., Awad, A. I., Khalaf, A. A., & Hamed, H. F. (2018). Two-phase multi-model automatic brain tumour diagnosis system from magnetic resonance images using convolutional neural networks. *EURASIP Journal on Image and Video Processing, 2018*(1), 97.

Bakas, S., Akbari, H., Sotiras, A., Bilello, M., Rozycki, M., Kirby, J. S., & Davatzikos, C. (2017). Advancing the cancer genome atlas glioma MRI collections with expert segmentation labels and radiomic features. *Scientific Data, 4,* 170117.

Bakas, S., Reyes, M., Jakab, A., Bauer, S., Rempfler, M., Crimi, A., & Prastawa, M. (2018). Identifying the best machine learning algorithms for brain tumor segmentation, progression assessment, and overall survival prediction in the BRATS challenge. arXiv:1811.02629

Chen, W., Liu, B., Peng, S., Sun, J., & Qiao, X. (2018, September). S3D-UNet: Separable 3D U-Net for brain tumor segmentation. In *International MICCAI Brainlesion Workshop* (pp. 358–368). Cham: Springer.

Çiçek, Ö., Abdulkadir, A., Lienkamp, S. S., Brox, T., & Ronneberger, O. (2016, October). 3D U-Net: Learning dense volumetric segmentation from sparse annotation. In *International Conference on Medical Image Computing and Computer-assisted Intervention* (pp. 424–432). Cham: Springer.

Ciresan, D., Giusti, A., Gambardella, L. M., & Schmidhuber, J. (2012). Deep neural networks segment neuronal membranes in electron microscopy images. In *Advances in neural information processing systems* (pp. 2843–2851).

Dong, H., Yang, G., Liu, F., Mo, Y., & Guo, Y. (2017, July). Automatic brain tumor detection and segmentation using U-Net based fully convolutional networks. In *Annual Conference on Medical Image Understanding and Analysis* (pp. 506–517). Cham: Springer.

El-Dahshan, E. S. A., Mohsen, H. M., Revett, K., & Salem, A. B. M. (2014). Computer-aided diagnosis of human brain tumor through MRI: A survey and a new algorithm. *Expert Systems with Applications, 41*(11), 5526–5545.

Havaei, M., Davy, A., Warde-Farley, D., Biard, A., Courville, A., Bengio, Y., & Larochelle, H. (2017). Brain tumor segmentation with deep neural networks. *Medical Image Analysis, 35,* 18–31.

Isensee, F., Kickingereder, P., Wick, W., Bendszus, M., & Maier-Hein, K. H. (2017, September). Brain tumor segmentation and radiomics survival prediction: Contribution to the brats 2017 challenge. In *International MICCAI Brainlesion Workshop* (pp. 287–297). Cham: Springer.

Kamnitsas, K., Bai, W., Ferrante, E., McDonagh, S., Sinclair, M., Pawlowski, N., & Glocker, B. (2017b, September). Ensembles of multiple models and architectures for robust brain tumour segmentation. In *International MICCAI Brainlesion Workshop* (pp. 450–462). Cham: Springer.

Kamnitsas, K., Ledig, C., Newcombe, V. F., Simpson, J. P., Kane, A. D., Menon, D. K., & Glocker, B. (2017a). Efficient multi-scale 3D CNN with fully connected CRF for accurate brain lesion segmentation. *Medical Image Analysis, 36,* 61–78.

Kayalibay, B., Jensen, G., & van der Smagt, P. (2017). CNN-based segmentation of medical imaging data. arXiv:1701.03056

Long, J., Shelhamer, E., & Darrell, T. (2015). Fully convolutional networks for semantic segmentation. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition* (pp. 3431–3440).

Menze, B. H., Jakab, A., Bauer, S., Kalpathy-Cramer, J., Farahani, K., Kirby, J., Burren, Y., Porz, N., Slotboom, J., Wiest, R., et al (2015). The multimodal brain tumor image segmentation benchmark (BRATS). *IEEE Transactions on Medical Imaging, 34*(10), 1993–2024.

Milletari, F., Navab, N., & Ahmadi, S. A. (2016, October). V-net: Fully convolutional neural networks for volumetric medical image segmentation. In *2016 Fourth International Conference on 3D Vision (3DV)* (pp. 565–571). IEEE.

Myronenko, A. (2018, September). 3D MRI brain tumor segmentation using autoencoder regularization. In *International MICCAI Brainlesion Workshop* (pp. 311–320). Cham: Springer.

Pereira, S., Pinto, A., Alves, V., & Silva, C. A. (2016). Brain tumor segmentation using convolutional neural networks in MRI images. *IEEE Transactions on Medical Imaging, 35*(5), 1240–1251.

Rączkowski, Ł, Możejko, M., Zambonelli, J., & Szczurek, E. (2019). ARA: Accurate, reliable and active histopathological image classification framework with Bayesian deep learning. *Scientific Reports, 9*(1), 1–12.

Rajan, P. G., & Sundar, C. (2019). Brain tumor detection and segmentation by intensity adjustment. *Journal of Medical Systems, 43*(8), 282.

Ronneberger, O., Fischer, P., & Brox, T. (2015, October). U-net: Convolutional networks for biomedical image segmentation. In *International Conference on Medical Image Computing and Computer-Assisted Intervention* (pp. 234–241). Cham: Springer.

Singh, P. K., Kar, A. K., Singh, Y., Kolekar, M. H., & Tanwar, S. (Eds.). (2019a). In *Proceedings of ICRIC 2019: Recent Innovations in Computing* (Vol. 597). Springer.

Singh, P. K., Panigrahi, B. K., Suryadevara, N. K., Sharma, S. K., & Singh, A. P. (Eds.). (2019b). In *Proceedings of ICETIT 2019: Emerging Trends in Information Technology* (Vol. 605). Springer.

Tuan, T. A. (2018, September). Brain tumor segmentation using bit-plane and UNET. In *International MICCAI Brainlesion Workshop* (pp. 466–475). Cham: Springer.

Urban, G., Bendszus, M., Hamprecht, F., & Kleesiek, J. (2014). Multi-modal brain tumor segmentation using deep convolutional neural networks. In *MICCAI BraTS (Brain Tumor Segmentation) Challenge. Proceedings, Winning Contribution* (pp. 31–35).

Zhao, X., Wu, Y., Song, G., Li, Z., Zhang, Y., & Fan, Y. (2018). A deep learning model integrating FCNNs and CRFs for brain tumor segmentation. *Medical Image Analysis, 43,* 98–111.

Zikic, D., Ioannou, Y., Brown, M., & Criminisi, A. (2014). Segmentation of brain tumor tissues with convolutional neural networks. In *Proceedings MICCAI-BRATS* (pp. 36–39).

Performance Comparison for E-Learning and Tools in Twenty-First Century with Legacy System Using Classification Approach

Akhilesh Kumar Sharma, Maheshchandra Babu Jampala, and Tina Shivnani

Abstract

In recent times, Covid-19 has changed the dimensions of the educational industry. Universities across the global are focusing on the changing trends, technologies, and practices influencing the teaching and learning among teachers and students. This research paper mainly focuses on the emerging technologies in the Covid-19 providing about the real-time examples and insight the brief about the transformational shift how the universities are architect the various ecosystems both for instructors and learners. The relevant dataset of exam, quizzes, etc., from heterogeneous department were utilized for proposed methodology. The research work also includes the implications and challenges faced by the universities while implementing these technologies. The accuracy obtained was higher in the twenty-first century e-learning tools and lesser in all other cases as well as for the legacy system. The performance was observed, and various inferences were discussed with the effective delivery of the teaching material and their issues.

Keywords

Machine learning • Random forest • SVM • Emerging technologies • Changing educational dimensions • NB • KNN • Covid-19 • Pandemic • E-learning

A. K. Sharma (✉) · M. B. Jampala · T. Shivnani
SCIT, Manipal University Jaipur, Jaipur, Rajasthan, India
e-mail: akhileshshm@gmail.com

M. B. Jampala
e-mail: mahesh.jampala@jaipur.manipal.edu

T. Shivnani
e-mail: teenashivnani13@gmail.com

1 Introduction

1.1 Adaptive Learning Technologies

Over the years, the teaching pedagogy is mainly teacher centric. Technology has changed into the student-centric approach of learning. The present concept of the learning includes adaptive learning technologies. Today, many universities have the adoptive systems to assist students in the learning activities. These technologies help the instructors to evolve as the mentors and leaders of the classroom teaching from the content delivery in the form of the lectures. These technologies also help students to access only to those resources which are directly available to them. Adaptive technologies also act as the supporting tool for the flipping classroom. Using the adaptive system, students can easily learn using Bloom's taxonomy using the remembering and understanding aspects. Then by using the flipped classroom technology, students can easily focus on the remaining levels of Bloom's taxonomy. This helps instructors to effectively organize the activities in the active classroom processes.

1.2 Open Educational Resources

The UNESCO defines that educational resources (OER) are learning, teaching, and using various materials which are openly available for students and teachers. OER includes presentations, videos, lessons, full text materials, articles, podcasts, and other learning materials. These materials are copyrighted in the various open sources and then are published in the various public domains. The major purposes of OER are retain, reuse, remix, revise, and redistribute. Retain includes where the learning materials can be retained by the students anytime and anywhere. Reuse includes the content can be modified by teachers and students. Remix includes the generation of new ideas using the existing content. Revise includes modification and alteration of the content

due to specific needs and redistributing includes content which can refer, shared in any format. The major advantages of the OER are first, assurance of the quality; while accessing the OER educators can collaboratively to improve the quality of the materials, second, development of the career; educators can access the new ideas and enhancements of the careers.

Based on these Rs, many universities are adapting various strategies to implement the OERs in the curriculum. Various incubators are using open education resources to bring instructors and students for developing the competencies in teaching pedagogy. OER has improved collaboration among instructors and learners by hands-on workshops, curated readings, and cohort discussions.

1.3 Analytics in Education

Over the years, many universities have majorly focused on the implementing the various strategies for promoting the better practices in teaching–learning modules. Gradually, universities are shifting toward the measurements, collection of data, analyzing the students' progress using the learning analytics tools. Learning analytics approaches for better understanding and support learning systems. Student analytics are been retrieved from the various learning management systems (LMS), customized university-level student information systems, institutional-level enterprise resource planning systems which includes financial records and research updates. As learning analytics becomes more important role for universities for strategic planning at institutions around the world. These include a range of practices which are including data privacy, equity, and ethical considerations.

Last 10 years, institutions have used analytics for functional support of the organisations which include enrollment, student management status to general student progress. Earlier, they are less used for assessing student learning outcomes. Present, many universities are focusing on the institutional accreditation, which is now being accompanied by analysis of student engagement and student performance data. The present shift of analytical technologies has redrafted vision of the global universities to achieve the student goals and policies.

The major advantages of the analytics are students can easily track and access the individual data and analyze the progress by themselves.

1.4 Machine Learning in Education

In the current era, the ML-based tools for analytics that can be applied and various predictive measures can be obtained

by using this. The various predictive analytics that can be done are related to the examination, learning outcomes, etc. The amount of time the students spends over online learning can also be analyzed, and predictions can be made as how good enough the learning happens while the students learn over the Internet in live classes. Various algorithms help to improve the learning and analyze how to improve the learning. The performance-based methods can also be applied so as to increase the learning and to develop the e-learning strategies.

Challenges of emerging technologies with in the higher education.

Many of the technologies have the various challenges as many of the technologies are in the embryotic stages in the higher education. Many technologies still have two major problems: first, cost. These technologies have major cost-related problems which includes, designing of the curriculum, preparation of the content, and redesigning evaluation pattern, and finally, the biggest challenge is the privacy of the data, as it is available in the free of cost. As many technologies are widely changing the perspective, still major challenge persists that lack of sufficient, continuing professional development for understanding the usability among teachers. Another major challenge is to majority of the learning is focusing on the informal learning rather than formal learning using these technologies.

2 Literature Review

Avella et. al. mentioned and discussed the various aspects of the online teaching and learning in higher education (Avella et al., 2016). Rana et.al. discuss regarding the issues and challenges in e-learning (Rana & Lal, 2014).

Tjhin and Kuchma (2002) they have discussed the computer-based radius designing methods.

Kearns (2012) have focussed their studies to assess the student performance with respect to the challenges associated to get the effective practices in teaching and learning process.

Dabbagh and Bannan-Ritland (2005) they have found the various online learning concept and how to put these strategies in the form of application and how to achieve the great learning experience manjot Kaur (2013) also found that the various learning challenges in a blending approach (Chatti et al., 2012; Diettrich & Langley, 2007; Moubayed et al., 2018). By delivering high-quality instructional information to students around the world, MOOC (Sharma & Shrivastav 2020; Pietquin & Lopes, 2014; Woolf, et al. 2013; Xiong & Suen 2018) also provides an ultimate way to provide digital content in higher education environments (Daniel 2015; Sharma et al., 2015). A new research agenda focused on forecasting and describing student dropouts and

poor retention rates in MOOCs have arisen, despite the gaps between conventional learning paradigms and MOOCs. We give a description of the prediction phenomena of MOOC student dropouts where machine learning approaches have been used.

In addition, they highlight some strategies that are used to solve the issue of dropout provide an overview of the problems of prediction models and provide some useful perspectives and suggestions.

Daniel (2015), Sharma et al., (2015) Higher education institutions work in an extremely diverse and competitive environment. It examines current issues facing higher education institutions around the world and discusses big data's ability to overcome these issues. In the sense of higher education, the paper also discusses a range of benefits and problems associated with integrating big data. It ends by developing potential strategies for growth and execution.

3 Methodology

The methodology section Fig. 1 describes the data processing performed on the data collected from the attendance, exam, quiz, and results and online and offline comparative data for the study. The ML algorithms discussed were used to perform the study, and Tables 1 and 2 show the error estimates and the performance ratio obtained on that data after applying the algorithms. The performance calculation was performed, and result obtained was studied after applying various algorithms.

Hence, the analysis indicative is for the better delivery and enhanced interactive learning in the twenty-first century e-learning environment. That is also inclusive of the dynamic availability of the participant's w.r.t. timing of the lectures as well. Figures 1 and 2 show the resultant performance chart. Now the various big MNCs also focusing on work from home life-time opportunities for their employees at the convenience at their doorstep. It will certainly boost the economy of the country.

3.1 Dataset

The dataset includes the records fetched from the university exams from various departments (compiled by individual faculty members). The dataset collected from the faculties while preparing the results during Covid-19 and before the pandemic time as well. The dataset then used for preprocessing and the available data outliers, and other errors were removed and data filtering were also applied to remove and cut short the irrelevant data.

Total of 1400 records were used for training the model, and 670 records were used to test the model. The data feed
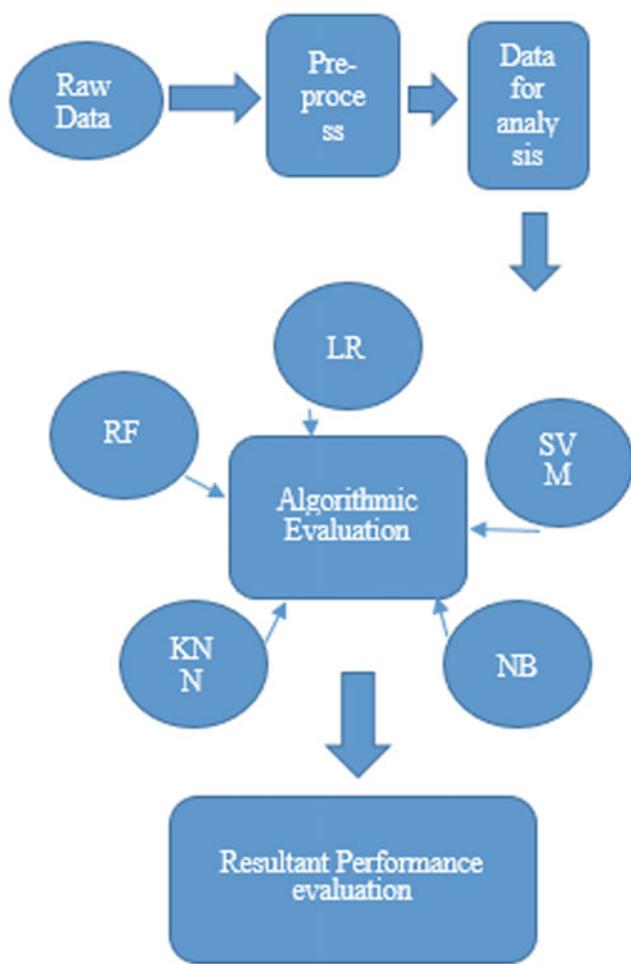
Fig. 1 Detailed methodology

into the system and the algorithms used to test the results on these dataset. The algorithms were used like linear regression, support vector machine, K-nearest neighbor, naïve Bayes, and random forest. The performance evaluated for these algorithms and discussed separately in the result section of this research article at the results and discussion section. Accuracy obtained for the random forest was the highest while compared to all the other algorithms used.

4 Results

4.1 E-Learning Twenty-First Century

As shown in Fig. 3 and Table 1, the dataset used was fed into the system and the algorithms were applied as per our model, and the results were studied. The performance was calculated using the estimated confusion matrix and studied. The results were very promising, and the accuracy levels were compared from which it was inferred that the random forest was performed best with the accuracy of 95% which

Table 1 Performance evaluation on the e-learning exam dataset

S. No.	Algorithm used	Error rates (%)	Accuracy (%)
1	Linear regression	43	65
2	SVM	30	78
3	NB	35	75
4	KNN	50	60
5	Random forest	20	95

Table 2 Performance evaluation on the Legacy exam dataset

S. No.	Algorithm used	Error rates	Accuracy
1	Linear regression	55	45
2	SVM	40	65
3	NB	35	55
4	KNN	60	40
5	Random forest	15	85

Fig. 2 Performance chart

Fig. 3 Performance chart

was way better than the legacy systems of 85%. Thus, these results were utilized to conclude that the learning tools usages and benefits in these era of the Covid'-19 situation and the normal one.

4.2 Legacy Systems

See Fig. 3 and Table 2.

5 Conclusion

This research deals with the latest analytics methods in e-learning and also discusses the data mining-related various methods, techniques, algorithms including prediction and discovery related to the models based on the curriculum development behavior of learners and the student learning outcomes.

This research work also deals with the instructor performance improvement-related data tracking activities as well as the issues related to the teaching and learning. It also discusses lake of connections between learner and the instructor to improve the teaching learning process.

6 Future Work

The future work would be based on the learning engagement with the latest tools of the modern era, and their impact on the learners and the trainers/educators can be studied, and various studies can be performed and results can be measured and studied. If possible some new suggestions and improvements can be proposed in order to improve upon the teaching learning activities so that it can be further enhanced.

References

Ahad, M. A, Tripathi, G., Agarwal, P. (2018). Learning analytics for IoE based educational model using deep learning techniques: architecture, challenges and applications. *Smart Learning Environments 5*(1), 1–16.

Amit K. S., Sandeep C., & Devesh K. S., Supervised rainfall learning model using machine learning algorithms. In *Intelligent systems and Computing book series* (Vol. 723, pp. 275–283). Springer.

Avella, J. T., Kebritchi, M., Nunn, S. G., & Kanai, T. (2016). Learning analytics methods, benefits, and challenges in higher education: A systematic literature review. *Online Learning Consortium, 20*(2), 13–29.

Chatti, M. A., et al. (2012). A reference model for learning analytics. *International Journal of Technology Enhanced Learning 4.5–6*, 318–331.

Dabbagh, N., & Bannan-Ritland, B. (2005). *Online learning: Concepts, strategies, and application*. Upper Saddle River, NJ: Pearson/Merrill/Prentice Hall.

Dalipi, F., Imran, A. S., & Kastrati, Z. (2018). MOOC dropout prediction using machine learning techniques: Review and research challenges. In *2018 IEEE Global Engineering Education Conference (EDUCON)*. IEEE.

Daniel, B. (2015). Big Data and analytics in higher education: Opportunities and challenges. *British Journal of Educational Technology, 46*(5), 904–920.

Dietterich, T. G., & Langley, P. (2007). Machine learning for cognitive networks: Technology assessment and research challenges. *Cognitive Networks*.

Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *International Journal of Technology Enhanced Learning, 4*(5–6), 304–317.

Kaur, M. (2013). Blended learning-its challenges and future. *Procedia-Social and Behavioral Sciences, 93,* 612–617.

Kearns, L. R. Student assessment in online learning: Challenges and effective practices. *Journal of Online Learning and Teaching, 8*(3), 198.

Marques, L. S., von Wangenheim, C. G., & Hauck, G. C. R. (2020). Teaching machine learning in school: A systematic mapping of the state of the art. *Informatics in Education, 19*(2), 283–321.

Moubayed, A., et al. (2018). E-learning: Challenges and research opportunities using machine learning & data analytics. *IEEE Access 6,* 39117–39138.

Pietquin, O., & Lopes, M. (2014). Machine learning for interactive systems: Challenges and future trends.

Rana, H., & Lal, M. (2014). E-learning: Issues and challenges. *International Journal of Computer Applications, 97*(5).

Sharma, A. K., et al. (2015). Categorization of ICMR Using feature extraction strategy and MIR with ensemble learning. *Procedia Computer Science, 57*(201), 686–694.

Sharma A. K., & Shrivastav D. (2020). Statistical approach to detect Alzheimer's disease and autism spectrum-related neurological disorder using machine learning. In *Proceedings of SmartCom 2020. Smart Innovation, Systems and Technologies* (Vol. 182). Springer.

Shi, X., et al. Challenges, best practices and pitfalls in evaluating results of online controlled experiments. In *Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*.

Tjhin, T. N., & Kuchma, D. A. (2002). Computer-based tools for design by strut-and-tie method: Advances and challenges. *Structural Journal, 99*(5), 586–594.

Wang, L., et al. Learning to represent student knowledge on programming exercises using deep learning." international educational data mining society.

Woolf, B. P., et al. (2013). AI grand challenges for education. *AI Magazine, 34*(4), 66–84.

Xiong, Y., & Suen, H. K. (2018). Assessment approaches in massive open online courses: Possibilities, challenges and future directions. *International Review of Education, 64*(2), 241–263.

Effectuation and Future of Provenance in Various Fields

Geetika Bhardwaj and R. K. Bawa

Abstract

The escalating magnitude of data and its availability has raised a question on the trustworthiness of data. The solution to this problem lies in an effective discipline of study known as provenance. Data provenance provides the history and description of data to authenticate the genuineness and reliability of data, by attaching some extra information along with the original data which gives a description about its origin as well as transformation. The applications of provenance have stepped into the various arenas of practical fields. It has the potential to become a metrics of measuring data reliability, data quality, and data ownership and has gradually become one of the key aspects of various domains, for instance, business, science, and information technology. This paper will discuss the versatility of provenance and its applications in latest fields of research.

Keywords

Data provenance • Data ownership • Data reliability • Data authenticity

1 Introduction

The word 'provenance' comes from the French word 'provenir' which means lineage or origin or history. Data provenance refers to the description of the origin, creation, and propagation process of data. Data provenance is the lineage and derivation of the data. It stores ownership and process history about data objects (Imran et al., 2014). The authenticity of the information on the Web or in organizations in the form of integrated data coming from multiple sources is always questionable as there is a possibility of data being collected from unreliable sources or wrong computations performed on the data giving erroneous data as results. Data provenance is the information about the origin and creation process of data. This data is of great use for debugging of the data and transformations, inspecting, evaluation of the data quality and trust in data, modeling authenticity, and to exercise control over the access of derived data (Glavic, 2014). Provenance information is used to infer the data semantics and trace back the transformations to the input data so as to trace the errors if any and understand the transformations and the input data which lead to the output data ensuring the reliability and correctness of the resultant data.

The provenance has a different context for origin and creation process of data. In terms of relational databases, the source is relations, tuples, and the values of attributes, and transformations are the SQL queries and various other SQL constructs like functions/procedures implemented on various data items in relations.

Given a query Q on a relational database D, on the execution of query Q, it returns the resultant set R. The provenance can be in two contexts:-

Data provenance-It conveys which tuples in D contributed in deriving the resultant set R.

Transformation provenance-It conveys which transformations have contributed in generating the resultant set R.

Provenance information can be used to ensure the genuineness of data and its trustworthiness, to visualize the relationship between tuples in different relations, or the derivation of certain results, or to trace errors in transformed data back to its origins.

Cheney (2007) formalized three main notions of database provenance which are as follows:

- Why provenance: It apprises about the witnesses to a query. A witness is that portion of the database records which ensures the existence of a given record in the output.

G. Bhardwaj (✉) · R. K. Bawa
Punjabi University, Patiala, India
e-mail: inbox.geetika@gmail.com

- How provenance: It describes how in the output of a given query tuple/stuples are derived.
- Where provenance: It shares information about the particular location from where data is taken.

Provenance computation determines the process of recording the provenance. It can be done either during the execution of the transformation or on demand as per the request of the user.

2 Applications of Provenance in Information Technology

The escalation in the number of technological devices containing crucial and private data of people demands for more accountability and transparency of data. Decision provenance makes use of provenance methods which furnishes information about the series of inputs and the flow on effects from decisions and the steps taken in design and run time stages of the systems (Singh et al., 2019).

There are many sub-categories of information technology where provenance is applicable and are discussed as follows:-

Social Networking Applications Determining patterns and defining relationships can be done by using the information aggregated from blogs, social bookmarking tools, and social networking sites. The monitoring of provenance of a user's comments, likes, and tagging behavior can help to comprehend his behavior, choices, and interaction with the virtual world.

Sensor Networking Applications Sensors collect data continuously, and the sensor data is being continuously stored in the centralized databases. Any wrong readings by sensors can lead to faulty compiled data. Data provenance plays an important role to handle inaccurate or incomplete data (Patni, 2010). Sensor provenance management system as proposed by Harshal.et.al captures time-related information and location-related information and is stored in the Virtuoso RDF store. Virtuoso RDF is an open-source triple store provided by OpenLink software (https://www.openlinksw.com).

Relational Databases Applications The databases generally stores the data in the form of tuples and attributes. The idea of provenance has devised new relational database systems which store provenance in the relational tables as a separate attribute or systems which does not store provenance as it can be generated as a result of querying provenance.

Cloud-Based Applications Many cloud-based architectures are designed which support provenance capture, storage, and analysis. These frameworks are highly useful in gathering provenance information and continuously acquire and monitor the provenance data for real time applications.

Big Data Applications The workflows which process Big Data need the execution of high-velocity data in a distributed fashion which makes the tracking and integration of provenance in a centralized way. Big Data provenance is often required to be recorded and fetched in a distributed environment (Wang et al., 2516).

Data Mining Applications Provenance information acts as a metadata for various data mining processes. PBWA use it to recognize relevant operation path and intermediate results which gets affected by hypothetical business contexts. The mining results are refreshed by partially rerunning the affected portions. The provenance can capacitate the translation of the generic concepts of data mining.

Data Visualization Applications A new system has been proposed which helps the crime analysts in uncertainty aware decision making. The basis for integrating analysis, user, and uncertainty information is data and analytic provenance techniques. An innovative approach in handling uncertainties and ensuring that accurate estimates of these uncertainties through data provenance techniques are conveyed (Stoffel et al., 2015).

The potential of provenance is being put to use in various research areas, and with the advent of new branches of study and new environments, the use of provenance has grown extensively. The versatility of provenance has been proved time and again by its efficient use in the upcoming fields. Lately, it is being used in Semantic Web services to give information about the creation, publication, and access of resources.

The World Wide Web Consortium has come up with a communication protocol known as Prov-AQ (Provenance Access and Query which aims at the representation and sharing of provenance information about resources in a standardized fashion. The incorporation of Semantics into Web-based services has led to the empowerment of agents in accumulation, discovery, and reuse of Web services and the information that they hold. The inclusion of provenance information is expected to bolster the trust on the Web and enhances the reuse of information and its discovery while deciding the services to be allocated in each application (Ochoa et al., 2020).

3 Provenance Architectures

There are certain provenance architectures which have been fabricated from scratch with specific goals in mind catering the needs of different types of data and its environment where they have been put to practical implementation and gave successful results. Some of the major architectures are as follows:-

3.1 PROV-DM

An all-inclusive data model for provenance which permits provenance to be modeled, serialized, shared, retrieved, converted, and reasoned over by using a set of specifications is known as prov family of documents. It has made the application-specific and domain-specific representations of provenance to be converted into a data model and interchanged between systems (https://www.w3.org/TR/prov-dm/).

3.2 CloudPROV

A framework used to integrate, model, and monitor provenance in cloud architecture with the aim to accumulate provenance information in such a manner that it can be used for real-time monitoring and for root cause analysis. It makes use of open APIs which allows standalone organizations that can create applications which may share and integrate provenance data (Hammad et al., 2014).

3.3 cPROV

A policy language (cProvl) and model (cProv) based on provenance provides basic essential tools for consolidation and creation of services which can create and utilize provenance data for provenance-based compliance control which is executed on a XACML engine (Ali et al., 2014).

3.4 HadoopPROV

HadoopPROV is an updated version of Hadoop which aims at capturing provenance and its analysis in MapReduce jobs. The tracking of provenance is treated individually in map and reduce phases and a deliberate delay in creating provenance graphs to the query stage. Both these steps helped in reduction of provenance capture overheads (Akoush et al., 2013).

3.5 GProM

An architecture and prototype implementation for a generic provenance database middleware (GProM) is based on the concept of query rewrites, which are applied to an algebraic graph representation of database operations. The system supports a wide range of provenance types and representations for queries, updates, transactions, and operations spanning multiple transactions (Arab et al., 2014).

3.6 CF-PROV

An architecture which is rich in content and is dedicatedly used in scientific workflows (SWF). The benefit of this model is that its pictorial representation of provenance in the form of graphs and formal expressions has decreased the programming overhead and added to its multiple uses (Qi et al., 2019).

3.7 BLINKER

It is an extensible framework based on standard provenance model specifications and blockchain technology for capturing, storing, exploring, and analyzing software provenance data (Jagadeesh, 2019).

Various architectures designed and used to cater to the needs of different fields, respectively, are being upgraded from time to time. New architectures are being proposed based on the fundamentals of the existing ones to handle the new issues faced in the same area of specialization. For instance, using the technique of blockchain, a framework for software provenance is designed by making modifications in the specifications of PROV family.

4 Provenance Management Systems

An information system which has the ability to automatically generate, collect, propagate, store, and query provenance information is known as provenance management system.

Some provenance management systems have been discussed and compared below.

4.1 WHIPS

Labio et al. proposed a system architecture for a data warehouse system called WHIPS (Warehousing Information Project at Stanford) to identify and track the changes in the

data of different heterogeneous data sources, making those changes and summarizing them and integrating them in data warehouse incrementally (Wiener et al., 1997).

4.2 TRIO

Jennifer Widom proposed a system called Trio that supported for provenance of relational databases with uncertainty. Uncertainty in the context of relational databases can be those values of attributes which are not exact values but a specified range or may be the relation has some records missed. It manages data, lineage, and uncertainty all put together in a system. Not only it is managed, but lineage and uncertainty can be queries individually or combined together. Lineage tables were used to store provenance in the form of mapping between input tuple identifier and output tuple identifier. The advanced version of Trio supported restricted Set-ASPJ queries (Widom, 2005).

4.3 DBNotes

Chiticariu et al. introduced a system for relational databases called DBNotes where every attribute value was associated with annotations. An annotation is a metadata attached as extra information to text, image, or other data which tells something unique about the data (Chiticariu et al., 2005; https://en.wikipedia.org/wiki/Annotation). The metadata in the context of provenance can be the address of source data or some additional information about data or an error report attached to a particular set of erroneous data. An annotation attribute is added for each attribute in the relation. Annotations values are stored in plain textual form in the annotations attributes. The propagation of annotation takes place on the basis of where provenance. The three main propagation schemes supported by psql are the default scheme, the default-all scheme, and the custom scheme. Unlike Trio where the post-processing of results take place to generate result representation, *DBNotes* rewrites a *psql* query into a single query.

4.4 MONDRIAN

Geerts et al. proposed a data model which made use of colored blocks to represent annotations and was used for both the manipulation and querying of data as well as annotations. Different color blocks represented different annotations. This model was implemented by using a color query language designed specifically for this data model. The extension of the attributes was done with purpose of storing colors in an extra attribute which became a trailblazer

for annotating standalone values as well as relationship between multiple values. Special color algebra was also created for this model which supported E-USPJ queries (Geerts, 2006).

4.5 MMS

Srivastava et al. proposed a system known as MMS which treats annotations as regular data. The relationship between annotation and annotated data is expressed in the form of SQL queries which are stored in the form of attribute values of a new data type 'query'. It records the transformation information and associates it to the source and transformed data through queries that are stored as data values. The result of query identifies the attribute values that has a specific annotation associated with it. A query is generated to get all the values of the query data type attribute and for each query value it checks if it contains the attributes in *A*. The result attributes of the evaluation of each query value are stored in additional relations where this check is performed. The rewriting takes place as a union of individual query parts that each represents the execution of the original query and one of the query values from the result of the first step. Unlike *DBNotes* and *Mondrian*, *MMS does* not support for automatic propagation of annotations (Srivastava et al., 2007).

4.6 PERM

Glavic et al. proposed an enhanced provenance management system known as PERM (Provenance Extension of the Relational Model) (Glavic, 2010). In the existing systems on provenance, the most considerable aspect was not addressed by the systems that was of the complex queries which included nested sub-queries, correlated queries. PERM is the first system that gave considerable attention to the ways of handling complex queries. It has formulated rules to rewrite queries to translate a query which can propagate provenance as well as the query results. The transformed query is expressed using relational algebra. The data model does not get impacted and uses SQL to fetch provenance. The system came up with a new term called provenance contribution which focused on how we can narrow down to specific input tuples which contributes to generate specific output tuples. It is unlikely that the entire input of a transformation becomes the provenance of its output. There were different meanings assigned to 'contribution' by the various management systems. It was given a new definition PERM contribution by this system which said that a subset of an input relation has the capability to be a part of the provenance of a resultant tuple if it produces exactly the same tuple and if each tuple in this set contributes to the result (Table 1).

Table 1 Comparison of various provenance management systems

Provenance management systems						
Basis of difference	WHIPS	TRIO	DBNotes	Mondrian	MMS	PERM
Working of the framework	To track and store changes in data warehouse	To store provenance in the form of mapping between input tuple identifier and output tuple identifier	An annotation attribute is added for each attribute in the relation. The propagation of annotation takes place on the basis of where provenance	An annotation-oriented data model for the manipulation and querying of both data which uses the concept of blocks to represent an annotated set of values	The relationship between annotation and annotated data is expressed in the form of SQL queries which are stored in the form of attribute values of a new data type 'query'	The system generates tuple-level provenance on its own for different kinds of queries and operations like aggregation, set operations and correlated sub-queries
Inverse/Rewriting of queries	Inverse query generation	Inverse query generation	Rewriting of queries takes place	–	Rewriting of queries takes place	Rewriting of queries takes place
Provenance computation approach	Lazy	Eager	Eager	Eager	Lazy	Lazy
Types of queries supported	Set-ASPJ, ETL process queries	Set-ASPJ queries with limitations	Extend-USPJ queries	E-USPJ queries	–	Basic SQL queries, sub-queries, correlated sub-queries
Propagation of annotation	NA	Propagation of annotation does not takes place at all	Automatic propagation of annotation takes place	Automatic propagation of annotation takes place	Automatic propagation of annotation does not takes place	Automatic propagation of annotation takes place
Kind of overhead involved	Computation overhead	Computation overhead	Storage overhead	Storage overhead	Computation and storage overhead	Computation overhead

From the comparison table, it can be deduced that the provenance systems which are using Eager approach of provenance computation are facing the storage overhead as in eager approach the system is unable to decide for which data objects and data processes it should generate data provenance and does it for all of them which strains the storage space badly.

One of the major limitations of provenance information is that it can surge the size of the data at an exponential rate. So it becomes very challenging to use the already existent database provenance systems for those who do not have deep understanding and knowledge of the data or the provenance models. It can have grave consequences when it comes to storage and the convenience of use.

Lately, to overcome this problem of using provenance data models, the two major challenges that amateurs face are as follows:-

1. Visualization of provenance data should be supported by not just the query results but also it should have the processes and the source tables that led to the creation of resultant data. The visualization should promote further exploration of data.

2. The provenance information of aggregate queries can be the entire relation which makes it difficult for the user to extract some meaningful information out of it at a glance

Pastwatch is a novel exploration tool which is addressing these two challenges single handedly by keeping the provenance information until it is asked for by the user. It has two major components, i.e., overview visualization and provenance graph. The former ones provide the controlled view of data, and the latter ones provide pictorial representation of a particular chunk of provenance data (Al Omeir et al., 2020).

5 Provenance Representation

5.1 Provenance Semirings

A comprehensive representation of provenance in case of incomplete databases, probabilistic databases, bag semantics, and why provenance is best possible through provenance semirings.

5.2 Annotations

Annotations are the metadata which consists of the sources of the data and information about various data processes used which lead to the current state of data. These annotations are quite useful in archival data.

5.3 Customized Relational Algebra

A special relational algebra is formulated, which has consolidated the computations related to provenance computation into a DBMS. The results established for algebra expressions have to be translated to SQL.

5.4 Provenance Graphs

The provenance graphs are fabricated by various provenance management systems dealing with workflow systems and those working on operating system level. They perform varying tasks which ranges from determining the inputs to a particular process to debugging entire workflow executions or tracking causal dependencies (Xu, 2014).

5.5 Provenance Circuits

A pragmatic approach to compute provenance queries over a relational database is to construct a provenance circuit; an arithmetic circuit whose gated are the operators of (m-) semiring for a compact representation (Amarilli et al., 2015; Deutch et al., 2014). Similarly, a Boolean provenance annotation can be used to create a Boolean circuit of data provenance of a query over a probabilistic database (Senellart et al., 2017).

5.6 Acyclic Graphs

Acyclic graphs are used in systems where provenance is generated for map and reduce functions. These systems are called RAMP (Reduce And Map Provenance). These graphs are used to process the input data sets to generate output. It depicts the use of provenance in map and reduce functions. It supports both backward and forward tracing to determine the input data sets which contributed in output generation and resultant data which got derived from specific input data elements, respectively (Ikeda et al., 2011).

There are various ways of representing the provenance data but with the emergence of novel techniques of implementing provenance techniques and its usage in different fields sometimes make the use of these representation tools very limited. For instance, the use of provenance graphs has its own limitations in analytic provenance. Usually, the analytic provenance is visualized as graphs using nodes and branches. Branches represent pivot points where the analyst tried different hypotheses. As the size of the graph grows big, it becomes increasingly difficult to understand the provenance graph. New scalable visualization methods need to be developed to visualize analytic provenance in a simple and intuitive fashion (Madanagopal, 2019).

6 Conclusion

In this paper, we presented the classification of various aspects of provenance, for instance, its applications, architectures, and techniques. It can be depicted that provenance is an interpretative field and has the potential to be explored to its fullest to be applied in various research disciplines. The effort is being made to design a framework which can use the concepts of provenance done on relational databases and big data to be applied on crime databases to authenticate the charges and acts put on the criminals are according to Indian Penal Code by backtracking the charge sheet history which will be stored in the form of annotations. Some machine learning techniques will be applied on these annotations to analyze the criminal charge sheet, and predictions will be made on the basis of available data. There is a scope of querying the provenance of crime data by designing a novel query language by using open source database management systems like PostgreSQL.

References

Ali, M., et al. A provenance-based policy control framework for cloud services. In: B. Ludäscher, & B. Plale (Eds.), *Provenance and Annotation of Data and Processes, IPAW 2014*. Lecture Notes in Computer Science (Vol 8628). Springer.

Al Omeir, O. et al. (2020). The pastwatch: On the usability of provenance data in relational databases. In *IEEE 36th International Conference on Data Engineering (ICDE)* (pp. 1882–1885). USA.

Amarilli, A., et al. (2015). Provenance circuits for trees and treelike instances. In M. Halldórsson, K. Iwama, N. Kobayashi, & B. Speckmann (Eds.), *Automata, languages, and programming. ICALP 2015*. Lecture Notes in Computer Science (Vol. 9135). Berlin, Heidelberg: Springer.

Akoush, S., et al., HadoopProv: Towards provenance as a first class citizen in MapReduce. In *Proceedings of 5th USENIX Conference Theory and Practice of Provenance* (p. 11).

Arab, B., et al. (2014) A generic provenance middleware for database queries, updates, and transactions (p. 8).

Cheney, J., et al. (2007). Provenance in databases: Why, how, and where. *Foundations and Trends Databases, 1*(4), 379–474.

Chiticariu, L., et al. (2005). DBNotes : A post-it system for relational databases based on provenance. Online (pp. 942–944).

Deutch, D. et al. (2014). Circuits for datalog provenance. https://doi.org/10.5441/002/icdt.2014.22

Geerts, F., et al. (2006) MONDRIAN: Annotating and querying databases through colors and blocks. In *Proceedings of International Conference on Data Engineering* (Vol. 2006, p. 82)

Glavic, B. (2010). Perm : Efficient provenance support for relational databases. No. University of Zurich.

Glavic, B. (2014). Big data provenance: challenges and implications for benchmarking. In *Specifications big data benchmarks* (pp. 72–80).

Hammad, R., et al. (2014). Provenance as a service: A data-centric approach for real-time monitoring. In *2014 IEEE International Congress on Big Data*, Anchorage, AK (pp. 258–265). https://doi.org/10.1109/BigData.Congress.2014.46

https://www.openlinksw.com. Last accessed August 30, 2018

https://www.w3.org/TR/prov-dm/. Last accessed August 30.

https://en.wikipedia.org/wiki/Annotation. Last accessed August 30, 2018.

Ikeda, R., et al.: Provenance for generalized map and reduce workflows. In *5th Proceedings CIDR* (pp. 273–283).

Imran, A., et.al. (2014). A layer based architecture for provenance in big data. In *2014 IEEE International Conference on Big Data (Big Data)* (pp. 29–31).

Jagadeesh et al. (2019). BLINKER: A blockchain-enabled framework for software provenance. In *2019 26th Asia-Pacific Software Engineering Conference (APSEC)*, Putrajaya, Malaysia (pp. 1–8).

Madanagopal, K., et al. (2019). Analytic provenance in practice: The role of provenance in real-world visualization and data analysis environments. *IEEE Computer Graphics and Applications, 39*(6), 30–45.

Ochoa O., et al. (2020). Accessing provenance records in semantic web services. In: *2020 IEEE 14th International Conference on Semantic Computing (ICSC)*, San Diego, CA, USA, 2020 (pp. 141–144). https://doi.org/10.1109/ICSC.2020.00027

Patni, H., et al. (2010). Provenance aware linked sensor data. In *CEUR Workshop Proceedings* (Vol. 576).

Qi et al. (2019). CF-PROV: a content-rich and fine-grained scientific workflow provenance model. *IEEE Access*, 1–1. https://doi.org/10.1109/ACCESS.2019.2900738.

Singh, J., et al. (2019). Decision privenance : harnessing data flow for accountable systems. *IEEE Access, 9*, 6562–6574.

Senellart, P., et al. (2017). Provenance and probabilities in relational databases: From theory to practice. *ACM SIGMOD Record*, 46. https://doi.org/10.1145/3186549.3186551

Srivastava, D. et al. MMS: Using queries as data values for metadata management. In *Proceedings of International Conference on Data Engineering* (pp. 1481–1482).

Stoffel, F., et al. (2015). VAPD—A visionary system for uncertainty aware decision making in crime analysis (pp. 3–4).

Wang, J., et al. (2015). Big data provenance: Challenges, state of the art and opportunities. In *2015 IEEE International Conference on Big Data (Big Data)* (pp. 2509–2516).

Widom, J. (2005). Trio: A system for integrated management of data, accuracy, and lineage. In *Proceedings of 2005 CIDR Conference* (pp. 262–276).

Wiener, J. L. et al. (1997). The WHIPS prototype for data warehouse creation and maintenance. In *Proceedings 13th International Conference on Data Engineering* (pp. 589–592).

Xu, L., et al. (2014). Information security in big data: Privacy and data mining. *IEEE Access, 2,* 1149–1176.

Attributes Affecting to Use Food Ordering App by Young Consumers

Sunil Atulkar and Bhupendra Kumar Verma

Abstract

Today, the young mobile users are increasing day by day with more dependency on online retail apps. Therefore, this study aims to identify the influence of perceived incentive, perceived price, perceived information and customer relationship management to use food ordering apps. Using convenience sampling method, data of 174 young customers' has been used to analyse through structural equation model analysis with the help of SmartPLS 2.0 and SPSS-20 software. Findings suggest that perceived incentives, perceived information and customer relationship management shows significant results while the perceived price shows insignificant result. Research suggests that the satisfaction and dissatisfaction level of the customer helps in enhancing their facility to use food ordering app. A customer always enjoys the facility of food ordering app, and customers always keep on changing with time and available technologies, motivate companies to continually offer new technologies and update their apps for providing better services.

S. Atulkar (✉)
Department of MBA, Lakshmi Narain College of Technology, Bhopal, MP, India
e-mail: sunilatulkar3030@gmail.com

B. K. Verma
School of Management Studies, Bastar Vishwavidyalaya, Jagdalpur, CG, India
e-mail: bhupendra.verma85@gmail.com

1 Introduction

According to economic times (2020) report, the Indian market is considered as one of the fastest-growing smartphone market globally with 560 million Internet subscribers in 2018 (Mckinsey, 2020) and second-largest in the world. It is suggested that in Indian mobile data, users consume 8.3 gigabits (GB) of data each month on average, compared with 5.5 GB for mobile users in China. Business insider (2020) report also suggests that there are about 450 million smartphone users as compared to 550 million feature phone users in India, and it is expected to grow in single digits in 2020, lower than the 2019 levels. Therefore, the markets of young mobile users are increasing day by day with more dependency on online retail apps (Hongwei & Liuning, 2011), as they are always ready to adopt the new technological changes (Atulkar & Kesari, 2018a). Among various available foods ordering apps, customers use some particular apps depending on their suitability based on multiple attributes offered by the app, which influences purchase behaviour (Wang et al., 2019).

There are some studies that explore the attributes affecting to use food ordering apps (Kapoor & Vij, 2018; Yang et al., 2015), but there is a scope to add some other attributes in the future research direction. Some studies (Kapoor & Vij, 2018; Yang et al., 2015) stressed primarily on the technical attributes of the app and their impact on purchase decision (Wang et al., 2019). Singh et al. (2020) study identifies the effects of technological and cultural attributes jointly on m-commerce adoption. Studies (Shanker & Datta, 2018) also determine performance expectancy and effort expectancy to use food apps. But today, the customers get influenced by some more attributes simultaneously which the service providers cannot be ignored. Therefore, based on famous technology acceptance model presented by Davis et al. (1989), present study identifies the influence of perceived incentive, price, information and customer relationship management to use food ordering apps (Fig. 1). As the

changing lifestyle motivate customers to avoid visiting restaurants for food, food order apps can be the better alternative.

2 Literature Review

2.1 Perceived Incentives

Researcher (Malik et al., 2017) identifies incentives as monetary benefits offered in the form of discount coupons, cashback, rewards, offers, referral coupons and loyalty bonus (Teo et al., 2015) in association with other online players (Johnson et al., 2018). It has been observed that Indian customers are very price sensitive, so these types of offer highly motivate and convert them in developing an attitude to use food ordering apps and influence on customer conversion. This practice has also been validated by some researchers in their past studies (Olivier & Terblanche, 2016). Some other studies (Slade et al., 2013; Unal et al., 2011) also validated that the customers are using these facilities as they perceived incentives and always keep on searching attractive offers provided by m payment apps. Based on these literature reviews, the study presents the following hypothesis.

H1: Perceived incentives have a relationship with attitude to use food ordering app.

2.2 Perceived Price

It has been observed that during the shopping time, customers always compare the vendors quoted price with other vendors in the market (Olivier & Terblanche, 2016) and then interpret offered prize as economical or costly. Researcher suggests that customer develops their price sense by comparing (Atulkar, 2019), understanding and make product decisions based on perceived price (Johnson et al., 2018). A customer always decides the quality of product and

services based on perceived price, even on the unavailability of a brand name or other relevant information. By previous research studies (Slade et al., 2013; Unal et al., 2011), perceived cost is a crucial and vital factor for users to decide the food ordering apps, as the transaction utility and perceived price by the customer negatively impact on perceived values by the customer (Osuna et al., 2016; Wang et al., 2019). Therefore, the study presents the following hypothesis.

H2: Perceived price has a relationship with attitude to use food ordering app.

2.3 Perceived Information

According to Yang et al. (2015), quality of information refers to the truthfulness, completeness, appearance and comprehensive information about product or services and converts the customers towards showing their purchase behaviour through m payment apps (Srivastava et al., 2010). Therefore, available information through m payment apps on any smart mobiles increases the engagement level of customers (Ting et al., 2016). Studies suggest that the amount and structure of information and services provided by m payment app will impact on satisfaction (Atulkar & Kesari, 2016) and loyalty (Elliot et al., 2013) levels of the customers for particular apps. Studies demonstrate that the information quality is the level of believable, applicable, accurate and understandable information on real-time bases for making a purchase decision (Atulkar & Kesari, 2017a). Thus, a good amount of relevant and useful information provided by online apps will increase trust in the customers (Atulkar & Kesari, 2018b). Therefore, the study presents the following hypothesis.

H3: Perceived information has a relationship with attitude to use food ordering app.

2.4 Customer Relationship Management (CRM)

Customer relationship management is the facility provided by food ordering apps, which offer customers to make their customized personal user profile on that particular app and access their account safely through secure password (Yang et al., 2015). CRM will create a relationship with the customer and one of the primary reasons for the customer to use m payment apps, which lead to customer conversion. Studies identify it as one of the conceptualized factor (Arvidsson, 2014; Huang et al., 2012) based on group interviews and discussion which help in maintaining the relationships and retaining the customer in the long run. Shanker and Datta (2018) identify that the m payment apps help users to save
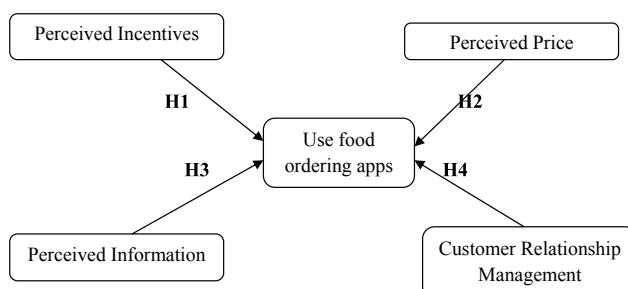
Fig. 1 Proposed research framework

their addresses, favourite dishes and restaurants, share their feedback on consumed foods and services (Atulkar and Kesari, 2014a), which help the customers in deciding foods and restaurants during future orders. Therefore, the study presents the following hypothesis.

H4: Customer relationship management has a relationship with attitude to use food ordering app.

2.5 Attitude to Use Food Ordering App

According to Kapoor et al. (2018), conversion means when any customer has accepted and use any particular food ordering app for placing an order through their smartphones (Unal et al., 2011). Studies suggest that when customers purchase anything through a mobile app, it is called customer conversion. For conversion, the food ordering apps offer monetary benefits in the form of incentives (Olivier & Terblanche, 2016; Taylor & Levin, 2014), discount coupons, promotional offers, loyalty discounts, cash back rewards, referral coupons, loyalty bonus points, etc. (Teo et al., 2015; Unal et al., 2011). Studies suggested that the Indian customers are highly price sensitive, and therefore, these types of activities motivate them to develop an attitude to use food ordering apps (Malik et al., 2017). In last, if any customer installs food ordering app in their mobile phone (Taylor & Levin, 2014), registered himself, scan the menu and select the dishes and restaurant to be ordered, make payment online is considered as a customer conversion (Kapoor & Vij, 2018).

3 Methodology

3.1 Constructs and Data Collection

Based on previous literature reviews, it has been suggested that customer conversion for food ordering apps has been variously influenced by perceived incentives, perceived price, perceived information and customer relationship management. Therefore, 14 research items for theses constructs are retrieved from existing literature reviews and update according to the research topic. The research questionnaire consists of two parts, first the demographic characteristics and second the questions related research objective and was measured in a five-point Likert scale. Using convenience sampling methods, data from 221 young customers' has been collected in March 2020. A final set of 174 questionnaires were used to analyse through structural equation model analysis using SmartPLS 2.0 and SPSS-20 software. The 18–30 years age group customers are the respondent for this research, as they are highly

techno savvy customers. Out of which, 105 customers are male, and 69 are a female customer.

4 Data Analysis and Result

Structural model analysis (Davison et al., 2003; Hair et al., 1998) has been utilized by the researcher using SmartPLS 2.0 statistical software, which helps to calculate the values of validity and reliability of the constructs. The study also estimates the values of factor loadings and path coefficient (Chin, 2001; Davison et al., 2003; Henseler et al., 2015), and it has been suggested that the path coefficient is significant if the t-value is higher than 1.96, with a significance level of 5%. Statistical significance is a determination about the null hypothesis, which hypothesizes that the results are due to chance alone. A data set provides statistical significance when the p-value is sufficiently small.

4.1 Validity and Reliability

First, the study measures the reliability and validity of the constructs. In reliability, the study observes the values of composite reliability and alpha (Raykov, 1997), where the values for both cases should greater than or equal to 0.70 (Nunnally, 1978). While in case of validity (Fornell & Larcker, 1981) of constructs, researcher observes the values of factor loading and average variance extracted under discriminant and convergent validity, which should be equal and greater than 0.50 (Bagozzi & Edwards, 1998). Findings for Cronbach's alpha are under 0.74–0.82, and the values for composite reliability are in between 0.73 to 0.81. Similarly, the factor loading values are in between 0.56 and 0.73, and for average variance extracted (AVE), the values are under 0.59 to 0.72, which suggests good validity and reliability of constructs (Tables 1 and 2).

4.2 Path Coefficients

Obtaining the values of path coefficient, regression analysis using SPSS 20 software has been done by the researcher. Table 3 shows the value of standardized path coefficients (β), t-value and associated significance levels for all relationships. Resulted value indicates that perceived incentive ($\beta = 0.167$; t-value $= 2.706$; $p = 0.0173$), perceived price ($\beta = 0.295$; t-value $= 2.245$; $p = 0.025$), perceived information ($\beta = 0.297$; t-value $= 3.153$; $p = 0.032$) and customer relationship management ($\beta = 0.142$; t-value $= 2.368$; $p = 0.019$) had positive and significant influence on customer conversion. Thus, all the hypotheses H1, H2, H3 and H4 were accepted by the researcher.

Table 1 Reliability and validity analysis

Constructs and their observable items	Loadings
Perceived incentives (PI) (AVE = 0.59, CR = 0.81, α = 0.74)	
PI 1: Food ordering apps gives cashback and discounts	0.65
PI 2: Food ordering apps offer attractive incentives	0.73
PI 3: I like food order apps, as they keep on giving a loyalty bonus	0.58
Perceived price (PP) (AVE = 0.72, CR = 0.76, α = 0.86)	
PP 1: I believe ordering food through an app is more economical	0.67
PP 2: I believe that I can save more money by using food ordering app	0.72
Perceived Information (PIN) (AVE = 0.64, CR = 0.73, α = 0.78)	
PIN 1: Food ordering apps gives me relevant and accurate information	0.58
PIN 2: Food ordering apps provide excellent restaurants available near to you	0.61
PIN 3: Customer's review on restaurants are available on the food ordering app	0.73
Customers relationship management (CRM) (AVE = 0.68, CR = 0.79, α = 0.82)	
CRM 1: Food ordering app offers comfortable users login facility	0.71
CRM 2: Food ordering app can store our personal address	0.68
CRM 3: I love food ordering apps because it saves our past favourite orders	0.69
CRM 4: Food ordering apps have the facilities of feedback and share information	0.56
Customer Conversion (CC) (AVE = 0.67, CR = 0.78, α = 0.82)	
CC 1: I love to use food order apps in the future	0.58
CC 2: I like to order food on an app instead to visit restaurants	0.62

Table 2 Latent variable correlation

Constructs	Mean	SD	PI	PP	PIN	CRM	CC
PI	4.11	0.78	**0.81**[a]				
PP	4.31	0.83	0.70	**0.85**[a]			
PIN	4.25	0.79	0.72	0.78	**0.80**[a]		
CRM	4.05	0.76	0.73	0.71	0.76	**0.82**[a]	
CC	4.31	0.86	0.84	0.73	0.78	0.75	**0.81**[a]

Note [a]Diagonal elements are squared AVE

Table 3 Main effects and path coefficients

Hypothesis	Beta	*t*-value	*p*-value	Result
H1: PI -> CC	0.167	2.706	0.017	Supported
H2: PP -> CC	0.295	2.245	0.025	Supported
H3: PIN -> CC	0.297	3.153	0.032	Supported
H4: CRM -> CC	0.142	2.368	0.019	Supported

Note Significance level $P < 0.05$, if *t*-value => 1.96, based on two-tailed *t*-test

5 Discussion and Conclusion

Based on findings, it has been suggested that all the attributes namely perceived incentives, perceived price, perceived information and customer relationship management influence on customer conversion to use food ordering apps, especially in developing countries like India, where customers are very prices sensitive.

Study finding shows a significant positive relationship between perceived incentives and customer conversion. The study observes that getting incentives from food ordering app plays an important in customer conversion to use these apps which is also supported by previous research studies (Olivier & Terblanche, 2016; Taylor & Levin, 2014; Teo et al., 2015; Unal et al., 2011). It has been suggested that the customers love to get various offers, schemes and discount available on particular food ordering apps. Indian customers

are more prices sensitive and always keep on searching for more offers, discount and loyalty bonus in the form of incentives. Therefore, H1 hypothesis is accepted by the researcher, which influence customer purchase behaviour from food ordering apps.

Findings for the relationship between perceived price and customer conversion also show significant positive results, and thus, the H2 hypothesis is accepted by the researcher. As the customers always search for the attractive prices for their order at food ordering app and also supported previous studies (Kapoor & Vij, 2018; Osuna et al., 2016; Slade et al., 2013; Unal et al., 2011), researcher suggests that the customers love to save money in terms of cashback, discount and bonus points. Thus, it has been recommended that choosing a particular food ordering apps depends on the offers provided by those players. It also helps customers to retain in the future and avoid them to shows switching behaviour. Therefore, various exciting offers and discounts available on food ordering app motivate a customer to show purchase behaviour regularly.

Similarly, the study outcome for the relationship between perceived information and customer conversion also shows the significant positive influence, and therefore, the H3 hypothesis is accepted by the researcher. Thus, the study supports the previous study findings (Elliot et al., 2013; Kim et al., 2009; Srivastava et al., 2010; Ting et al., 2016). The study suggests that the food ordering apps provide regularly updated information related to food, quality and prices. Mostly, the images of food on the menu and list of nearby restaurants motivate customers to view the food ordering apps and to connect them for food ordering. Therefore, updated and authentic information supports customers in decisions making while ordering food from particular apps and leads to customer conversion.

Resulted findings for the relationship between customer relationship management and customer conversion show the significant positive influence and supported by previous research studies (Arvidsson, 2014; Huang et al., 2012; Shanker & Datta, 2018; Srivastava et al., 2010; Teo et al., 2015; Unal et al., 2011). Therefore, it has been suggested that the customer have the facility to prepare their profile on the app, which allows them to secure login and customized their orders. It is easy to use, offers a facility to save addresses, customized pickup and delivery time and payment facilities through multiple online modes. Therefore, perceived information from food ordering app is considered as a crucial antecedent in adopting mobile app technology.

Finally, the study concludes that perceived incentives, perceived price, perceived information and customer relationship management show the significant favourable influence on customer conversion towards food ordering apps.

The study observes that food ordering apps need to develop in terms of attractiveness, have to offer attractive price, incentives and always have to maintain a relationship with the customer in this competitive e-commerce scenario. Therefore, food ordering apps need to provide meaningful, attractive, precise, accurate and relevant information to their customers. The study demonstrates that perceived price and incentive in the form of various schemes, discount and offers influence customer conversion to use food ordering app. Similarly, customer relationship management with the help of complete information helps service providers to convert their customer towards food ordering apps from outside restaurants eating habits. Thus, the entire attribute plays an essential role in customer conversion.

6 Research Implications

The present study explores the relationship between four attributes on customer conversion to use food app service. It suggests that with the growing mobile apps business globally, there is a need to recognize every variable, which leads to the conversion of customers. Today, the expectation of customer keeps on changing with time and technology, where all these factors play an essential role. Thus, it creates a massive scope for penetrating and expanding consumers market in India. The service providers need to hold and attract new customers by offering various lucrative offers through apps in this growing competitive online business market. Similarly, positive customer reviews and feedbacks are very fruitful for service providers to improve their services for attracting new user while using and placing orders through theses apps and also increasing satisfaction levels of the customer.

7 Limitations and Further Research

The present study mainly focused on customers of central India and age group between 18 and 30 years creates scope of future research on all age group customers. Future research can also focus on customers from other regions and even the other country to make the study more generalized and uniform. The study only focuses on customer's attributes, so some more attributes like visual design and website attractiveness need to be considered by future researchers. Therefore, the study would help academicians and future researchers to focus on customers interest to use mobile app technologies for obtaining more fruitful results for improving the services.

References

Arvidsson, N. (2014). Consumer attitudes on mobile payment services-results from a proof of concept test. *International Journal of Bank Marketing, 32*(2), 150–170.

Atulkar, S. (2019). Measuring the effects of retail functional strategies on the growth of organised retail environments. *Journal of Marketing Vistas, 09*(1), 58–68.

Atulkar, S., & Kesari B. (2014a) A review of customer preference towards organised retail stores. *IRC's International Journal of Multidisciplinary Research in Social and Management Science, 2*(3), 24–28

Atulkar, S., & Kesari, B. (2014). Adoption of retailer centric philosophy in organising buying process: A case study on Indian buying systems. *ZENITH International Journal of Multidisciplinary Research, 4*(9), 204–209.

Atulkar, S., & Kesari, B. (2016). Shopping experience of hypermarket shoppers on weekends. *Indian Journal of Marketing*, *46*(11), 36–49.

Atulkar, S., & Kesari, B. (2017). Impulse buying: A consumer trait perspective in context of central India. *Global Business Review, 19*(2), 477–493.

Atulkar, S., & Kesari, B. (2017). Satisfaction, loyalty and repatronage intentions: Role of hedonic shopping values. *Journal of Retailing and Consumer Services, 39*(6), 23–34.

Atulkar, S., & Kesari, B. (2018). A review on art of creating values in retail for improving business performance. *Journal of Business Administration Research, 7*(1), 22–26.

Atulkar, S., & Kesari, B. (2018). Role of consumer traits and situational factors on impulse buying: Does gender matter? *International Journal of Retail and Distribution Management, 46*(4), 386–405.

Bagozzi, R. P., & Edwards, J. F. (1998). A general approach to construct validation in organisational psychology: Application to the measurement of work values. *Organisational Research Methods, 1*(1), 45–87.

Business Insiders. (2020). *Report*. Retrieved on 03 February 2020 from https://www.businessinsider.in/politics/india/news/indian-online-food-delivery-market-to-hit-8bn-by-2020/articleshow/73696722.cms

Chin, W. W. (2001). *PLS-graph user's guide*. Houston, TX, USA: University of Houston, CT Bauer College of Business.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982–1003.

Davison, A. C., Hinkley, D. V., & Young, G. A. (2003). Recent developments in bootstrap methodology. *Statistical Sciences, 18*(2), 141–157.

Elliot, S., Li, G., & Choi, C. (2013). Understanding service quality in a virtual travel community environment. *Journal of Business Research, 66*(8), 1153–1160.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39–50.

Hair, J., Anderson, R., Tatham, R., & Black, C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Henseler, C. M. R., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of Academics and Marketing Sciences, 43*(1), 115–135.

Hongwei, Y., & Liuning, Z. (2011). Extending TPB and TAM to mobile viral marketing: An exploratory study on american young consumers mobile viral marketing attitude, intent and behaviour. *Journal of Targeting, Measurement and Analysis for Marketing, 19*(2), 85–98.

Huang, H. S., Chiou, C. C., Chiang, H. K., Lai, S. H., Huang, C. Y., & Chou, Y. W. (2012). Effects of multidimensional concept maps on fourth graders' learning in web-based computer course. *Computers and Education, 58*, 863–873.

Johnson, V. L., Kiser, A., Washington, R., & Torres, R. (2018). Limitations to the rapid adoption of M-payment services: Understanding the impact of privacy risk on M Payment services. *Computers in Human Behavior, 79*, 111–122.

Kapoor, M. J., & Vij, M. (2018). Technology at the dinner table: Ordering food online through mobile apps. *Journal of Retailing and Customer Services, 43*(7), 342–351.

Kim, G., Shin, B., & Lee, H. G. (2009). Understanding dynamics between initial trust and usage intentions of mobile banking. *Information Systems Journal*, *19*(3), 283–311.

Malik, A., Suresh, S., & Sharma, S. (2017). "Factors Influencing Consumers" attitude towards adoption and continuous use of mobile applications: A conceptual model. *Procedia Computer Science, 122*(2017), 106–113.

Mckinsey. (2020). *Report*. Retrieved on 16 March 2020 from https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Digital%20India%20Technology%20to%20transform%20a%20connected%20nation/MGI-Digital-India-Report-April-2019.ashx

Nunnally, J. C. (1978). *Psychometric theory*. New York, NY: McGraw-Hill.

Olivier, X., & Terblanche, N. S. (2016). An Investigation into the antecedents and outcomes of the M-shopping experience. *The Business and Management Review, 7*(5), 263–268.

Osuna, I., González, J., & Capizzani, M. (2016). Which categories and brands to promote with targeted coupons to reward and to develop customers in supermarkets. *Journal of Retailing, 92*(2), 236–251.

Raykov, T. (1997). Estimation of composite reliability for congeneric measures. *Applied Psychological Measurement, 21*(2), 173–184.

Shanker, A., & Datta, B. (2018). Factors affecting mobile payment adoption intention: An Indian perspective. *Global Business Review, 19*(3S), 1–18.

Singh, N., Sinha, N., & Liebana-Cabanillas, F. J. (2020). Determining factors in the adoption and recommendation of mobile wallet services in India: Analysis of the effect of innovativeness, stress to use and social influence. *International Journal of Information Management, 50*(2020), 191–205.

Slade, E. L., Williams, M. D., & Dwivedi, Y. K. (2013). Mobile Payment adoption: Classification and review of the extant literature. *the Marketing Review, 13*(2), 167–190.

Srivastava, S. C., Chandra, S., & Theng, Y. L. (2010). Evaluating the role of trust in consumer adoption of mobile payment systems: An empirical analysis. *Communications of the Association for Information Systems, 27*(1), 561–588.

Taylor, D. G., & Levin, M. (2014). Predicting mobile app usage for purchasing and information-sharing. *International Journal of Retail & Distribution Management, 42*(8), 759–774.

Teo, A. C., Tan, G. W. H., Ooi, K. B., Hew, T. S., & Yew, K. T. (2015). The effects of convenience and speed in M-payment. *Industrial Management and Data Systems, 115*(2), 311–331.

Ting, H., Yacob, Y., Liew, L., & Lau, W. N. (2016). Intention to use mobile payment system: A case of developing market by ethnicity. *Procedia-Social and Behavioral Sciences, 224*, 368–375.

Unal, S., Erciş, A., & Keser, E. (2011). Attitudes towards mobile advertising—A research to determine the differences between the attitudes of youth and adults. *Procedia-Social and Behavioral Sciences, 24*(9), 361–377.

Wang, Y. S., Timmy, H. T., Wang, W. T., Ying, W. S., & Chan, P. Y. (2019). Developing and validating a mobile catering app success model. *International Journal of Hospitality Management, 77*(1), 19–30.

Yang, Y., Liu, Y., Li, H., & Yu, B. (2015). Understanding perceived risks in mobile payment acceptance. *Industrial Management & Data Systems, 115*(2), 253–269.

Exploring Influencing Factors for M-payment Apps Uses in the Indian Context

Ashish Kumar Singh and Madhvendra Pratap Singh

Abstract

Purpose This paper aims to understand the effect of enjoyment (ENJ), facilitating condition (FC), mobility (MOB), collaboration and trust in developing a positive attitude for Indian customers to use m-payment apps. *Methodology* The study proposed a new paradigm on the grounds of extended technology acceptance model (TAM). By using structural equation modeling (SEM), the frameworks were empirically examined on responses from 328 respondents. *Findings*—The empirical results indicate that five factors—collaboration, enjoyment, facilitating condition, mobility and trust, positively affect the consumer's attitude for using m-payment services. However, it has been found that the collaboration and trust construct have no direct impact on the attitude to use m-payment apps. *Research limitations/implications*—The study highlights the significance of these other variables that are critical when it comes to using m-payment apps to identify buyer behaviour. The study will, therefore, guide for all m-payment service providers to develop their services accordingly.

A. K. Singh
Raj Kumar Goel Institute of Technology, Ghaziabad, India
e-mail: ashishs80@gmail.com

M. P. Singh (✉)
KNIPSS Management Institute, Sultanpur, UP, India
e-mail: madhvendra99@gmail.com

1 Introduction

In recent decades, financial service firms have transformed. For the Indian payment market, 2018 was a formative year. Mobile payments have shown their unparalleled ability to alter our way of dealing. As a result of this convergence and growing technical developments, the international payment environment is changing rapidly (KPMG, 2019). Mobile apps allow consumers throughout their lives, from knowledge searches to purchases (Taylor & Levin, 2014). Consumers mean mobile users, who download apps and use them to scan, purchasing, networking, banking, and streaming video for details. All customers and the industry face a new technological surge. The 2021 vision for payment and settlement systems in India strengthens the strong basis established during the past two decades. Although the search for a 'cashless' society goes on, followed by the desire to include India with a cheaper card, efforts are also being made to ensure increased efficiency, continuous availability of protected, safe, reliable and affordable payment systems, as well as to serve sections of the community that are not affected by payment systems until today (RBI, 2019). By 2025, digital transactions may amount to United States Dollar 1 trillion yearly in India, with 4 out of 5 digitally-based transactions. India is currently nearly 90 million digital transactions. However, it will have been able to triple to 300 million by 2020 when new users come into the market from rural and half-urban regions. (ET, 2018).

The rise in India's mobile payments has been driven by highly competitive countryside and foreign investment. India has many payment providers, with more than 45 wallet apps, 50 payment providers based on UPIs and 142 banks on the UPI network, compared to China and Japan. The business landscape stretches from telephone providers, banks, to online firms, and messaging service provider. (KPMG, 2019) The researchers need special attention to be paid to this fast-developing user of humble Indian mobile applications. The factors influencing the purpose of adopting

payment are, therefore, to be discussed (Dahlberg et al., 2008). The implementation of m-payments is of particular significance to managers and researchers, as it can be a significant advantage for business enterprises, payment processing providers, software service providers and third parties (Lim, 2008; Ondrus & Pigneur, 2006). In India, no researchers have considered the effect of constructs, namely collaboration, enjoyment, facilitation condition, trust and mobility on attitude, to use the m-payment apps. Therefore, the study aims to explore variables that influence the attitude of using the m-payment apps.

2 Literature Review

2.1 Collaboration (COLL)

After experiencing various research and literature, we have recognised a significant component of m-payment, i.e., collaboration. In the Indian context, this construct is not used in a study for m-payment. Collaboration alludes to the relationship of a specific m-payment company with some other specialist organisation for the business. For instance, Amazon pay (an m-payment app) in India has a tie-up with Pharm Easy (Online Medicine supplier), wherein, "when you pay through Amazon pay, at the same time, purchase of medicine, the client is incited with a message that he will get additional cashback up to Rs. 300 on Amazon Pay + Get 18% off on first medication request."

Also, numerous partners have tied up with various m-payment service providers and receive instant cashback by using those particular m-payment apps. The user gets the money back immediately by using the coupons displayed at the transaction point. Collaboration, as a construct, was adopted through various interviews and study done by Kapoor and Vij (2018) on food ordering apps. Therefore, the following hypotheses have been propounded based on the above-mentioned study.

H1: Collaboration has a favourable influence on the perceived ease of use of m-payment applications to establish an attitude to use.

2.2 Enjoyment (ENJ)

Enjoyment (Davis et al. 1992) is characterised as "The level over which computer work is considered on its own to be friendly, except any anticipated performance consequences." In our research, the concept of how much m-payment is considered to be enjoyable by a consumer can be interpreted. (Venkatesh 2000), who researched PEOU's effect on user acceptance, His study model gained insight and noticed a

strong relationship between customers through improved capabilities for ENJ and PEOU. Following the current literature and the role of ENJ in approving m-payment study, the following hypotheses have been formulated:

H2: Enjoyment has a significant influence on the perceived ease of use of m-payment applications to establish an attitude to use.

2.3 Facilitating Conditions (FC)

Facilitating conditions are described as the level whereby a person feels that the technological and organisational infrastructure assists the programme "(San Martín & Herrero, 2012). Such circumstances may illustrate variables that influence the chances of a person using a programme (Maruping et al., 2016; Venkatesh et al., 2003). Facilitating conditions can minimise ambiguity or misunderstanding in applications (Al-Gahtani et al., 2007). The following hypothesis is suggested to validate this relationship within the context of m-payment applications:

H3: Facilitating conditions have a favourable influence on perceived ease of use m-payment applications.

2.4 Mobility (MOB)

Mobility includes three aspects in literature: comfort, timeliness and imminence (Seppala & Alamaki, 2003). This allows users to access resources or information on mobile platforms at any and all times by mobility. As a consequence, the m-payment app can help users manage their financial assets efficiently. Earlier studies have revealed that consumers regard mobile services as the prime reward of performance and quality and that these advantages are the product of mobility (Hill & Roldan, 2005). A new direction of providing access to financial services via mobile devices is supplied by m-payment app, thus enabling a unique aspect of bank and customer interaction. Therefore, due to their mobility, m-payments are valuable. Therefore, as a precedent for the attitude to use the m-payment app. We have incorporated mobility into the original TAM. The following assumptions were made:

H4: Mobility is favourably correlated with the perceived usefulness of the m-payment app.

2.5 Perceived Ease of Use (PEOU)

Perceived ease of use can be described as' the extent of effort-free use by a person "(Davis, 1989). Effort refers to the limited resources for which an individual is responsible. So many research studies have found a positive influence of

PEOU on PU at a substantial level in different domains, like mobile businesses (Wu & Wang, 2005), online commerce and banking. Based on these results, we assumed that all the relationships of TAM hypothesised are also crucial for the m-payment app. The following hypotheses have been formulated:

H5: Perceived ease of use is linked positively to perceived usefulness of the attitude to use the m-payment app.

2.6 Perceived Usefulness (PU)

In m-payment, the system is beneficial for quick transactions, such as payment services for utilities, bills, online buying and ticket bookings. Perceived usefulness (PU) defines Davis (1989) as "A person thinks that using a platform would increase their work performance." Consumers objectively assess all the advantages they get when they are using any novel product before using it. Mobile technology literature also provides empirical evidence of consumers' ability to use digital technology (Mallat, 2007; Ondrus & Pigneur, 2006). If consumers find the program useful for transaction needs or financial issues, they can use m-payment systems. We also assume that using m-payment for positive results is advantageous. The following assumptions have been made:

H6: Perceived usefulness is linked positively to the attitude to use the m-payment app.

2.7 Trust (TR)

Trust can be interpreted as a significant consumer expectation of service providers (Mayer et al., 1995). According to these concepts, customer convictions on the protection of online shopping are focused on trust. Honesty, skill and benevolence are the three convictions of trust (Palvia, 2009). Trust is the strongest driver of customer trust in electronic services (Mallat, 2007; Yan et al., 2009). With regard to the use of mobile payment systems, individual and financial details from customers, trust is an effective way of using m-payment (Duane et al., 2014; Kim et al. 2010). The following assumptions have been made:

H7: Trust is significantly related to the perceived usefulness of the m-payment application.

2.8 M-payment Attitude to Use (MPAU)

In emerging economies, demand in m-payments is the result of rapid technological, regulatory and environmental changes. In light of TAM with certain advanced factors, Pousttchi

and Wiedemann (2007) performed a study of the adoption of m-payment in Germany. They claimed that PU and PEOU had a big influence on the behaviour toward m-payment. Due to the rising importance of mobile trade and associated m-payment, different device characteristics are required, and their personal effects can be evaluated on both the perceived usefulness of m-payment and its perceived ease of use. So, based on the above literature, the following hypotheses have been formulated:

H8: The perceived ease of use is positively related to the attitude towards using the m-payment app.

3 Research Methodology

3.1 Measuring Constructs

As part of this research, a survey instrument was established based on analysis of literature relating to m-payment and another attitude-related literature on adoption. For collecting the response, a five-point Likert scale (anchored to strongly disagree = 1 to strongly agree = 5) was used. The researcher has identified a definitive collection of 27 items, out of 29 items and used them for the final creation of the questionnaire. So the questionnaire is made up of two parts. First, the demographic characteristics of the respondent and the second part contain the questions of dependent and independent constructs.

3.2 Data Collection Process

Our study used a survey of m-payment users to collect data to test hypotheses and discuss research goals. An online survey was performed by sending the questionnaire to graduates, staff, business people and other citizens of the society in February through mid-March 2020, assuming they are m-payment app customers. All the respondents are from major cities, ideally from India's Lucknow and other East UP cities. We approached 483 respondents, and finally, we managed to obtain a total of 328 responses from questionnaires with a response rate of 67.9%.

Among respondents, 64% are male, and 36% are female. Our 41% of respondents are less to age 24 years, 33% having between the age group of 24–30 yrs, 17% are in the age between 30 – 43 years. 45% respondents are graduates, and 49% are postgraduate, 32 and 53% are students and employees. Maximum 40% of respondents use m-payment apps either once in a day or week each, and 20% use the app in a month. 36% of respondents are using m-payment apps for less than 1 year, 45% from 2 years, 20% for 3 years and 1% for more than 3 years. (Table 1).

Fig. 1 Proposed research
framework
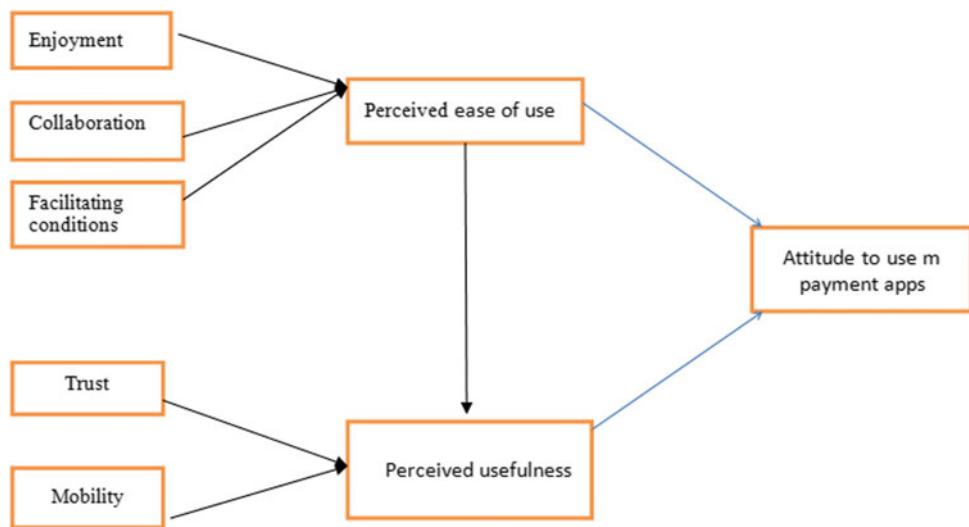
Table 1 Detailed demographic
profile of respondents

Variable	Levels	Count	Percentage
Gender	Male	210	64
	Female	118	36
Age	Less than 24 years	135	41
	25–30 years	108	33
	31–36 years	55	17
	37–43 years	55	17
	Above to 43 years	4	1
Education	Intermediate	13	4
	Graduation	149	45
	Post-graduation	161	49
	Other	5	1
Occupation	Student	106	32
	Employee	174	53
	Entrepreneur	41	13
	Other	7	2
M-payment apps frequency	At least once in a day	131	40
	At least once in a week	134	40
	At least once in a month	63	20
Usage of m-payment apps	Less than one year	116	36
	1–2 year	147	45
	2–3 year	65	20
	>3 year	4	1

4   Data Analysis and Result

The researcher used SmartPLS 3.0 statistical software for data analysis and processing of the structural model analysis (Bagozzi and Yi, 1988, 2012; Hair et al., 1998; Davison et al., 2003) through the partial least square method. The researcher found the PLS-SEM method to be suitable (Hair et al., 2013) since it is considered ideal for both parametric and nonparametric data. This is useful for determining the causal relationship between independent constructs and dependent ones.

4.1 Validity and Reliability

The study of reliability and validity was carried out to ensure the accuracy of the proposed structures. To calculate the reliability of the research objects, we checked the composite reliability values and Cronbach's alpha (Raykov, 1997). In both cases, we found the minimum standard of 0.70 to be higher or equal (Nunnally, 1978). The results of the study show that values for Cronbach's alpha are almost 0.70–0.86. The value for composite reliability is between 0.72 and 0.85 (Table 2).

Likewise, for the calculation of construct validity, the researcher observes internal consistency values (Fornell & Larcker, 1981) utilising loading factors and AVE values that should be higher than 0.50 and in our analysis, every constructs AVE values of greater to 0.6. (Bagozzi & Edward, 1998).

Table 2 Reliability and validity analysis

Constructs and their observable items	Loadings
Perceived ease of use (PEOU) (AVE = 0.64, CR = 0.85, α = 0.85) (Davis (1989)	
PEOU 1: I think the process would be quick and simple if I use m-payment	0.86
PEOU 2: I think it is easy for me to be professional with m-payment	0.796
PEOU 3: I think it is easy to use m-payment	0.839
Perceived usefulness (PU)(AVE = 0.67, CR = 0.86, α = 0.86) (Davis, 1989; Kim et al., 2010)	
PU 1: With m-payment, I would be able to pay quicker	0.801
PU 2: It is simpler for me to make transactions with m-payment	0.832
PU 3: It would be helpful to use M-payment	0.831
Collaboration (COLL) AVE = 0.61, CR = 0.86, α = 0.86) (adapted from Kapoor & Vij, 2018)	
Coll 1: Using the mobile app gives me cash back choices	0.8
Coll 2: The m-payment app has links to other players in e-commerce	0.776
Coll 3: Every time I get incentive while placing an order through the m-payment app	0.821
Coll 4: The mobile app gives me coupons that can be used at a step later	0.729
Enjoyment (ENJ) AVE = 0.66, CR = 0.87, α = 0.88) (adapted from Cyr et al., 2006; Davis, 1989; Shih, 2004)	
ENJ 1: Using m-payment would be a new exciting experience	0.877
ENJ 2: Using m-payment for online payments would be a speedy process	0.81
ENJ 3: M-payment process involves only a few steps for payments	0.797
ENJ 4:Using m-payment make me feel happy	0.834
Trust (TR) AVE = 0.61, CR = 0.82, α = 0.82) (adapted from Shankar and Datta, 2018)	
TRUST 1 I think legal frameworks for providing m-payments are sufficient Strong enough to defend customers	0.803
TRUST 2 I think m-payment service provider has appropriate skills and Resources to deliver those services	0.759
TRUST 3 I think m-payment service provider can behave ethically when my data is collected, retained, processed and managed	0.78
Facilitating conditions (FC) AVE = 0.66, CR = 0.85, α = 0.85) (adapted from Riffai et al., 2012; Sun et al., 2013)	
FC 1 I possess all the requirements for operating m-payment	0.823
FC 2 I would obtain enough information for operating m-payment	0.839
FC 3 M-payment would be suitable for my online transactions	0.782
Mobility (MOB) AVE = 0.64, CR = 0.85, α = 0.85) (adapted from Huang et al. 2007)	
MO 1 M-payment can be easily accessed every time, anywhere	0.829
MO 2 Mobility allows real-time data to be obtained	0.794
MO 3 Mobility is an excellent benefit of m-payment	0.822
M-payment Attitude to use (MPAU) AVE = 0.58, CR = 0.85, α = 0.84) (Kim et al., 2010)	
MPAU 1 Currently, I pay with a cell phone for the transactions	0.7
MPAU 2 I intend to use the m-payment, assuming I have access	0.81
MPAU 3 I will be paying for shopping with a mobile phone in the next six months	0.809
MPAU 4 I plan to pay for purchases by using mobile phones for the next five years from now	0.769

4.2 Discriminant Validity and Multicollinearity

Consequently, the extracted factor values and mean–variance (AVE) exceed the minimum standard of 0.50. The research analysis also describes the findings for the discriminant validity of heterotrait-monotrait (HTMT) (Henseler et al., 2015), which reflect the degree of uniqueness of one construct with other constructs, based on the low correlation between the constructs. As all HTMT values are lower than 0.90, which satisfies the requirements of HTMT (<0.9) suggested by Kline (2015) for all study constructs, it is assumed that the measurement model is adequately accurate, discriminating and convergent (Tables 3 and 4).

4.3 Multicollinearity Assessment

The values of HTMT should be below 0.9 (which is in our study, Table 3), and Fornell and Larcker values should between 0 and 1 (our study value exists between 0 and 1, Table 4). There is also no multicollinearity between the independent variables. (Grewal et al., 2004; Hair et al., 2011).

4.4 Hypothesis Test and Path Coefficients

To verify the formulated hypotheses based on scientific significance values of factor loading and path coefficients, the researcher applied a nonparametric bootstrap method on the SmartPLS 3.0 programme (Chin, 2001; Davison et al., 2003). Table 5 demonstrates the importance for all relationships of standardised path coefficients (β), t-value and related significance levels.

5 Discussion

The suggested model was assessed in this study using partial least square structural equation modeling (PLS-SEM). R^2 value for attitude to use m-payment apps is 0.61, which allocates 61% variance of a customer to use m-payment apps, 55% variance to PEOU and 54% variance to PU which are considered to be a good model (Hair et al., 2011), and all R^2 are statistically significant. Model fit was checked by evaluating SRMR, where the approximate average for the saturated model is 0.041 and 0.061, which is less than the acceptable value of 0.1 (Hu & Beutter, 1998). Therefore, the model being proposed is good to go forward.

Bootstrapping was performed with 5000 subsamples, proposed in 2011 by Hair et al. All hypotheses were tested statistically significant except for collaboration to PEOU and trust to perceived use. As already mentioned, this study was conducted primarily to access the crucial factors and their effect on Indian customers to use m-payment app.

H1: The statistically relevant hypothesis was not confirmed. In this analysis, there is no correlation between PEOU and collaboration. This tells Indian consumers that the app was not easy to use and still earn cashback, rewards and discounts by using the m-payment app. The collaboration was described in the previous study by Kapoor et al. (2018) as an essential factor in the ease of use in India by online aggregators.

H2: Hypothesis guarantees that it is easy to use, enjoyable and pleasant for clients who enjoy using the payment app. In the earlier research of Al-Hawari and Mouakket (2010), it was concluded that enjoyment has no significant impact on e-satisfaction among students contrary to our research. Enjoyment has a positive influence on m-payment attitude as well as PEOU, which is consistent with the study findings.

H3: Facilitating conditions have a favourable influence on both attitudes to m-payment and PEOU, endorsing with previous literature of Venkatesh et al. (2012) as the stimulating effect of facilitating conditions on the acceptance and adoption of technical innovations by users. Facilitating conditions in the sense of mobile apps include all details for downloading and configuring the application and its efficiency.

H4: Hypothesis is statistically significant, which is consistent with a Kim et al. (2010) past study where mobility has a positive impact on PU for m-payment applications. Hypothesis verifies that the m-payment software can be conveniently used by customers anywhere, at any time.

H5: The relationships PEOU and PU are supported on the basis of the hypothesis test. In a previous study of Driedigera and Bhatiasvib (2019), positive ties between PEOU and PU are confirmed by research, which means customers who find m-payment apps easy to use, or who believe they can quickly become good at using it, are likely to view it as beneficial.

H6: Hypothesis notes that the PU would positively affect the attitude towards using the m-payment app in Kim et al. (2010) previous research, where transaction speed and simple usability have a critical impact on PU for m-payment devices.

H7: The hypothesis has not provided statistically significant support. There is no correlation between trust and PU for this study, which runs counter to the result of many (Duane et al.

Table 3 Discriminant validity—HTMT criterion

	ATT TO USE	COLL	EJ	FC	MOB	PEOU	PU	TR
ATT TO USE								
COLL	0.891							
ENJ	0.826	0.743						
FC	0.89	0.801	0.752					
MOB	0.833	0.767	0.699	0.78				
PEOU	0.872	0.758	0.814	0.808	0.741			
PU	0.867	0.76	0.791	0.777	0.767	0.849		
TR	0.841	0.752	0.704	0.848	0.713	0.763	0.745	

Table 4 Fornell–Larcker criterion

	ATT	COLL	EJ	FC	MOB	PEOU	PU	
ATT	0.767							
COLL	0.936	0.782						
ENJ	0.826	0.741	0.815					
FC	0.886	0.802	0.751	0.815				
MOB	0.83	0.764	0.699	0.778	0.815			
PEOU	0.871	0.758	0.813	0.808	0.739	0.832		
PU	0.866	0.759	0.792	0.776	0.767	0.848	0.821	
TR	0.838	0.753	0.704	0.846	0.713	0.763	0.745	0.781

Table 5 Main effects and path coefficients

Hypothesis	Beta	t-value	p-value	f^2	Result
H1: COLL -> PEOU	0.141	1.249	0.212	0.025	**Not supported**
H2: ENJ -> PEOU	0.429	4.313	0	0.289	Supported
H3: FC -> PEOU	0.373	3.1	0.002	0.172	Supported
H4: MOB -> PU	0.263	2.938	0.003	0.12	Supported
H5: PEOU -> PU	0.548	5.04	0	0.443	Supported
H6: PU -> ATT	0.453	4.268	0	0.314	Supported
H7: TR -> PU	0.139	1.628	0.104	0.031	**Not supported**
H8: PEOU -> ATT	0.487	4.368	0	0.362	Supported

Note Significance level $P < 0.05$, if t-value $\geq$ 1.96, based on two-tailed t-test

2014; Yan et al. 2009; Zhou 2011) m-payment adoption studies.

H8: The finding is statistically significant, which means that PEOU is the determinant of India's decision to accept m-payments. The major impact of PEOU on m-payment is similar to previous results from studies conducted on m-payment (Apanasevic et al., 2016; Chen, 2008; Kim et al., 2010; Zhou, 2011).

6 Conclusion

As a separate financial transaction method, m-payment is taken into account by consumers worldwide. There is no study available in India to examine the plan to accept payments. To resolve this disparity, a complete model has been built to explore variables impacting India's intention to implement m-payments. These results show that the attitudes to use m-payment apps are significantly influenced by PEOU, PU, fun, ease of use and mobility.

The study examined the factors affecting the intention of Indians to accept payment. In the Covid-19 pandemic, individuals are using m-payment applications more (Singh et al., 2020). The findings indicate that enjoyment, facilitating condition and mobility have a considerable effect on adoption. However, the impact of collaboration and trust on adoption intentions is not essential. Results also show that PEOU is influenced by the enjoyment and facilitation condition. Results show that PU is greatly influenced by mobility. The findings also show that PEOU and PU are primary factors influencing the intention to accept payment.

Such results provide the provider with guidance to consider the expectations of consumers.

While very few studies in countries like India have been carried out on the adoption of the payment application, the extended TAM for the payment app has already been explained and validated. In their payment app, India and other Asian neighbours, the emergence of tremendous potential in helping understand developing countries' business actions.

Finally, to keep consumers happy and engaged, companies should involve with lucrative deals. We hope that m-payment apps service providers will integrate all of the above considerations into their thoughts and practice.

7 Limitations and Further Research

There are some restrictions in the current analysis. First of all, our respondents constitute a tiny Indian community, so future studies should look at how various lifestyles and demographics affect m-wallet services recommendations. There may be different results from a broad and various study. Besides, future research could include the efficacy and impact, for both developing and developed countries, of online pharmacy app with the user acceptance and recommendations of technology. Visual design, the attractiveness of the website, that potential researchers should recognise.

8 Research Implications

Many banks in India introduced and released their wallet to enter the market. Established m-payment services providers also implement creative offerings for new customers. As India is a developing m-payment market, this analysis offers a better interpretation of user-centred variables impacting the purpose of adopting m-payment. The research examined the relationship among five attributes for encouraging customers to use the m-payment app service. We have attempted, through extended TAM, to address elements that influence the purpose to adopt m-payment. With an executive point of view, the research findings have many repercussions for developing the m-payment system to improve the rate of adoption in India. There is a positive association between enjoyment and m-payment adoption, which means if a customer finds m-payment fun, they quickly adopt m-payment services. Both PEOU and PU significantly affect m-payment adoption. Providers must build specific creative techniques to persuade customers that this new method is more useful than conventional payment systems.

References

Al-Gahtani, S. S., Hubona, G. S., & Wang, J. (2007). Information technology (IT) in Saudi Arabia: Culture and the acceptance and use of IT. *Information Management, 44*(8), 681–691.

Al-Hawaii, M. A., & Mouakket, S. (2010). The influence of technology acceptance model (TAM) factors on students' e-satisfaction and e-retention within the context of UAE e-learning. *Education, Business and Society: Contemporary Middle Eastern Issues, 3*(4), 299–314

Alwahaishi, S., & Snáše, V. (2013). Consumers' acceptance and use of information and communications technology: A UTAUT and flow based theoretical model. *Journal of Technology, Management and Innovation, 8*(2), 61–73.

Apanasevic, T., Markendahl, J., & Arvidsson, N. (2016). Stakeholders' expectations of mobile payment in retail: Lessons from Sweden. *International Journal of Bank Marketing, 34*(1), 37–61.

Arenas-Gaitani, J., Peral-Peral, B., & Ramon-Jeronimo, M. A. (2015). Elderly and internet banking: An application of UTAUT2. *Journal of Internet Banking and Commerce, 20*(1), 1–24.

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science, 16*(1), 74–94.

Bagozzi, R. P., & Edwards, J. F. (1998). A general approach to construct validation in organisational psychology: Application to the measurement of work values. *Organisational Research Methods, 1*(1), 45–87.

Bagozzi, R. P., & Yi, Y. (2012). Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science, 40*(1), 8–34.

Chen, L. D. (2008). A model of consumer acceptance of mobile payment. *International Journal of Mobile Communications, 6*(1), 32–52.

Chin, W. W. (2001). PLS-Graph User's Guide, CT Bauer College of Business, University of Houston, USA.

Cyr, D., Head, M., & Ivanov, A. (2006). Design aesthetics leading to m-loyalty in mobile commerce. *Information and Management, 43*(8), 950–963.

Dahlberg, T., Mallat, N., Ondrus, J., & Zmijewska, A. (2008). Past, present and future of mobile payments research: A literature review. *Electronic Commerce Research and Applications, 7*(2), 165–181.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology, 22*(14), 1111–1132.

Davison, A. C., Hinkley, D. V., & Young, G. A. (2003). Recent developments in bootstrap methodology. *Statistical Sciences, 18*(2), 141–157.

Driedigera, F., & Bhatiasevib, V. (2019). Online grocery shopping in Thailand: consumer acceptance and usage behaviour. *Journal of Retailing and Consumer Services, 48*, 224–237.

Duane, A., O'Reilly, P., & Andreev, P. (2014). Realising M-payments: Modelling consumers' willingness to M-pay using smartphones. *Behaviour and Information Technology, 33*(4), 318–334.

ET. (2018). *By 2025, digital transactions in India could be worth $1 B a year.* https://economictimes.indiatimes.com/industry/banking/finance/banking/by-2025-digital-transactions-in-india-could-be-worth-1-trn-a-year/articleshow/63284898.cms?from=mdr. Last accessed August 08, 2020.

Fornell, C., & Larker, D. (1981). Evaluating structural equation models with unobserved variables and measurement errors. *Journal of Research Marketing, 27*(3), 445–466.

Grewal, R., Cote, J. A., & Baumgartner, H. (2004). Multicollinearity and measurement error in structural equation models: Implications for theory testing. *Marketing Science, 24*(4), 519–529.

Hair, J., Anderson, R., Tatham, R., & Black, C. (1998). Multivariate data analysis (5th ed.). Upper Saddle River, NJ: Prentice-Hall.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practices, 19*(2), 139–151.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modelling: Rigorous apps, better results and higher acceptance. *Long Range Planning, 46*(1–2), 01–12.

Henseler, J., Ringle, C. M., Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of Academics and Marketing Sciences, 43*(1), 115–135.

Hill, T. R., & Roldan, M. (2005). Toward third-generation threaded discussions for mobile learning: Opportunities and challenges for ubiquitous collaborative environments. *Information Systems Frontiers, 7*(1), 55–70.

Hong, S., Thong, J. Y., & Tam, K. Y. (2006). Understanding continued information technology usage behaviour: A comparison of three models in the context of mobile internet. *Decision Support Systems, 42*(3), 1819–1834.

Kapoor, A. P., & Vij, M. (2018). Technology at the dinner table: Ordering food online through mobile apps. *Journal of Retailing and Consumer Services, 58*, 342–351.

Kim, C., Mirusmonov, M., & Lee, I. (2010). An empirical examination of factors influencing the intention to use mobile payment. *Computers in Human Behavior, 26*(3), 310–322.

KPMG. (2019). *Fintech in India—Powering mobile payments.* https://assets.kpmg/content/dam/kpmg/in/pdf/2019/08/Fintech-in-India%E2%80%93Powering-mobile-payments.pdf. Last accessed August 01, 2020.

Lai, V. S., & Li, H. (2005). Technology acceptance model for internet banking: An invariance analysis. *Information Management, 42*(2), 373–386.

Lim, A. S. (2008). Inter-consortia battles in mobile payments standardisation. *Electronic Commerce Research and Applications, 7*(2), 202–213.

Lu, Y., Yang, S., Chau, P. Y., & Cao, Y. (2011). Dynamics between the trust transfer process and intention to use mobile payment services: A cross-environment perspective. *Information & Management, 48*(8), 393–403.

Mallat, N. (2007). Exploring consumer adoption of mobile payments—A qualitative study. *The Journal of Strategic Information Systems, 16*(4), 413–432.

Maruping, L. M., Bala, H., Venkatesh, V., & Brown, S. A. (2016). Going beyond intention: Integrating behavioral expectation into the unified theory of acceptance and use of technology. *Journal of the Association for Information Science and Technology.* https://doi.org/10.1002/asi.23699.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review, 20*(3), 709–734.

Nunnally, J. C. (1978). *Psychometric Theory.* New York, NY: McGraw-Hill.

Oliveira, T., Thomas, M., Baptista, G., & Campos, F. (2016). Mobile payment: Understanding the determinants of customer adoption and intention to recommend the technology. *Computers in Human Behavior, 61,* 404–414.

Ondrus, J., & Pigneur, Y. (2006). Towards a holistic analysis of mobile payments: A multiple perspectives approach. *Electronic Commerce Research and Applications, 5*(3), 246–257.

Palvia, P. (2009). The role of trust in e-commerce relational exchange: A unified model. *Information & Management, 46*(4), 213–220.

Peng, R., Xiong, L., & Yang, Z. (2012). Exploring tourist adoption of tourism mobile payment: an empirical analysis. *Journal of Theoretical and Applied Electronic Commerce Research, 7*(1), 21–33.

Pousttchi, K., & Wiedemann, D. G. (2007). What influences consumers' intention to use mobile payments. In *Proceedings of the 6th Annual Global Mobility Roundtable* (pp. 1–16). Los Angeles.

Rao, S., & Troshani, I. (2007). A conceptual framework and propositions for the acceptance of mobile services. *Journal of Theoretical and Applied Electronics Commerce Research, 2*(2), 61–73.

Raykov, T. (1997). Estimation of composite reliability for congeneric measures. *Applied Psychological Measurement, 21*(2), 173–184.

RBI. (2019). *Payment and settlement systems in India: Vision–2019–21.* Retrieved on 02 August, 2020. https://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/PAYMENT1C3B80387C0F4B30A56665DD08783324.PDF. Last accessed August 02, 2020

Riffai, M. M. M. A., Grant, K., & Edgar, D. (2012). Big TAM in Oman: Exploring the promise of online banking, its adoption by customers and the challenges of banking in Oman. *International Journal of Information Management, 32*(3), 239–250

San Martín, H., & Herrero, A. (2012). Influence of the user's psychological factors on the online purchase intention in rural tourism: integrating innovativeness to the UTAUT framework Tour Manage (Vol. 33, Vol. 2, pp. 341–350).

Schierz, P. G., Schilke, O., & Wirtz, B. W. (2010). Understanding consumer acceptance of mobile payment services: an empirical analysis. *Electronic Commerce Research and Applications, 9*(3), 209–216.

Seppala, P., & Alamaki, H. (2003). Mobile learning in teacher training. *Journal of Computer Assisted Learning, 19*(3), 330–335.

Shankar, A., & Datta, B. (2018). Factors affecting mobile payment adoption intention: An Indian perspective. *Global Business Review, 19*(3), 1–18.

Singh, A. K, Agrawal, B., Sharma, A., & Sharma P. (2020). COVID-19: Assessment of knowledge and awareness in Indian society. *Journal of Public Affairs,* e2354.

Srivastava, S. C., Chandra, S., & Theng, Y. L. (2010). Evaluating the role of trust in consumer adoption of mobile payment systems: an empirical analysis. *Communications of the Association for Information Systems, 27*(1), 561–588.

Sun, Y., et al. (2013). Understanding the acceptance of mobile health services: A comparison and integration of alternative models. *Journal of Electronics Commerce Research, 14*(2), 183.

Taylor, D. G., & Levin, M. (2014). Predicting mobile app usage for purchasing and information-sharing. *International Journal of Retail & Distribution Management, 42*(8), 759–774.

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research, 11*(4), 342–365.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly, 36*(1), 157–178.

Viehland, D., & Leong, R. S. Y. (2010). Consumer willingness to use and pay for mobile payment services. *International Journal of Principles and Applications of Information Science and Technology, 3*(1), 35–46.

Wu, J.-H., & Wang, S.-C.: What drives mobile commerce?: An empirical evaluation of the revised technology acceptance model. *Information Management*, 42(5), 719–729.

Yan, A. W., Md-Nor, K., Abu-Shanab, E., & Sutanonpaiboon, J. (2009). Factors that affect mobile telephone users to use mobile payment solution. *International Journal of Economics and Management, 3*(1), 37–49.

Zarmpou, T., Saprikis, V., Markos, A., & Vlachopoulou, M. Modeling users' acceptance of mobile services". *Electronic Commerce Research, 12*(2), 225–248.

Zhou, T. (2011). The effect of initial trust on user adoption of mobile payment. *Information Development, 27*(4), 290–300.

Modelling Enablers of Customer-Centricity in Convenience Food Retail

Vishal Srivastava and Manoj Kumar Srivastava

Abstract

This research article identifies the factors most needed to establish customer-centricity (CC) that convenience food customers most enjoy. The study collected primary data from 216 customers in India. In the study, potential variables were identified by concurrent research articles. This study identifies the factors required for customer-centricity and arranges them in order of priority, so that retailers can use them without any complexity. To develop such a model, the study has used the AHP tool. The study has classified the criteria of customer centricity into criteria and sub-criteria categories. Expanded food counters, attractive deals and discounts, store reputations and customer-oriented operations make convenience food retailing the main criteria for customer-centricity, while ambient, innovation, effective CRM as sub-criteria for customer-centricity. This study suggests that for convenience food retailing, retailers need to further empower these factors. Further studies on un-packaged food articles can identify more areas of improvement in existing food retail operations.

1 Introduction: Convenience Food Retail

The food and grocery market is classified as processed convenience food and commercially prepared food. Such food intake can be reduced or uncooked (Ahmed et al. 2005). The food category includes semi-processed and processed foods, ready to eat and frozen pizzas, sandwiches, sausages and crumbs, canned vegetables and canned fruits, salads, confectionery, salads, dry-ready meals and similar foods (Jackson and Weihoff 2016). Convenience food is commonly defined as "ready to cook or ready to eat" (Pafau and Saba 2009) foods. Although such foods are easy to store, carry and consume, they also have some harmful effects (Gomez and Rickets 2013; Warde 1999).

The convenience food market is growing with CAGR 10.7% (Prasannan 2017). According to the report of the Global Ready Meal Market, the total value of this market will be the US $ 146,247 million by 2023 as compared to the US $ 72,257 million in 2016. Marketers believe that although convenience food is associated with food retailing (Jackson et al. 2018), this subdivision reflects its different types of characteristics and needs. Teenagers contribute the most to the convenience food market (Wahlen et al. 2016). However, the trend is somewhat different in medium-sized cities. People here prefer vegetarian products over non-vegetarians. Surprisingly, residents of a medium-sized city do not like any type of packaged food (i.e., vegetarian or non-vegetarian) (Kumar and Kapoor 2015). Fruits and vegetables are most commonly purchased in these cities (Ali et al. 2010).

1.1 Customer Centricity in Convenience Food Retailing

In the present highly competitive era, customer-centricity is the best tool to handle the complex needs of customers (Gabauer et al. 2011). Customer's buying behaviour of food is quite different from any other category of product. People tend to rely more on local food supply chains (Thomas-Francois et al. 2017) for regular foods, while people use online stores with specific precautions for particular foods (Onozaka et al. 2010). We can classify food buyers based on their daily needs, such as traditionalists or

V. Srivastava (✉)
Dr. A.P.J. Abdul Kalam Technical University, Lucknow, India
e-mail: drvsmba@gmail.com

M. K. Srivastava
Management Development Institute, Gurgaon, India

adventurous and health-conscious shoppers (Rong-Daliang and Lim 2011). Based on food habit, food market can also be classified as core food market and non-core food market (Sharma et al. 2017). This convenience food comes under the non-core food market.

Since food is the basic need of every person, retailers in today's competitive market need to focus on customer-centricity in order to take advantage of its business opportunities. A case study on fast-food chains found that despite the excellent quality of food, the seller's lack of good relationships with customers would harm the store (Pinto et al. 2018). A convenience food retailer cannot afford to adopt a customer-centric approach as just an option. A study in Africa established that customer convenience, in addition to quality, diversity and price, is one of the essential factors for the stability and growth of the store (Nilsson et al. 2019).

1.2 Customer Centricity Enablers

Through concurrent literature, the study identified twenty-seven customer-centricity enablers.

2 Problem Discussion

Maslow (1943) in his theory of human motivation classifies the basic or biological and physical needs of man as food, air, drink, shelter, warmth, sex and sleep. In the early era of civilization, the primary form of trade was barter (Samuelsson 1939), in which goods or services are exchanged with necessities. Food and grains were mainly used for barter in those days. In the early days, food vendors used to be independent retailers, who sold food products produced by local producers and farmers to the nearby market (Grimmer 2019). By the twenty-first century, food sales have changed from simple business to modern, technology-based supermarkets. Fotex is considered to be the first food supermarket, started in Denmark by Herman Saling in the year 1960 (Stanton 2018). "Food and Grocery Retail—Global Market Outlook 2020" is forecasting its global market size to be USD 12.24 trillion by the end of the year 2020 with a CAGR of 6.9%.
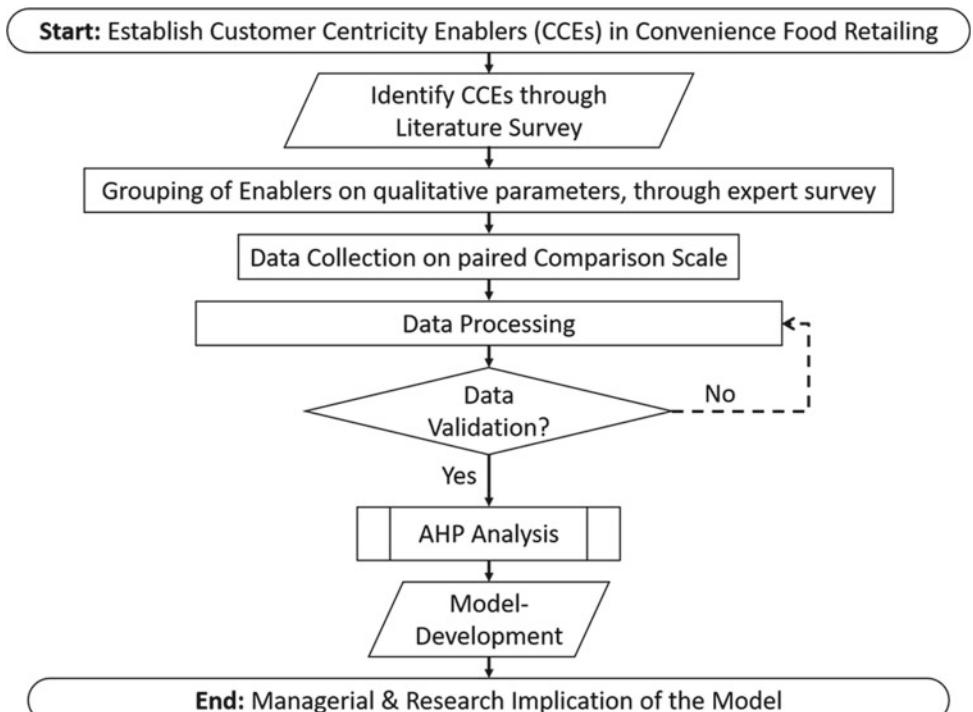
With the adoption of new technology and open economy policy worldwide, the level of competition has also increased manifold. The study by Ali and Alam (2017) gave analytical evidence of severe competition in food retailing. In his study, customer-centricity has been considered as the best tool not only to maintain the existing customer base but also to attract new customers.

The current research study aims to identify ways through which retailers can enable customer-centric approaches in their retail operations. The outline of the study is given in Fig. 1.

The study attempts to identify and arranges the customer centricity in order of priority so that that retailer can enable it without any complexity. This type of hierarchy cannot be developed by regression, conjoint or any other known tool. Therefore, to develop such a model, the study is using AHP

Fig. 1 Outline
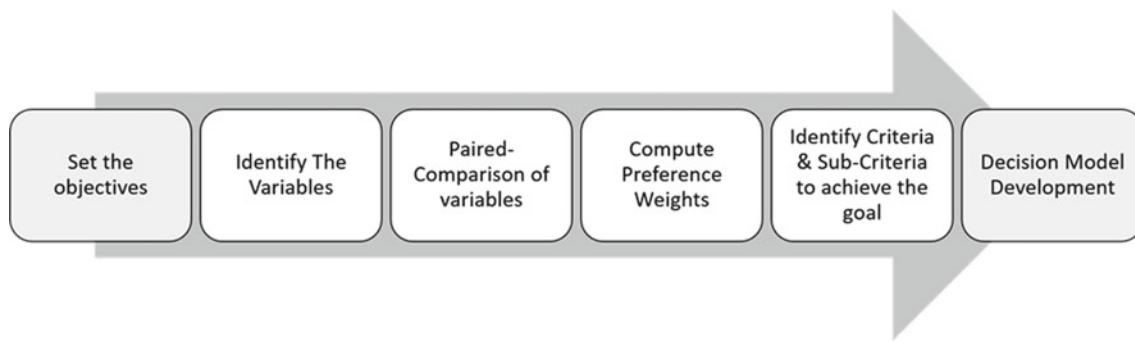
Fig. 2 Process framework for AHP

tool. Analytic hierarchy process is a decision-making tool developed by (Saaty 1988). This tool helps to evaluate a various alternative to achieve a goal. The judgement of priority variables works over the eigenvalues of customer preference. An AHP model can build the model over pre-selected variables associated with a specific goal. It is also termed as the benefits measurement model. Ease in analysis and managerial judgement, quick identification of differences in managerial judgements and perceptions make this tool widely accepted (Calantone et al. 1998). The model builds a hierarchy structure from goal, criteria and sub-criteria (Fong and Choi 2000). A summarized process framework for AHP is given in Fig. 2. We can detail the AHP technique in the following steps:

(1) Define objective.
(2) Identify variables.
(3) Develop AHP pairwise comparison matrix.
(4) Normalize the matrix.
(5) Check the consistency.
(6) Perform pairwise comparison.
(7) Calculate preference weights.
(8) Select the criteria.
(9) Build the model.

An outcome of the AHP model looks like a hierarchy structure (Fig. 3), as described by (Xi and Qin 2013). Here, Gaol denotes the objective of the modal.

3 Research Methodology

This study follows the model-building research design. It involves secondary and primary data that was collected through detailed literature and public survey. The list is given in Table 1. For data analysis and decision making, AHP technique is used. A significant challenge associated with AHP is, the application complexity multiplies with the number of variables, considered in the study. The study

Fig. 3 Hierarchy structure

used an expert survey method to reduce the number of variables. The purpose of this survey was to reduce the number of variables by grouping the similarity or close association.

This survey grouped twenty-seven identified enablers into eight variables. The list of newly framed variables and their codes are given in Table 2.

The primary data was collected through mall intercept and an online survey. For this, a random sample of two hundred fifty (250) shoppers were selected from the various metro and semi-metro cities of India. Among these, two hundred nineteen (219) records were found complete for the study purpose. The study used a structured questionnaire to collect responses.

The scale used here is slightly modified to make better clarity about the question among respondents. This questionnaire is consists of twenty-eight (28) semantic differential like nine (09) point scales, for paired comparison of variables. In place of 1 to 9 scale, the study used a bipolar nine-point scale. The scale has two extreme values, five (05), to measure the relative opinion of respondents on variable A over B and vice-versa. This scale is calibrated into nine (09) parts, among which, the mid-value (01 points)

Table 1 Customer centricity enablers

Sr no	Reference	Customer centricity enablers
1	(Shah et al. 2006)	Customer-oriented organizational structure, externally focused format, focusing customer lifetime value, managing portfolio of customers
2	(Bianchi 2009)	Feelings of personal safety
3	(Dodds et al. 1991)	Positive perceptions of product quality
4	(Eid 2011)	Customer interaction quality
5	(Ero et al. 2013)	Existence of meat section, existence of bakery, vegetables and fruits counters, frozen food counters, number of staff, recognition of retail, efforts and expenses on advertising
6	(Fairchild and Peterson 2003)	E-business governance mechanism, continuous process improvement
7	(Gebauer et al. 2010)	Practising solution business, orientation towards services, service-focused organizational structure, orientation towards customers
8	(Homburg et al. 2002)	Customer-focused organizational structure
9	(Surianarayanan and Kumar 2016)	Encouraged in the from the government policies
10	(Jaworski and Kohli 1993)	Market-oriented organization
11	(Kumar and Petersen 2005)	Encourages cross-buying, encourages up-buying, encourages multichannel shopping
12	(Lemmink and Mattsson 1998)	Loyalty towards store
13	(Lukhanyu 2018)	Premium location of store, offering membership card, clean and spacious atmosphere, attractive display and decoration, small queues at counters, frequency of promotions and discounts, recognizing loyal customers
14	(Neu and Brown 2005)	Healthy relationship with customers, product-service integrated organization structure
15	(Ondrus and Pigneur 2004)	Innovative payments system
16	(Parasuraman et al. 1985)	Store know the needs of customers, store has best interests of customers at heart
17	(Seiders et al. 2000)	Availability of sit-down tables
18	(PK 2013)	Store differentiate themselves from competitor
19	(Zambre et al. 2010)	Opportunities in food and beverages
20	(Srivastava 2012)	After sales services

demonstrates that both variables are equally important. The format of one sample scale (question) of the questionnaire is given in Table 3.

The collected responses are tabulated in such a way that, if the respondent prefers any variable, another variable will get the reciprocal of the first one. An example is given below (Table 4):

In Table 4, column 1 and row 1 have the same variable A, so both are equally preferred. Therefore, the cell value is 1. Whereas, in row 2, column 1, A is more preferred over B by score 4, therefore, the opposite cell (column 2, row) will have reciprocal value, i.e., 1/4.

Similarly, in the third column and first row variable C is more preferred over variable A by 2. Therefore, the value is

2, whereas the opposite column 1 and row 3, will have the reciprocal of it, i.e., 1/2.

Thus, each respondent was asked to give their opinion on above-defined paired comparison scales. The scaling was done.

V1/V2, V1/V3, V1/V4, V1/V5, V/V6, V1/V7, V1/V8,

V2/V3, V2/V4, V2/V5, V2/V6, V2/V7, V2/V8,

V3/V4, V3/V5, V3/V6, V3/V7, V3/V8,

V4/V5, V4/V6, V4/V7, V4/V8,
V5/V6, V5/V7, V5/V8,

Table 2 Grouped enablers variables

Code	Enabler	Variables
V1	Ambience	Clean and spacious atmosphere, attractive display and decoration
V2	Social image	Market-oriented organization, recognition of retail, externally focused format, premium location of store, store differentiate themselves from competitor, positive perceptions towards product quality
V3	Orientation towards customers	Managing portfolio of customers, orientation towards customers, focusing customer lifetime value, feelings of personal safety, store has best interests of customers at heart, customer-focused organizational structure, product-service integrated organization structure, availability of sit-down tables
V4	Innovation	Small queues at counters, innovative V5 payments system, continuous process improvement, e-business governance mechanism
V5	Service orientation	Number of staff, customer-oriented organizational structure, orientation towards services, service-focused organizational structure, encourages multichannel shopping
V6	Extended counters	Existence of meat section, existence of bakery, vegetables and fruits counters, frozen food counters, opportunities in food and beverages
V7	Sales promotion policy	Efforts and expenses on advertising, frequency of promotions and discounts, encourages cross-buying, encourages up-buying
V8	Effective CRM	Customer interaction quality, recognizing loyal customers, strong relationship with customers, loyalty towards store, practising solution business, store know the needs of customers

Table 3 Paired comparison scale

Statement	Variable A
A is definitely more important than B	5
A is strongly more important than B	4
A is moderately more important than B	3
A is slightly more important than B	2
Both A and B are equally important	1
B is slightly more important than A	2
B is moderately more important than A	3
B is strongly more important than A	4
B is definitely more important than A	5
	Variable B

Table 4 AHP-survey data handling

Variables	A	B	C
A	1 (equal preference)	1/4 (non-preferred)	2 (C preferred over A)
B	4 (A preferred over B)	1 (equal preference)	1 (equal preference)
C	1/2 (non-preferred)	1 (equal preference)	1 (equal preference)

V6/V7, V6/V8,

V7/V8.

4 Data Analysis

As mentioned above, to perform AHP analysis, the study follows the mentioned steps.

4.1 Define Objective

The prime objective of this study is to achieve customer-centricity in convenience food retail stores. To attain customer-centricity, retailers need to know the enablers of customer-centricity. Therefore, the purpose of this study is to evaluate the enablers of customer-centricity in food retail and arranging them in a hierarchy (Fig. 4).
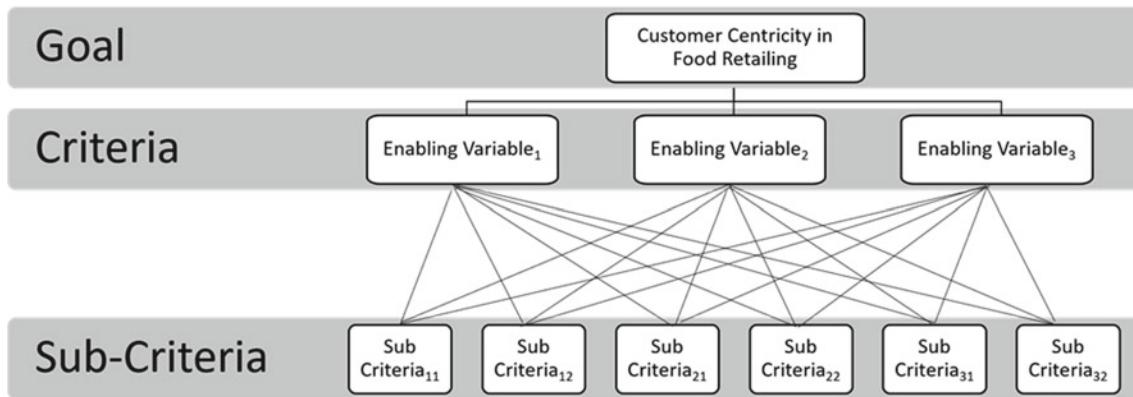
Fig. 4 Hierarchy Arrangement

4.2 Identify Variables

As mentioned in Table 1, after a detailed literature survey, the study identified 27 customer-centricity enables in convenience food retails, which are grouped in eight variable, from V1 to V8.

4.3 Develop AHP Pairwise Comparison Matrix

The study collected pair-comparison data from 116 respondents (shoppers) over the above-mentioned eight variables. 119 AHP matrices developed for every observation. An AHP pairwise comparison matrix is given below. In this matrix, 'I' stands for a row, where 'j' stands for column and 'ij' for respective cell, whereas cell C_{ij} denotes the preference of the column variable (V_j) over row variable (V_i).

$$\begin{bmatrix} Variable & V1 & V2 & V3 & Vj \\ V1 & C_{11} & C_{12} & C_{.........} & C_{1j} \\ V2 & C_{21} & C_{22} & C_{.........} & C_{2j} \\ V3 & C_{31} & C_{32} & C_{.........} & C_{3j} \\ Vi & C_{i1} & C_{i2} & C_{.........} & C_{ij} \end{bmatrix}$$

$$\begin{bmatrix} Col.Sum & CS_1 & CS_2 & CS.... & CS_j \end{bmatrix}$$

Here, the cell value denotes the preference of the column variable (V_j) over row variable (V_i).

4.4 Data Cleaning

The study used a scatter plot to identify the outliers. The study used principal eigenvalues of the observation to measure it. As visible in Fig. 5 three observations, respondent ID—98, 126 and 204, are found with extreme values. For further analysis, these observations are removed from the data set.

4.5 AHP Execution

The study used 116 responses for decision making, after removal of outliers mentioned above. The mean score of 116 matrices used in this study is given in Table 6. The column sum values and mean preference values of all the paired comparison sum are demonstrated in Fig. 6.

4.6 Normalize the Matrix

After filling the matrix from pared comparison, one needs to sum of every column (C_{sj}). Now, to normalize matrix in the

Fig. 5 Observations
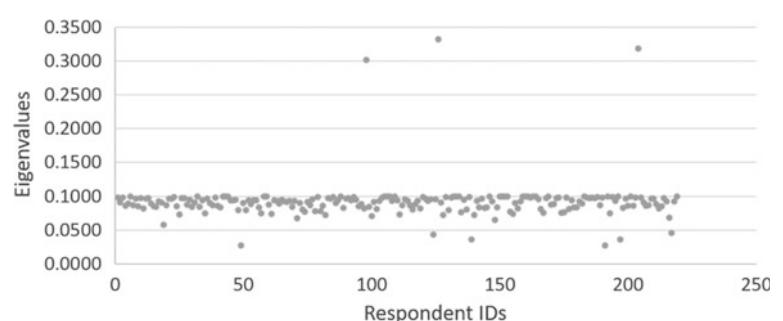
Table 5 Preference weights of each variable

Variable	V1	V2	V3	V4	V5	V6	V7	V8
Mean	0.1568	0.1002	0.1003	0.1583	0.1430	0.0826	0.0814	0.1773
Variance	0.0034	0.0028	0.0008	0.0011	0.0020	0.0002	0.0001	0.0058
SD	0.0582	0.0530	0.0280	0.0336	0.0451	0.0154	0.0114	0.0763

Table 6 Mean matrix of pairwise comparison matrices

|	V1	V2	V3	V4	V5	V6	V7	V8
V1	1	1.956897	2.034483	1.423851	1.29023	2.409483	1.681034	1.221264
V2	0.691092	1	1.220546	0.966954	1.024425	1.31681	1.130747	1.161638
V3	0.691092	1.399425	1	0.70546	1.246408	1.685345	1.577586	0.978448
V4	1.474138	1.659483	2.137931	1	1.619253	2.452586	2.224138	1.113506
V5	1.274425	2.007184	1.873563	0.862787	1	2.685345	2.655172	1.313218
V6	0.551724	1.409483	1.014368	0.595546	0.488218	1	1.422414	0.882184
V7	0.952586	1.435345	0.873563	0.612787	0.496839	1.119253	1	0.956178
V8	1.783046	1.941092	1.793103	1.742816	1.454454	1.771552	2.156609	1
Total	8.418103	12.81753	11.94756	7.910201	8.662931	14.44899	13.88218	8.626437

order of 1, first each cell value C_{ij} is divided by its respective column sum (CS_j). The newly created matrix is given below.

$$\begin{bmatrix} Variable & V1 & V2 & V3 & Vj \\ V1 & N_{11} & N_{12} & N_{\ldots} & N_{1j} \\ V2 & N_{21} & N_{22} & N_{\ldots} & N_{2j} \\ V3 & N_{31} & N_{32} & N_{\ldots} & N_{3j} \\ Vi & N_{i1} & N_{i2} & N_{\ldots} & N_{ij} \end{bmatrix} \begin{bmatrix} RowSum \\ R_1 \\ R_2 \\ R_3 \\ R_i \end{bmatrix}$$

Afterwards, the cell values (N_{ij}) of new matrix are added-up to get row-wise sum (R_i) of variables. The mean values of the matrices in this study are given in Table 7

4.7 Calculate Preference Weight

To calculate the preference weights of variables (PW_i), each row sum (R_i) is divided by the number of variable n (in this study n = 8) (Eq. 1). These preference weights of variables are considered for decision making. However, before this, the study needs to evaluate the consistency of survey responses.

$$(PW_i) = \frac{R_i}{n} \tag{1}$$

The mean of preference weights of the observation, under this study, are given in Table 8

4.8 Check the Consistency

To test consistency, as prescribed by (Saaty 2008), study follows the following process:

(1) Calculation of eigenvalues.
(2) Calculation of principal eigenvalue.
(3) Calculation of consistency indices.
(4) Calculation of consistency ratio.

As per AHP model, eigenvalue (λ) of variable is a product of preference column sum (CS_j) of variable and preference weight (PW_i) of a variable (Eq. 2). The eigenvalues of the observations are given in Fig. 7.

$$\lambda = (CS_j) \times (PW_i) \tag{2}$$

The principal eigenvalue (λ_{max}) is a sum of all eigenvalues (λ). From principal eigenvalues, AHP model calculates the consistency indices, which ultimately used to validate the model.

The AHP model prescribes, the formula to calculate the consistency indices (CI) as (Eq. 3)-

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3}$$

Fig. 6 Comparison
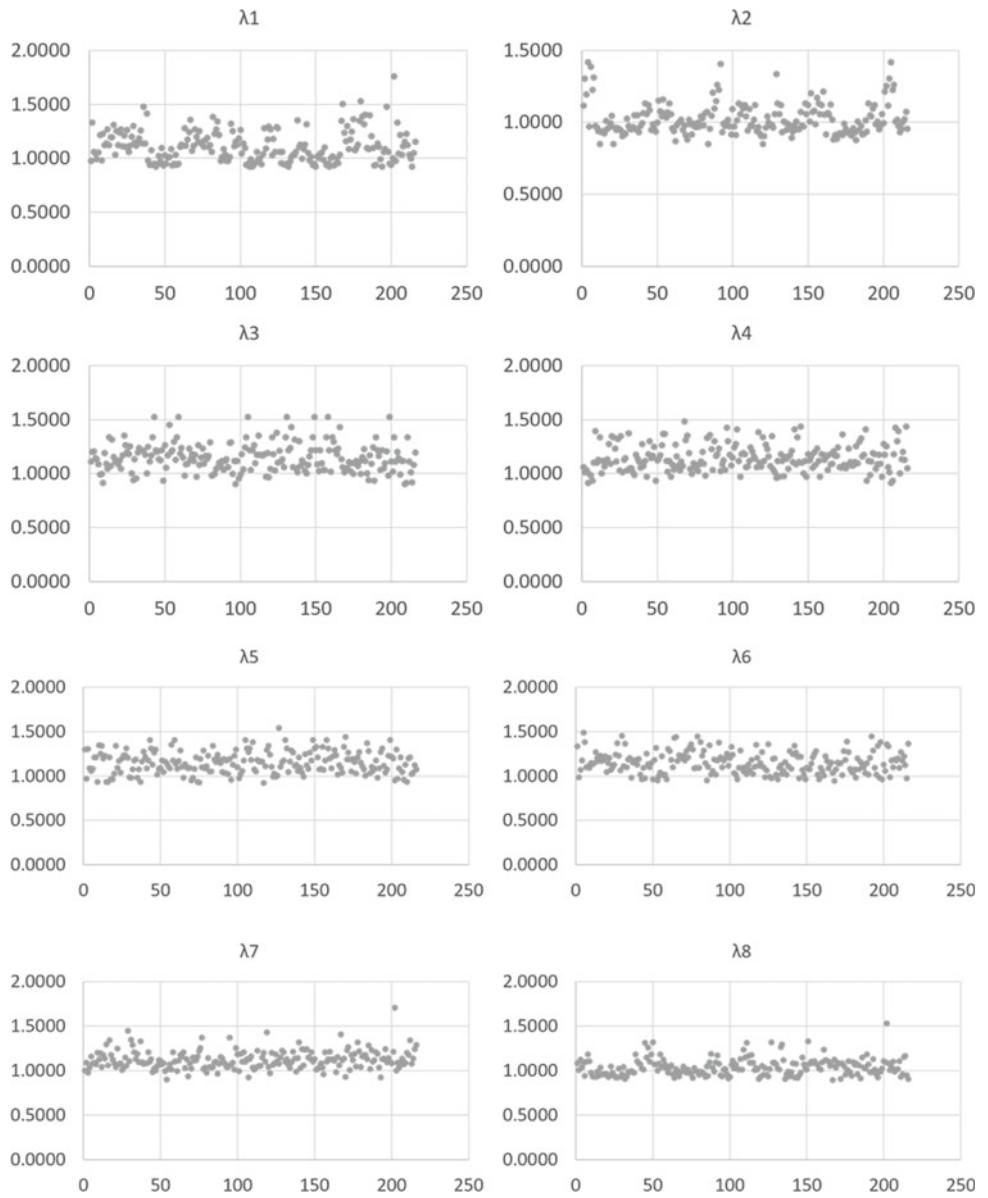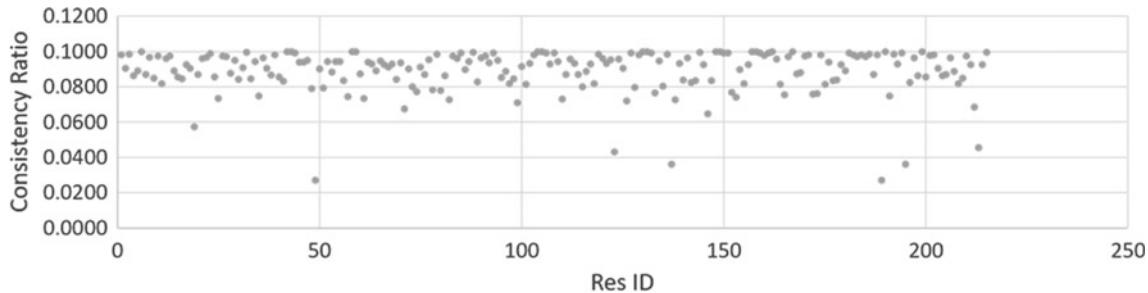
Table 7 Mean matrix of normalize matrices

	V1	V2	V3	V4	V5	V6	V7	V8	Row sum
V1	0.147613	0.179474	0.181601	0.165791	0.138355	0.17765	0.124466	0.13958	1.254531
V2	0.096251	0.096762	0.109417	0.11756	0.097447	0.093147	0.083346	0.107891	0.801821
V3	0.078381	0.098597	0.087069	0.078619	0.114056	0.116584	0.113835	0.115055	0.802196
V4	0.158683	0.123432	0.179758	0.139297	0.208401	0.174194	0.16966	0.113106	1.266531
V5	0.141985	0.14333	0.149217	0.097942	0.129526	0.170571	0.174769	0.136869	1.144209
V6	0.068533	0.101915	0.079445	0.063863	0.058241	0.072511	0.100078	0.116551	0.661138
V7	0.10889	0.103059	0.066602	0.066435	0.059431	0.076256	0.075333	0.095262	0.651268
V8	0.199663	0.153431	0.146892	0.270493	0.194542	0.119087	0.158514	0.175686	1.418308
	1	1	1	1	1	1	1	1	n = 8

Table 8 Mean preference weights of variables

Variables	V1	V2	V3	V4	V5	V6	V7	V8	Total
Mean preference weights	0.156816	0.100228	0.100274	0.158316	0.143026	0.082642	0.081408	0.177289	1

Fig. 7 Eigenvalues of the observations

Table 9 Random inconsistency indices (RI) for N = 10

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.46	1.49

Source Satty (1980)

Table 10 Summary of consistency ratio

Minimum	Maximum	Mean	Median	Mode	Standard deviation
0.02712979	0.09999175	0.08885341	0.09253111	0.09989295	0.01240193

The consistency indices of 166 observation, as per the mentioned Eq. 3, are given in Fig. 10. Finally, to test the validity, the study calculates the consistency ratio. The CR defines whether the model is consistent or not. (Saaty 2008) suggested to ensure consistency, and the CR must not be higher than 10% or 0.10. (Saaty 2008). For testing the consistency, the study divides the CI by respected consistency random indices (RI), from Table 9. The formula for CR is (Eq. 4).

$$CR = \frac{CI}{RI} \qquad (4)$$

The study is considering eight variables; therefore, N is 8 for each observation. In this study, all the values of CR are found less than 0.10, which validates the model. The description and details of the observations' CR values are given in Table 10.

5 Findings and Interpretation

So, the outcomes of the above data analysis can be interpreted as:

(1) Based on preference weights, the customer priorities are found as—extended food counters (V6), promotion activities (V7), social image or reputation (V2), orientation towards customers (V3), service orientation (V5), ambience (V1), effective CRM (V8) and innovation (V4) in descending order.

(2) The variance of preferences of respondents over other variable reflects that they have differences in their opinions, especially for enabler CRM effectiveness (V8) and ambience of retail (V1). In contrast, their opinion towards orientation towards customers (V3),

extended food counters (V6) and sales promotion activities (V7) is quite uniform. (Table 5).

(3) Based on preference weights, the variables can be classified into two groups: category-1 of social image or reputation (V2), orientation towards customers (V3), extended food counters (V6) and sales promotion activities (V7); whereas category-2 of ambience of retail (V1), innovation (V4), service orientation (V5) and effective CRM (V8) to achieve customer-centricity in convenience food retailing

(4) AHP model classifies the higher weight variable as criteria and lower weight variables as sub-criteria to achieve customer-centricity in convenience food retailing.

(5) The study can model the enablers to establish customer-centricity in convenience food retails with the calculation mentioned in Fig. 8.
   (a) Goal: customer centricity in convenience food retail
   (b) Criteria: extended food counters (V6), promotion activities (V7), social image or reputation (V2), orientation towards customers (V3)
   (c) Sub-Criteria: service orientation (V5), ambience (V1), effective CRM (V8) and innovation (V4)

6   Implication

This study is a vital tool for the convenience food retailer to not only retain their customer base but to attract new customer also.

(1) The study suggests that retailers need to focus on the variety of need of customers towards customization of their CRM services, and the layout of various types of food counters and handling customer choices. Even with high consistency in weights, the high variance of such enabling factor in their preference score is the pieces of evidence for it.

(2) Against of present practices of stocking all the convenience food article together, retailers need to work upon the extension of food counters (category wise), which makes better clarity in customer mind towards the availability and variety of convenience food articles.

(3) Retailers can maximize their sales, attract and retain more customers, through better and attractive sales promotion schemes like—increased frequency of deals and discounts, encouraging cross-buying and encouraging up-buying.

(4) Specifically, for food retails, the social image or reputation in public plays a pivot role. People prefer to buy food articles from reputed stores only. Therefore, such retailers need to cautious in this field.

7   Conclusion

This study model the enablers to establish customer-centricity in convenience food retails. The study used AHP tool for model building. The study identified that extended food counters, attractive deals and discounts, and the reputation of the store and customer-oriented operation could enable the customer centricity in convenience food stores. However, the other enablers like—ambience, innovation and
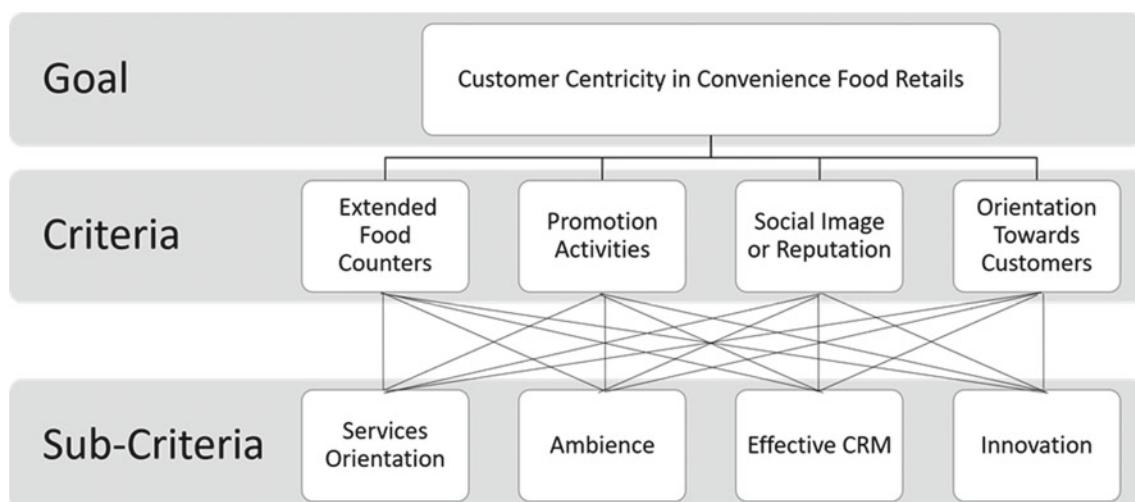

Fig. 8 Food retails with the calculation

effective CRM are also found useful as sub-criteria to enable the customer centricity in such stores. This study can be further extended to other segments of retailing like—lifestyle product and FMCGs. This study conducted in metro and semi-metro cities of India, and its applicability needs to be tested in rural, semi-urban areas and other countries.

References

Ahmed, A., Ahmed, N., & Salman, A. (2005). Critical issues in the packaged food business. *British Food Journal, 107*(10), 760–780.

Ali, J., Kapoor, S., & Moorthy, J. (2010). Buying behaviour of consumers for food products in an emerging economy. *British Food Journal, 112*(2), 109–124.

Ali, T., & Alam, A. (2017). Understanding competition across retail distribution channels of health and wellness food products in India. *Journal of Asia-Pacific Business, 18*(2), 117–130.

Bianchi, C. C. (2009). Investigating consumer expectations of convenience-store attributes in emerging markets: Evidence in chile. *Journal of International Consumer Marketing, 21*(4), 309–320.

Calantone, R. J., Graham, J. L., & Mintu-Wimsatt, A. (1998). Problem-solving approach in an international context: Antecedents and outcome. *International Journal of Research in Marketing, 15*(1), 19–35.

Dodds, W. B., Monroe, K. B., & Grewal, D. (1991). Effects of price, brand, and store information on buyers' product evaluations. *Journal of Marketing Research, 28*(3), 307–319.

Eid, M. I. (2011). Determinants of e-commerce customer satisfaction, trust, and loyalty in Saudi Arabia. *Journal of Electronic Commerce Research, 12*(1), 78.

Eroğlu, E., et al. (2013). Factors affecting consumer preferences for the retail industry and retailer selection using the Analytic Hierarchy Process. *Kafkas Üniversitesi İktisadi Ve İdari Bilimler Fakültesi Dergisi, 4*(6), 43–57.

Fairchild, A. M. and Peterson, R. R. (2003). Business-to-business value drivers and e-business infrastructures in financial services: Collaborative commerce across global markets and networks. In *Proceedings of the 36th Annual Hawaii International Conference on System Sciences*, 2003 p 10, IEEE.

Fong, P.S.-W., & Choi, S.K.-Y. (2000). Final contractor selection using the analytical hierarchy process. *Construction Management and Economics, 18*(5), 547–557.

Gebauer, H., Edvardsson, B., Gustafsson, A., & Witell, L. (2010). Match or mismatch: Strategy-structure configurations in the service business of manufacturing companies. *Journal of Service Research, 13*(2), 198–215.

Gebauer, H., Gustafsson, A., & Witell, L. (2011). Competitive advantage through service differentiation by manufacturing companies. *Journal of Business Research, 64*(12), 1270–1280.

Gómez, M. I., & Ricketts, K. D. (2013). Food value chain transformations in developing countries: Selected hypotheses on nutritional implications. *Food Policy, 42,* 139–150.

Grimmer, L. (2019). Disrupting the giants: how independent grocers respond to the supermarket duopoly in Tasmania, Australia. In *Case Studies in Food Retailing and Distribution*, pp 13–24. Elsevier.

Homburg, C., Hoyer, W. D., & Fassnacht, M. (2002). Service orientation of a retailer's business strategy: Dimensions, antecedents, and performance outcomes. *Journal of Marketing, 66*(4), 86–101.

Jackson, P., & Viehoff, V. (2016). Reframing convenience food. *Appetite, 98,* 1–11.

Jackson, P., Brembeck, H., Everts, J., Fuentes, M., Halkier, B., Hertz, F. D., Meah, A., Viehoff, V., and Wenzl, C. (2018). The spatialities of convenience food. In *Reframing Convenience Food*, pp. 117–135. Springer.

Jaworski, B. J., & Kohli, A. K. (1993). Market orientation: Antecedents and consequences. *Journal of Marketing, 57*(3), 53–70.

Kumar, N., & Kapoor, S. (2015). Does the consumers' buying behaviour differ for vegetarian and non-vegetarian food products? Evidence from an emerging market. *British Food Journal, 117*(8), 1998–2016.

Kumar, V., & Petersen, J. A. (2005). Using a customer-level marketing strategy to enhance firm performance: A review of theoretical and empirical evidence. *Journal of the Academy of Marketing Science, 33*(4), 504–519.

Lemmink, J., & Mattsson, J. (1998). Warmth during non-productive retail encounters: The hidden side of productivity. *International Journal of Research in Marketing, 15*(5), 505–517.

Lukhanyu, M. W. (2018). The Influence of marketing on customer satisfaction: a case of mini supermarkets in Nairobi County. PhD thesis, Strathmore University.

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review, 50*(4), 370.

Neu, W. A., & Brown, S. W. (2005). Forming successful business-to-business services in goods-dominant firms. *Journal of Service Research, 8*(1), 3–17.

Nilssen, R., Bick, G., & Abratt, R. (2019). Comparing the relative importance of sustainability as a consumer purchase criterion of food and clothing in the retail sector. *Journal of Brand Management, 26*(1), 71–83.

Ondrus, J. and Pigneur, Y. (2004). Coupling mobile payments and CRM in the retail industry. In *Proceedings of the IADIS International E-Commerce*, Lisbon, Portugal.

Onozaka, Y., Nurse, G., McFadden, D. T., et al. (2010). Local food consumers: How motivations and perceptions translate to buying behaviour. *Choices, 25*(1), 1–6.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing, 49*(4), 41–50.

Pfau, C. and Saba, A. (2009). Preparing meals in later life. In *Food for the ageing population*, pp 560–579. Elsevier.

Pinto, G., Ribeiro, H., Alves, S. R., and Veloso, C. M. (2018). Customer satisfaction, product and service quality in retail management: The case of a fast-food chain. In *Economic and Social Development: Book of Proceedings*, pp. 483–491.

PK, M. (2013). Problems and prospects of the retailing industry in India: A macro perspective. *CLEAR International Journal of Research in Commerce & Management, 3*(5).

Prasannan, A. (2017). *Ready meals market*.

Rong-Da Liang, A. and Lim, W. M. (2011). Exploring the online buying behaviour of speciality food shoppers. *International Journal of Hospitality Management, 30*(4):855–865.

Saaty, T. L. (1988). What is the analytic hierarchy process? In *Mathematical models for decision support*, pp. 109–121. Springer.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences, 1*(1), 83–98.

Samuelson, P. A. (1939). The gains from international trade. *Canadian Journal of Economics and Political Science/Revue Canadienne De Economiques Et Science Politique, 5*(2), 195–205.

Seiders, K., Berry, L. L., & Gresham, L. G. (2000). Attention, retailers! How convenient is your convenience strategy? *MIT Sloan Management Review, 41*(3), 79.

Shah, D., Rust, R. T., Parasuraman, A., Staelin, R., & Day, G. S. (2006). The path to customer-centricity. *Journal of Service Research, 9*(2), 113–124.

Sharma, Y., Nasreen, R., & Mishra, V. (2017). Impact of consumer-centric marketing-mix on purchase behaviour of non-core food items: An empirical study of urban subsistence marketplace. *Asian Journal of Managerial Science, 6*(2), 28–41.

Srivastava, V. (2012). Passenger car owners perceptions of after-sales service quality of service centres: An assessment of the SERVQUAL dimensions. *SAARANSH Bi-Annual International Journal of Management, 4*(1), 97–101.

Stanton, J. L. (2018). A brief history of food retail. *British Food Journal, 120*(1), 172–180.

Surianarayanan, R., & Kumar, V. S. (2016). Issues and challenges in retail marketing: With special reference to Thanjavur district. *International Journal of Business and Administration Research Review, 3*(15), 58–63.

Thomas-Francois, K., von Massow, M., & Joppe, M. (2017). Service-oriented, sustainable, local food value chain–a case study. *Annals of Tourism Research, 65,* 83–96.

Wahlen, S., van der Horst, H., and Pothoff, R. (2016). How convenient. Adolescents â€™ vistas on food competences in a convenience context. *British Food Journal, 118*(11), 2828–2838.

Warde, A. (1999). Convenience food: Space and timing. *British Food Journal, 101*(7), 518–527.

Xi, X., & Qin, Q. (2013). Product quality evaluation system based on AHP fuzzy comprehensive evaluation. *Journal of Industrial Engineering and Management (JIEM), 6*(1), 356–366.

Zambre, S. S., Venkatesh, K., & Shah, N. (2010). Tomato redness for assessing ozone treatment to extend the shelf life. *Journal of Food Engineering, 96*(3), 463–468.

Comparative Analysis of Banks in Terms of Service Quality

Monika Arora and Megha Mehta

Abstract

In India, banking sectors is facing a dynamic challenge regarding the base of customer base and its satisfaction. Quality in service or service is considered to be an important asset which helps in evaluation of customer satisfaction. Getting customer satisfaction can serve as a basis for customer retention. The banks are working hard to achieve customer satisfaction by providing high quality services. This study measures and compares customer perceptions on service quality of private sector and public banks using SERVQUAL model. For this research, the structured questionnaire was built and primary data have been collected using five different sections consisting of different questions. The study found that the service quality of private sector banks is working much better than public sector banks. The five parameters reliability (R), responsiveness (R), assurance (A), empathy (E) and tangibles (T) (RATER) for service quality for the bank were selected. The chi-square test was chosen to be applied for categorical variables where two variables are independent. The chi-square test was applied to all the parameters and the significant parameter was considered for further analysis for customer satisfaction

Keywords

Bank • Service quality • Customer satisfaction

M. Arora (✉)
Apeejay School of Management, Dwarka, New Delhi, India
e-mail: marora.asm@gmail.com

M. Mehta
Apeejay School of Management, Dwarka, New Delhi, India
e-mail: meghamehta28.asm@gmail.com

1 Introduction

The inclusion of any bank have the important role in the economic development of the country. Without an effective banking sector, no country can have economic growth. It solves the problem of credit needs of all sections of the country. Banking is one of the most important service sectors in India. It performs many functions. The primary function of any bank includes the features such as depositing the money, grant of loan, giving advance—cash, credit, overdraft, etc. Also, discounting in bills in offers, etc., it also have secondary functions such as letters of credit issued, custody of valuables undertaking, consumer financing for different needs, educational loans facility, etc. (Demetriades and Luintel, 1996). It consists of public sector and private sector banks with the overall objective of serving people for their banking, financial, and economic needs.

Public sector banks are the banks where more than 50% stake is held by a government. Banking sector became an important tool for economic development of the country in the 1960. In 1969, the nationalization of banks took place. The main objective behind nationalization was to provide rural areas with banking facilities and cheap finance to Indian farmers. State Bank of India was the only public sector bank in India before 1969. Over 70% of the market share is dominated by the public sector banks. Nationalized Bank and State Bank are the two groups of banks in which they are classified. In India, the 27 public sector banks are in differ in their sizes. Out of these, 19 nationalized banks and eight state banks of India Associates.

Private sector banks works on majority by the individuals and corporations. They are divided into two groups: nationalized and non-nationalized banks. The non-nationalized carried on their operations, known as Old Generation Private Sector Banks. When the liberalization policy was coined in India, the banks which got licenses like ICICI bank, HDFC bank, and Axis bank were considered as New Generation Private Sector Banks. In post liberalization, due to emergence

of over the time, the private sector banks has changed the banking industry all together. Their presence has been constantly increasing, and their offering has a diverse range of products and services for their customers. It leads to competition in the economy. The role of banking plays an important role in society. The bank is considered to have different roles.

The objectives studied in this research paper are as follows: (a) To compare the public and private banks on the basis of customers' expectations and perceptions of quality of services. (b) To identify the degree of importance attached to various dimensions of service quality reliability (R), responsiveness (R), assurance (A), empathy (E), and tangibles (T) (RATER) by the customers. The research paper organization of section is as follows: The present Sect. 1 Introduction discusses about the bank and its services. Section 2 Literature review discusses the bank, its services, and its quality. It also discusses the various parameters in which the service quality can be determined. Section 3 discusses the research methodology. The data and its analysis were discussed in Sect. 4. Section 5 discussed the conclusion and recommendations for future.

2 Literature Review

Banking is a business which considers various factors that decide upon the bank services being looked at by the customers. The major services in bank accounts are saving accounts, certificates of deposit, and account access. The customer need of services can be determined by the services one is actually looking for choosing the right bank. It can be the use of ATM services, availability of customer service, and relationship accessibility. It can be parking space around the bank, product and services they offer, fees deposit funds, availability of checking out balance, operating account zero balance. The individuals also look for the features of banks which do not mix the business and personal transactions. They keep them separately and also want the book keeping to be separately made so the consequences of tax follow proper protocol to transfer funds. They also want the payroll services to prevent potential fraud and forgery recordkeeping. Customers also want convenience and risk additional bank service merchant processing services to expand capability and sales. They also want different features with their bank account that is credit cards, debit cards, gift cards, and online payment. The role of the banks with respect to the banks and many other paramaters may be discussed further.

Developing countries face capital deficiency which is removed by banks. Banking sector mobilizes small savings and makes them available for investment in productive enterprises. Financial assistance to industries where banks provide financial assistance to industries in a different ways. They provide different options such as short-term, medium-term and long-term options in loans to industries (Vinesh, 2018). Promote savings where the banks provide a high rate of interest and wide range of deposit schemes which helps in attracting customers toward it. Every customer opens an account with their preferred banks. So, banks open different accounts in the name of customers as per their needs and requirements like current account, fixed account, saving account, recurring account, etc. As a result, it promotes savings of the people (Sekhar, 2020). The first contribution is that banks provide financial assistance to industries which helps in automatically generating employment opportunities (Fan et al., 2000). The Reserve Bank of India depends upon commercial banks for monetary management and they are keeping a record of requirement of a developing economy using implementing monetary policy. So, the commercial banks help in implementing monetary policy of the RBI (Mohanty, 2011). Banks play a vital role in internal and external trade banking. Banks help retailers and wholesalers to purchase goods by providing them with loans. Movement of goods from one place to another is also facilitated by the banks. Banks provide all facilities needed to undertake trade such as overdraft facilities, issuing drafts, discounting, and accepting bills of exchange. Banks also provide foreign exchange facilities to both importers and exporters of goods of developing countries (Burkart and Ellingsen, 2004). Foreign currency loans help in setting up new industrial projects. Banks help in expansion, diversification, modernization or renovation of existing units by providing them with loans. It also helps in importing experience such as technical knowhow from abroad (Karunagaran, 2006).

Banks also help in creating new entrepreneurs. New and some technically skilled entrepreneurs lack financial resources. So, banks help them by providing special capital and seed capital schemes. Development banks are the ones who actively participate in entrepreneurship development programs. One of the most important tools for economic development is innovation. In developing countries, innovations are financed by bank credit but due to lack of adequate funds in underdeveloped countries, entrepreneurs fear to undertake innovations and investment. So, banks by providing loans help in their investment, this will increase the economy by adopting new methods of production (Priyanka and Jain, 2605). Large number of banks like SBI, Citi Bank, PNB, Baroda are spreading their operations throughout the world. They are also spreading their services in semi urban and rural areas which in turn helps in achieving balanced regional development. Credit-related schemes have been implemented by the government with the help of the banking sector to lift poor and under-privileged sections of the country (Mohan, 2006). Apart from agriculture, banks also provide financial assistance for dairy farming, animal husbandry, poultry farming,

and horticulture. The financial support is provided by regional rural banks to small and marginal farmers. It also applied to landless agricultural workers, shopkeepers, and artisans. The quality in the banks is more of the quality in services as called as service quality. Service quality is defined as superiority or excellence as perceived by the customer. It is an intangible and multi-dimensional feature. Service quality is an important factor that determines competitiveness of the bank (Hu et al., 2009). A bank can survive only if they differentiate from other banks and also provide the high quality services. Service quality can be measured by the extent to which customer needs and expectations are met. In order to meet those needs and expectations, banks have to develop new strategies and ideas which will help in satisfying customers.

Customer satisfaction depends on customers' perception and expectation about the quality of service becomes an important tool (Mohan, 2006). Customers always compare their perceived experience with that of expectations. If the expectations meet the perceived service, a customer is satisfied. If perceived experience exceeds expectations, a customer is delighted. If perceived value does not meet expectations, a customer is dissatisfied. Whether a customer is satisfied or not by the service determines his future purchasing behavior. Maintaining service quality management is the most critical task for banking companies in order to retain existing customers and add new customers. They should provide continuous improvement in service quality (Al-Hawari et al. 2009). There are five basic dimensions of service quality, i.e., reliability (R), responsiveness (R), assurance (A), empathy (E), and tangibles (T) (RATER) which helps in determining perception of customers about service quality. These drivers have been identified through SERVQUAL model (Kumar et al. 2009) refer to Table 1.

Reliability is the foremost important driver of perception of service quality. Reliability is the ability to be relied on or depended on, as for accuracy, honesty, or achievement. It means that the bank should fulfill all its promises in terms of delivery of services, inquiry, problem solving, customer handling, service provision, or any other service desired by the customer. It is important because customers want to retain with those companies that meet their promises timely and accurately about the service (Korda and Snoj 2010).

Responsiveness means the quality of banks of reacting quickly and positively to help customers and provide fast service. This driver pays focus on attention and promptness toward customer grievances, questions, requests, and problems. Customers often measure banks responsiveness by their customer-focused management, waiting time for assistance, responding to their queries and changing customer needs, answering questions, and problem handling staff (Kheng et al. 2010).

Assurance is the courtesy and knowledge of employees and their ability to communicate trust and confidence is known as assurance so the customer has the trust in bank (Chu et al. 2012).

Empathy is the care, ability to understand, and individualistic attention provided by the banks to its customers. Customers want to feel important to banks from where they take service. It also shows that the employees know customer requirements and preferences personally. This characteristics of small companies serves as an important tool when competing with large firms (Dash et al. 2009).

Tangible tha can be touch and has physical characteristics such as equipment, personnel, and communication materials that are in physical format such as pamphlet, etc. Tangibles are used for evaluation of service quality through representations or images that can be used by both existing customers as well as new customers. Along with tangibles, hospitality services are also included in which the customer visits the establishment to receive the service (Pattanayak et al. 2017).

The most important concept that helps in understanding of the key concepts, strategies, and decisions in service quality is service-gap model (Ali et al. 2014). It also helps in guiding the service provided to customers. The difference between expected service and perceived service is known as service-gap model. Customer expectations refer to the standards set by the customers for service quality whereas customer perceptions are the assessment of actual perceived service (Qadri 2015).

The gap between expected value and perceived value can be met by properly delivering the best quality service to the customers. It serves as the basis for the gaps model. So banks must gain clear understanding of its customers in order to meet their needs. Also customer satisfaction helps in competitiveness of firms (Raza et al. 2020).All these four provider gaps must be closed if banking companies want to deliver high quality service to its customers. If any of the gaps exist, it will lead to a shortfall in delivering service quality. This service-gap model helps banks in understanding the causes that may prevent them from performing and then designing tools, techniques to improve quality (Pattanayak et al. 2017).

The Banking Service Quality (BSQ) Model is an extension of the SERVQUAL model used in retail banking. It talks about various elements such as service/product, place, process, participants, physical surrounding, price, and promotion. Thirty-one items are included under seven dimensions of BSQ model are effectiveness, access, price, tangibles, reliability, service portfolio, and assurance. BSQ model provides a range of dimensions based on which banks' service quality can be measured. Also, these dimensions can be used to apply the concept of gaps model. It will help in making a comparison between customers'

Table 1 Parameters details

S. no	Parameter	Description	Author contribution
1	Reliability	The service dependably should be accurate which is promised and has to be performed	Korda and Snoj 2010)
2	Responsiveness	The response to the customer should be inprompted	Kheng et al. 2010)
3	Assurance	The customer should have trust and confidence in you	Chu et al. 2012)
4	Empathy	A special and individual caring to customers	Dash et al. 2009)
5	Tangibles	The appearance of physical touch format such as equipment, personnel, and phamplets	Pattanayak et al. 2017)

expectations of service quality and existing quality on a particular dimension (Lenka et al. 2009).

3 Methodology Used

3.1 Sample Design

A descriptive research design was undertaken to know customers' perception toward desired value and perceived value of service quality provided by public and private sector banks. The respondents were the general public who were using the financial services provided by both the banks.

3.2 Data Collection

For this study, a questionnaire for the survey was designed and distributed, where targeted respondents come from different locations, genders, age groups, marital status, occupation, and education backgrounds. The survey questionnaire was set up and a link was created via an online survey platform using Google sheets to get responses online. A total of 141 responses have filled the survey and was used for the research.
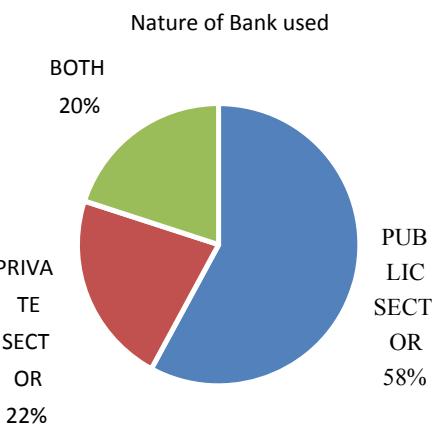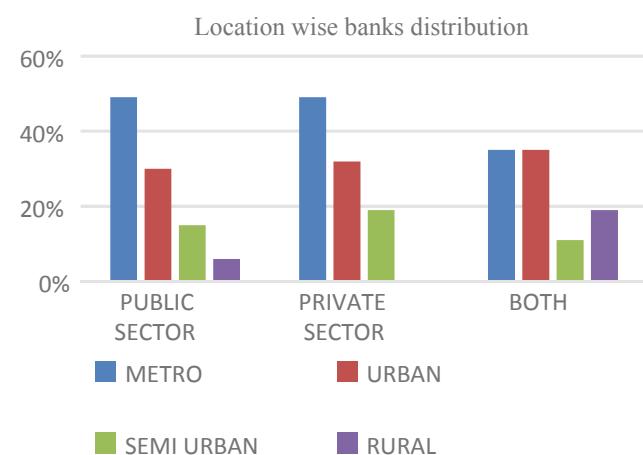
3.3 Questionnaire Design

For an easy analysis and interpretation, the SERVQUAL instrument was adopted. The instrument consists of different

sections. The first section was based on the demographic profile of the respondents followed by five other sections or parameters naming tangibility, reliability, responsiveness, assurance, and empathy. Each parameter consists of different questions relating to service quality. A four-point likert scale, i.e., (1) Strongly disagree (2) Disagree (3) Agree (4) Strongly agree was used where the respondents were asked to give their ratings based on their perceptions.

The data collected where there were more respondents are using the public banks. Though they are not very satisfied with the use of this banks in quality parameters. Also, the location plays an important role. It was found the most of the respondents are from metro city and compare to other areas refer to Fig. 1. These demographics are important to concentrate for the further analysis refer to Fig. 2.

For the data analysis, the model used is the chi-square test. The chi-square test has been used for the comparision of desired and perceived value of customer satisfaction of the different service quality parameters. The results have been


Fig. 1 Nature of bank used

Fig. 2 Location-wise distribution

analyzed in the summarized table discussed in the section data analysis and interpretation.

Chi-squared test also called Pearson chi-square test. A chi-squared test, also known as χ^2 test, is a statistical hypothesis test that is used to perform when the test statistic is chi-square distributed under the null hypotheses, specifically Pearson chi-squared test and variants. Pearson chi-squared test helps in determining whether there is a significant difference between the expected frequencies and the observed frequencies. The observations are classified into mutually exclusive classes. The test static computed from the observation follows a χ^2 frequency distribution if the null hypothesis is true. The main motive of this test is to find how likely the observed frequencies would be assuming that the null hypothesis is true.

4 Data Analysis and Interpretation

The data analysis of the service quality using SERVQUAL model. The parameters are considered one by one and based on the hypothesis were designed. The test is applied for both the groups', i.e., private and public banks. The first parameter is tangibility where 14 questions were asked and the details of the parameter is under:

Tangibility: The parameter tangibility is divided into 14 sub-parameters whose findings are as follows: For all the sub-parameter 1:- have considered the individual parameters one by one and taken the decision. Based on 1 sub-parameter of tangibility, there is no significant difference between desired value and perceived value related to sufficient physical space to serve customers. This is with respect to comfort in the branches of the bank. A chi-square test has applied and found that there is no significant difference between the desired value and perceived value. This is for the customers regarding the availability of sufficient numbers of counters in the banks. The hypothesis was created as null hypothesis, which was Ho.

Ho: There is no significant difference between desired value and perceived value regarding sufficient space to serve customers with reasonable comfort in the branch of this bank.

H1: There is a significant difference between desired value and perceived value regarding sufficient space to serve customers with reasonable comfort in the branch of this bank. The test was applied for both the banks separately and are discussed.

For public sector banks, Pearson chi-square value is 1.341e-09, if less than 0.05 (at 5% value of significance) so the null hypothesis (H_0) was rejected. It means that there is a significant difference between respondent's desired value and perceived value regarding sufficient space to serve customers and enough counters at the banks. For the case, such as in case private sector banks, Pearson chi-square value is 0.0006157, which is greater than 0.05(at 5% value of significance). This case where the null hypothesis (H0) was accepted. In consideration of tangibility, for both the banks were examined and found that out of 14 sub-parameters, public bank have accepted in two null hypothesis but in case of private banks have accepted in four null hypothesis. This means that in tangibility parameter, the private banks are doing better than the public banks. Hence, we may conclude that private banks have sufficient space for the smooth conduct of customer dealing and also have met the customer's expectation level. In the same way, chi-square tests for the other 13 sub-parameters of Tangibility have been done and also got the findings. The findings are summarized for significant sub-parameters are mentioned in the following table where any of the bank parameters is accepted (Table 2).

The consolidated result, i.e., out of 14 parameters, 4 are significant where of the chi-square tests for tangibility as discussed in the summary table where for the public banks, the sub-parameters accepted is 2 and rejected is 12 and for private sector banks, out of 14 sub-parameters, accepted is 4 and rejected is 10. The summary table is drawn with the same reference as discussed in Table 2. It shows that in

Table 2 Tangibility

S. no	Hypothesis	Public banks (p-value)	Remarks	Private banks (p-value)	Remarks
1	Ho: based on sufficient space to serve customers	1.3e-09	Ho rejected	0.0006	Ho accepted
2	Ho: based on more number of machines available for updating the passbook	1.419e-05	Ho rejected	0.003278	Ho accepted
3	Ho: based on bank premises. Should have parking facilities	0.07062	Ho accepted	1.652e-05	Ho rejected
4	Ho: based on the seating facilities and other mandatory facility such as drinking water and toilet facilities for customers	0.000668	Ho accepted	0.008316	Ho accepted

Table 3 Consolidated table-chi-square pearson result

Parameters	Total sub-parameters	Public banks		Private banks	
		Accepted	Rejected	Accepted	Rejected
Tangibility	14	2	12	3	11
Reliability	7	0	7	0	7
Responsiveness	6	0	6	3	3
Assurance	4	0	4	0	4
Empathy	5	0	5	2	3
Total	36	2	34	8	28

public sector banks, 2 hypotheses have been accepted and 12 hypotheses have been rejected. The acceptance of hypothesis means that there is no significant difference between the desired value and perceived value among the respondents regarding any particular service. This means that the customers are satisfied with the services if the hypothesis is accepted and vice-versa. The table shows that public banks have been able to satisfy the customers for 16% of the sub-parameters (2 out of 14) of Tangibility. But for private banks, 4 out of 14, i.e., 28% of the sub-parameters hypotheses have been accepted. Hence, we can conclude that private banks provide better quality of service regarding the parameter tangibility.

Reliability: In the same way, chi-square tests for the 7 sub-parameters of reliability have been measured. The consolidated result of the chi-square tests for reliability is discussed in Table 3. The table shows that for both public sector banks and private sector banks, all 7 sub-parameters on reliability have been rejected.

Responsiveness: In the same way, chi-square tests for the 6 sub-parameters of responsiveness have been measured. The consolidated result of the chi-square tests for responsiveness is discussed in Table 2. The table shows that for both public sector banks, all the sub-parameters where the null hypothesis was rejected, but in case of private sector banks, 3 out of 6 (50%) where the null hypothesis was accepted. So, we can conclude that private sector banks provide better quality of services than public sector banks regarding the parameter responsiveness.

Assurance: In the same way, chi-square tests for the 4 sub-parameters of assurance have been measured. The consolidated result of the chi-square tests for assurance is discussed in Table 2. The table shows that for both public sector banks and private sector banks, all 4 sub-parameters on assurance have been rejected. So, we can conclude that both public banks and private banks do not provide better quality of service regarding the parameter assurance.

Empathy: In the same way, chi-square tests for the 5 sub-parameters of empathy have been measured. The consolidated result of the chi-square tests for empathy is discussed in Table 2. The table shows that for both public sector banks, all the sub-parameters where the null hypothesis was rejected, but in case of private sector banks, 2 out of 5 (40%) where the null hypothesis was accepted. So, we can conclude that private sector banks provide better quality of services than public sector banks regarding the parameter Empathy.

Thus we can conclude that private banks provide much better quality of service than public banks regarding the parameter Empathy. The consolidated table defined for all the parameters for their sub-parameters are defined in Table 2.

Based on the study, it was found that in case of public sector bank, 2 out of 36 where the H0(Null hypothesis was accepted), i.e., 0.05% and in case of private sector bank, 8 out of 36, i.e., 22% cases have been accepted. Based on the results, the private banks are better the pubic banks.

5   Conclusion

It is clear from the study that in today's world, service quality of banks plays an important role in survival in the long run. For this to happen, banks have to retain their old customers in addition to approaching new customers by providing high quality of financial services. Below is the conclusion of five parameters of service quality. The private sector banks provides better quality of service in relation to tangibility, responsiveness, and empathy. For the parameters such as reliability and assurance, both public and private banks are providing the quality. Out of the two banks, the private banks are better than the public banks.

The future lies in the private sector banks because of technological superiority and its outlook. In private sector banking, the people are more professional and also required to meet stiff targets. The people working there have to perform a par to meet the target and also ensure the good career growth. A risk is higher and remuneration is better.

In comparison to the private sector banks, the public sector banks are differentiated in terms of legacy, and also holding majority of its shares but in private sector banks, majority of shares are held by the corporations and private individual by in public sector banks, majority of shares are held by the government. The private banks as make up for these security concerns through their technological advancements and superior customer service. The functioning of private banks is viewed, i.e., fast-paced, efficient, and easier to deal with.

References

Al-Hawari, M., Tony, W., Leonce, N. (2009). The relationship between service quality and retention within the automated and traditional contexts of retail banking. *Journal of Service Management, 20* (4), 455–72. https://doi.org/10.1108/09564230910978539.

Burkart, M., Ellingsen, T. (2004). In-Kind finance: A theory of trade credit. *American Economic Review, 94*(3), 569–90. https://doi.org/10.1257/0002828041464579

Chu, P.Y., Lee, G.Y., Yu C. (2012). Service quality, customer satisfaction, customer trust, and loyalty in an E-Banking context. *Social Behavior and Personality: An International Journal, 40* (8), 1271–83.https://doi.org/10.2224/sbp.2012.40.8.1271

Dash, S., Ed, B., Manaswini, A. (2009). The effect of power distance and individualism on service quality expectations in banking: a two-country individual- and national-cultural comparison. *International Journal of Bank Marketing, 27*(5), 336–58. https://doi.org/10.1108/02652320910979870.

Demetriades, P.O., Luintel, K.B. (1996). Financial development, economic growth and banking sector controls: Evidence from India. *The Economic Journal, 106* (435), 359. https://doi.org/10.2307/2235252.

Fan, S., Peter, H., Sukhadeo, T. (2000). Government spending, growth and poverty in rural India. *American Journal of Agricultural Economics, 82* (4), 1038–51. https://doi.org/10.1111/0002-9092.00101.

Hu, H.-H. (Sunny), Jay, K., Thanika, D. J. (2009). Relationships and impacts of service quality, perceived value, customer satisfaction, and image: An empirical study. *The Service Industries Journal, 29* (2), 111–25. https://doi.org/10.1080/02642060802292932.

Karunagaran, A. (2006). Foreign banks in historical perspective. *Economic and Political Weekly, 41*(11), 1087–1094.

Kheng, Lo, L., Osman, M., Ramayah, T., Rahim, M. (2010). The impact of service quality on customer loyalty: A study of Banks in Penang, Malaysia. *International Journal of Marketing Studies, 2*(2), 57. https://doi.org/10.5539/ijms.v2n2p57.

Korda, Aleksandra, P., Boris, S. (2010). *Development, Validity and Reliability of Perceived Service Quality in Retail Banking and Its Relationship With Perceived Value and Customer Satisfaction*, 8(2), 19.

Kumar, M., Kee, F. T., & Manshor, A. T. (2009). Determining the relative importance of critical factors in delivering service quality of banks: An application of dominance analysis in SERVQUAL model. *Managing Service Quality: An International Journal, 19*(2), 211–228. https://doi.org/10.1108/09604520910943198.(2009).

Lenka, U., Damodar, S., Pratap K., Mohapatra, J. (2009). Service quality, customer satisfaction, and customer loyalty in Indian commercial banks. *The Journal of Entrepreneurship, 18* (1), 47–64. https://doi.org/10.1177/097135570801800103.

Melnic, E. L. (2016). Techniques for measuring customers' satisfaction in Banks. *Bulletin of the Transilvania University of Brasov. Economic Sciences. Series V, 9*(1), 23.

Mohan, R. (2006). Agricultural credit in India: Status, issues and future agenda. *Economic and Political Weekly, 41*(11), 1013–1023.

Mohanty, D. (2011). *How Does the Reserve Bank of India Conduct Its Monetary Policy?*

Pattanayak, D., Koilakuntla, M., & Punyatoya, P. (2017). Investigating the Influence of TQM, Service Quality and Market Orientation on Customer Satisfaction and Loyalty in the Indian Banking Sector. *International Journal of Quality and Reliability Management, 34* (3), 362–377. https://doi.org/10.1108/IJQRM-04-2015-0057.

Priyanka, Jain, D. P. (2015). Empirical study of development banks and entrepreneurship promotion. *Oman Chapter of Arabian Journal of Business and Management Review, 34* (2605), 1–9. https://doi.org/10.12816/0019080.

Qadri, U.A. (2015). Measuring service quality expectation and perception using SERVQUAL: A gap analysis. *Business and Economics Journal, 06* (03). https://doi.org/10.4172/2151-6219.1000162.

Raza, S. A., Umer, A., Qureshi, M. A., & Dahri, A. S. (2020). Internet banking service quality, e-customer satisfaction and loyalty: the modified e-SERVQUAL model. *The TQM Journal*.

Sekhar, B. R. A. (2020). Comparative study of service quality of selected Indian Banks: A study in Hyderabad region. *Tathapi with Issn 2320–0693 Is An Ugc Care Journal, 19*(19), 438–451.

Vinesh, M. (2018). *Impact and Requirement of Banking Industry and Government on Economy Development, 5*(4), 4.

Impact of Gamification, Games, and Game Elements in Education

Kavisha Duggal, Parminder Singh, and Lovi Raj Gupta

Abstract

Educational studies usually correspond to routine teaching methods and textbook literature. Although as an essential process of making learning effective and exciting for students, it is considered that the classroom courses must involve interactive activities. Implementation of such interactive methods can be achieved by fusing playful classroom games, engaging the students with use of the latest methodologies, engaging the students with high enticement can make the course learning more interesting. In this new era of technology, games have grown prevalent in today's media. Besides games, gamification is another trending technology in education, workplaces, business, etc. Gamification extends a simple way to motivate and promote learning and facilitate the development of sustainable life skills helping students to increase engagement in the learning process with creativity and imagination. Game elements in the form of game mechanics and dynamics act as motivators to achieve the desired goals. The findings in the educational contexts on the efficacy of gamification and game elements of this research achieved till date are concluded as carefully promising.

Keywords

Education • Engagement • Games • Game elements • Gamification

K. Duggal · P. Singh (✉)
School of Computer Science and Engineering, Lovely Professional University, Phagwara, India
e-mail: parminder.16479@lpu.co.in

L. R. Gupta
Lovely Faculty of Technology and Sciences, Lovely Professional University, Phagwara, India

1 Introduction

In education, usage of games or game elements is not new. In the early 1960, Piaget (1962) figured out that the games would not only help learners to master their skills but also help to build a life of their thoughts and creativity. Throughout the history of mankind (Colteli et al., 2014), games have been a part of human societies. They take on numerous forms specifically: card games, tabletop games, dice games, different sports, etc. In the present era, games are getting progressively common with the approach of computers and the Internet. It tends to be inferred that practically everybody conceived in a created nation after 1980 plays or has played computer games. Elements that make games amusing accompanying the nature of games themselves are assumed to be intrinsically motivating, so applying game mechanics may rise the intrinsic motivation of students to learn better in the classroom (Hanus and Fox, 2015). Gamification means using the gaming elements and structure to entice the users to lure into the specified task and, in turn, provide a better user experience and more effective learning (Cahyani, 2016). Gamification is defined as changing the non-gaming environment into game settings (Deterding et al., 2011) which includes proper usage of game elements. In higher education, gamification is used to enhance learner's engagement and motivation in a task. Gamification tends to increase the engagement of people in the activities being undertaken by means of increasing their intrinsic and extrinsic motivation (Buckley and Doyle, 2017). The engagement word can be implicated in various meanings based upon various situations. Engagement in the context of learning is defined as (Deater-Deckard et al., 2013) "a collection of mindfully goal-directed states in which motivation arising from positive emotions serves to grab and sustain the learner's cognitive and motor competencies, typically requiring some level of effort." Throughout the game, active involvement of the players is referred to as engagement in the context of gamification.

Gamification is a process of utilizing the gamified structure and providing a platform for each student to act like a player. This feeling of involvement increases their focus and learning ability. Gamification has successfully influenced people to use a piano staircase instead of the elevator, and it acted as a medium to change one's habit (The Fun Theory, 2016). Several day-to-day activities in our routine work include the process of gamification. Therefore, by inculcating various levels with increasing difficulties and the requirement of different skills we can help them imbibe new skills and perform higher difficulty problems by focusing on the key areas and increasing their concentration (Dias, 2017). One way to show how implementing a gamified environment can be helpful is including a game in the class in which every day the teacher asks the students 5 questions from the newspaper and gives them the points which get reflected in their semester grades. This will lure or motivate the students to read the newspaper daily leading to overall development.

Motivation: This work aims to find various guidelines to implement the concept of gamification in the education system. Different methodologies and terminologies are used to make the education system more interesting and engaging. The concept of gamification, game-based learning, and usage of various game elements are applied at various stages of the education system. The important aspect of the work is to enlighten the various parameters used to make the education system more engaging and enticing. There is a need to explore game elements that inculcate intrinsic motivation among students irrespective of the course they study.

Contribution: Future researchers will be benefited from this article as the latest advancements done in the field of the gamified education system are explored. The taxonomy based on various gamified educational methods is analyzed by defining the number of participants, descriptions, benefits, and findings in this field. The motivation behind the work is Rq1: to provide insight into the work done in the field of education to enhance the students' motivation, engagement by examining the different learning modules that explore the impact of gamification on learners.

A description of how games are different from gamification is elaborated with the use of a flow diagram. The taxonomy based on various game elements with the demarcation of the element type, description, and benefits is analyzed and evaluated for RQ2. RQ2: The correct usage of game elements in the Gamified framework to enhance the learning process among the students. Even after attaining successful results in the field of the gamified education system, various challenges need to be addressed to enhance the overall education system. RQ3: Various challenges faced in the gamified education system are elaborated.

The sequencing of the paper is done into the following sections: Introduction, motivation, and contribution in Sect. 1. The RQ1 is addressed in Sect. 2. The impact of gamification is illustrated, highlighting the benefits and findings of the present gamified approaches used in the education sector. Section 3 defines the types of games that are part of our education system, and the difference between game and gamification is demarcated. Section 4 defines the key requirements of various game elements, and RQ2 is addressed. Challenges in the gamified education system RQ3 are mentioned in Sect. 5 followed by a conclusion in Sect. 6.

2 Impact of Gamification in Education

The setup provided through the gamified approach will prove to be beneficial in the present-day approach of higher education institutions (Aparicio et al., 2019). The study lays stress on the fact that the gamified approach will be highly beneficial as it will entice much more participation and will be an enjoyable method of both teaching and learning. Gamification will be a major role player in the success of MOOCs due to the influence that it will have on the individuals and the organizations (Aparicio et al., 2019). Reflex is the study of a newly developed gamified learning system. It presents the 3D virtual world in a browser that helps the user to enhance his learning and give his feedback. Based on the concept of gamification design, reflex can predict learner behavior during interaction (Herbert et al., 2014). Components like relatedness, flow, autonomy, mastery, and purpose in the design have been integrated into the proposed framework. The main focus is on dimensional flow and motivational determinants to deliver a sustainable gamified experience to the user. The author has constructed game-based learning for law students. The gamified approach has to be used for teaching purposes and is based on the test scenario. They have discussed the challenges being faced during the designing of game elements for better, engaged learning for law students. An interactive slide-based storyline was developed for the teachers for the creation of simulations quickly and easily for the addition of game-based elements in interactive learning (Bouki et al., 2014). Programmers, developers, or learners may face a challenge when it comes to the understanding of programming. There are Web forums available like Stack Overflow where one can post his questions and queries, and get n rapid response from online communities. To let the system go on Web sites like Stack Overflow, community people must come up with a rapid response. As gamification proposes a reward-driven.

approach, measured by response time. It has become a popular method for increasing active participation on such Web sites (Jin et al., 2015). Classroom lectures are a traditional staple of formal education. Due to advancements in technology and the importance of class attendance, students

are bound to sit in classes. To increase the students' engagement and motivation to attend classes, gamification has been introduced in teaching. Experimental work is done to use technological aids to encourage students for better attendance and engagement in classes. Quantitative analysis has been done to estimate the impact of gamification on students' learning and attendance. Students who work and study simultaneously may face certain challenges like arriving on time in class, low participation in-class activities, and submission of assignments on time. It may be tough for these students to survive in today's trending world. Virtual 3D blends are being used very commonly these days. The gamified concept introduced by using a virtual 3D environment to teach programming in classes got excitement among students. Due to a lack of motivation and high students' dropouts in programming classes, a need for gamification was identified. Gamification helps students to gain confidence in their capabilities and increased participation in classes (Lückemeyer, 2015). In the reference of gamification, basic game elements such as game mechanics and game dynamics are precisely used and applied in rural schools to facilitate the integration of user devices in the teaching and learning environment. Among various design fundamentals, gamification was used in teaching and learning engagement to engage and encourage teachers with an end goal (Botra et al., 2014). Table 1 based on various gamified educational methods is analyzed by defining the number of participants, descriptions, benefits, and findings in this field.

Over the past years, gamification is intended to leverage the interest in academics which seems to remain a trending methodology among the few percentages of teachers and approximately 11.30% utilize the gamification in their courses consistently. In the educational research area, there is negligence in the actual use of gamification teachers' perspectives toward gamification (Martı-Parrenõ et al., 2016). The concept of gamification is not only implementing a system that is effective and useful, and can change behavior. An efficacious gamified application should provide the experience more engaging and enjoyable, and should have different levels of enticement (Rapp et al., 2019).

3 Games and Edification

A lot of researchers are influenced by PC games due to their capability to engage and allure the player's consideration for broadened time frames (De Freitas, 2018). A player while in the field always feels engrossed and committed in the game and lays stress on each minute detail of the scenario for accomplishing his goal and succeed. The educational instructional practices have been redefined and reshaped with the help of gaming (Clark, 2009). It is very imperative for the professor to recognize the role of games for his

students and himself in learning. The majority of students carry an optimistic approach to the usage of games in their classes during teaching. But the game design has a major and crucial role to play for the successful game mechanics can be used.

implementation of game-based learning. Learning based on games is considered an efficient learning process that helps the students to understand the topic by visualizing and learning the concept with the help of a game designed to overcome a specific task (Söbke et al., 2013). Technology-oriented games are considered a vital part of our social and cultural environment.

3.1 Game-Based Learning

Games-based learning plays a major role in creating different impressions on the mind-set of players. Various studies have been implemented to show such effectiveness of game-based learning on human emotions. Researchers have shown an experimental study to analyze the impact of various traditional games that produce the different intensities of emotions like positive, negative, or ambiguous. This helps in examining the different social structures and various emotion levels produced while participants taking part in traditional games (Lavega et al., 2014). The suggested way of combining two game-based approaches to analyze the learning behavior of students by providing empirical evidence. The study included real competition and virtual competition covering aspects of easy tasks and difficult tasks that can be synthesized for improvising the competitive design of digital game-based learning (DBGL). In the game-based learning (GBL) context, students usually get instant feedback about their solution and are required to submit their responses. Based on this concept, a comparison of the performance of learners with persistence on various methodologies was proposed. The study illustrated that each learner provides multiple computations for every methodology (Israel-Fishelson and Hershkovitz, 2020). In the earlier years, game-based learning has been evolved with the utilization of video games, serious games, and more other technologies providing integration of analysis on the impacts of DGBL on the various fields in education. GBL provides comprehensive learning with a sense of authentic circumstances giving a chance to expand one's aspects of science. As an operative training approach, GBL facilitates students with captivating participation. The study presented an approach to encourage students to take part in the GBL implemented physics class. The approach explains the interest and involvement of students in physics toward various aspects. The study proposed a method explaining the usage of a simple board game to enhance the learning skills of students and creating awareness about complex subjects

Table 1 Research on previous gamified methodologies implemented in education

References	Participants	Description	Benefits	Findings
(Sailer and Sailer, 2020)	205 students (average age = 23)	The research proposes a concise view of representing a basic methodology of game design elements that utilize definite mechanisms for reward points and group leader boards	A quick task-level response which means learningprocess progress provides an application-specific experience	Limited use of game components and mechanics with short intervention and short duration composition
(Legaki et al., 2020)	365 college students	A gamification approach named "Horses for Courses" to investigate the effects concerning challenge-based gamification on learning in the area of statistics. The study comprises focuses, levels, challenges, and a leader board	Three diversified study domains were considered	Game design by incentivizing the posttest experience. The main focus is to achieve a higher rank on the final leader board
(Nand et al., 2019)	120 primary students	The adequacy of gamification in an educational context has been examined, to teach numeracy. Two versions are created in this study, i.e., Feature Deviod Game (FDG) and Feature Enriched Game (FEG)	Well-defined game mechanics are implemented and are utilized for result analysis	More emphasis is given on game-based learning. The progression loop of gamification is not defined
(Mohamad et al., 2018)	30 higher education	Gamification can be applied to six categories used for teaching and learning to enhance student's engagement. Course without online support, MOOC, flipped classroom learning, e-learning site, gamified platform, \mobile learning	Good examples are discussed how gamification can be applied to the 6 categories	The framework for gamification categories for teaching and learning is not explained
(Halloluwa et al., 2016)	103 grade 3 students	This study focuses on the development of a base model for basic comprehension to acknowledge the use of gamified mobile applications along with creating a classroom learning environment to engage students and teachers to learn mathematics	A balanced mix of student-centric learning approach is followed along with those students cooperatively helping each other to finish their games. Learning is taken by the students utilizing the technology	It is more like game-based learning rather than gamified learning
(Cahyani, 2016)	30 students Age 6–8	To inspire students to attempt new things and avoiding the dread to make mistakes, a gamified learning situation as an activity is used. Further, the study retains the game-like environment	The activities consist of fun elements, motivation, and engagement	The game elements involved in gamified learning activity are not highlighted
(Hanus and Fox, 2015)	80 students	The comparative study over time showed that learners enrolled in the gamified classroom recorded insufficient inspiration, fulfillment, and empowerment than the students in the non-gamified course	Students enrolled for two courses, measuring their social comparison, effort, satisfaction, learner empowerment, motivation, and academic performance were analyzed for a semester	More focus is on earningbadges, coins, leader boards. The framework lacks game elements like narration, cooperation, feedback that leads to intrinsic motivation
(Gonzalez and Carreño, 2014)	3-year students	The objective is to analyze and build a technological platform aiming to introduce gamification methodologies or game mechanics in the teaching and learning process of engineering students in the computer science field	The steps and mechanics involved lead to the enhancement of student motivation for formal and informal learning	Engagement and progression loop are not discussed in the methodological proposal

Table 1 (continued)

References	Participants	Description	Benefits	Findings
(Akpolat, 2014)	50software engineering students	Explored the value and the trend of adoption of gamification in a software development team. In the entire process, it is being noted that the gamification pattern is going in very encouraging	It appears that usage of game design and game mechanics can be the best fit in teaching software development processes	Team performance evaluation and observation were done manuallywhich makes the system dependent on the facilitator

like physics. The methodology developed in this study has reduced the subject complexity and utilized the course syllabus in a systematic approach to mitigate the efforts of teachers (Cardinot and Fairfield, 2019). With the flexible adaptation environment to various education goals and skill improvement, game-based learning facilitates a student-centric strategy toward education.

Serious games: Serious games provide the learning process with the guidance of accomplishing one's goal. This learning assists in aiming to track user behavior while inhibiting the unsuitable activity of the user during the process. Gamification can be employed in the context of serious games. In addition to this, game dynamics and in any subjective field. Serious games can fit into a training course which can be improved while teaching. Serious games are highly impactful and are of wide capability on learning methods of participants in education due to its dynamic and normal design. Other than entertainment, serious games emphasize on learning mechanics to implement engagement, motivation, and amusement. Here, research proposed describing the findings utilizing a novel serious game. The study was conducted across schools in Ireland using a game directed on coaching along with entertainment. The study estimates the opinion of student and teacher while operatively involving students with astronomy and physics and using the game-based learning receiving the learning process (Cardinot and Fairfield, 2019).

3.2 Impact of Games on Education

The successful development of games has to overcome plenty of challenges like a more attractive design and better user experience. The authors have identified four commercial games which can be used for education. Their gameplay experience and potential learning may be used as an enhanced learning tool during implementation. Moreover, a systematic approach should be used to facilitate video games into educational settings (Söbke et al., 2013). Information technology subjects have been incorporated into medicine degrees of Spain to achieve horizontal competencies in the curriculum. Medicine disciplines lack tailor-made technologies so to engage learners in complex real-world situations is a big challenge. A model has been proposed to draft a simple method for the identification of teaching needs in the subjects of medicine degrees so that serious game-based implementations may be deployed during the development process (Colteli et al., 2014). In the past decade, research in gaming has brought valuable changes in the form of career awareness area or as a tool (STEM) to help students to learn subjects. Gaming motivated struggling students to continue their studies and avoid dropouts (Clark and Ernst, 2009). Good games usually hold successive sub-targets and as an alternative approach to solve its problem that can be very challenging and encouraging. Good games impersonate and personalize learning maintaining morale and engagement between the players. Furthermore, good game plans utterly meet the player's intellectual capabilities with the complexity level (Cahyani, 2016).

3.3 Differentiate Between Games and Gamification

In the present era, gamification is an innovative concept that is realistic play-based learning. Introducing the concept of game-based learning is considered as one of the numerous exercises that can be part of the gamified curriculum; on the other hand, demarcation of gamification goes much beyond this conventional game concept where the engagement students will be from the beginning to the finale lecture of the course. The students act as players provided with many challenges, competitions ahead to overcome (Dias, 2017). Games are dependent on good graphics (Cahyani, 2016). The idea of gamification is based on the capability to meet the basic.

human motives or necessities such as appreciation, bonus, fulfillment, competition, collaboration, self-expression, and selflessness. The design of the game is not the only parameter of gamification but is directly associated with the habituation element of its implementation in various conditions to successfully execute specific activities (Gonzalez and Carreño, 2014). Using gamification, the students can

Table 2 Difference between games and gamification

	Games	Gamification
Goals	Short-term goals	Long-term goals
Co-relation	Turning the learning process as a whole into a game	Using a game as part of the learning process
Motive	Teaching a skill: specific learning outcome focused on teaching a discrete skill	Learning system: complete pedagogical system
Elements	Usage of play-based elements, e.g., puzzles, quizzes, etc	Usage of game mechanics and gameplay elements, e.g., leader boards, badges, trophies, point systems, etc
Focus	Typical game structure for playing and training	Emphasizes on motivation and user engagement

observe their earlier mistakes and because of repetition failure, it benefits students to improve the performance based on the analysis. This led students to accomplish the required target. The students are engaged to perform difficult tasks achieving the desired goal within a short period, wherein games permit the user to replicate a specific mission in the event of failure (Hakak et al., 2019). The difference between games and gamification is specified in Table 2.

4 Game Elements

In gamification, the game components are applied in non-gaming conditions with the main objective of enhancing the experience of the user (Nand et al., 2019). Deployment of gamification in the education system results in various game mechanics. Motivation, commitment, and good behavior from students are the generic expected outcomes from students. The use of game elements in a non-game environment is increasing so that everyone can acquire appropriate skills and knowledge (Gonzalez and Carreño, 2014). It has been elaborated that introduction of play elements into non-game environments is quickly going on top. Gaming has emerged as a new marketing strategy. Educators are using digital games in their classes to increase students' engagement. Activists are using serious games to raise awareness about aspects of gaming as it has become a common way of engagement (Colteli et al., 2014). Gamification is being used to deploy game elements in educational environments to improve student learning and engagement in classes. Game elements like experience points and badges are being used in the gamification process. It was identified that the.

correlation of badges with learning is high as compared to experience points (Botra et al., 2014). Online courses are becoming tremendously popular these days. The involvement of game mechanics like points, rewards, goal setting, reputation, etc., is the primary reason for this popularity. Massive Online Open Courses (MOOCs) are influenced by
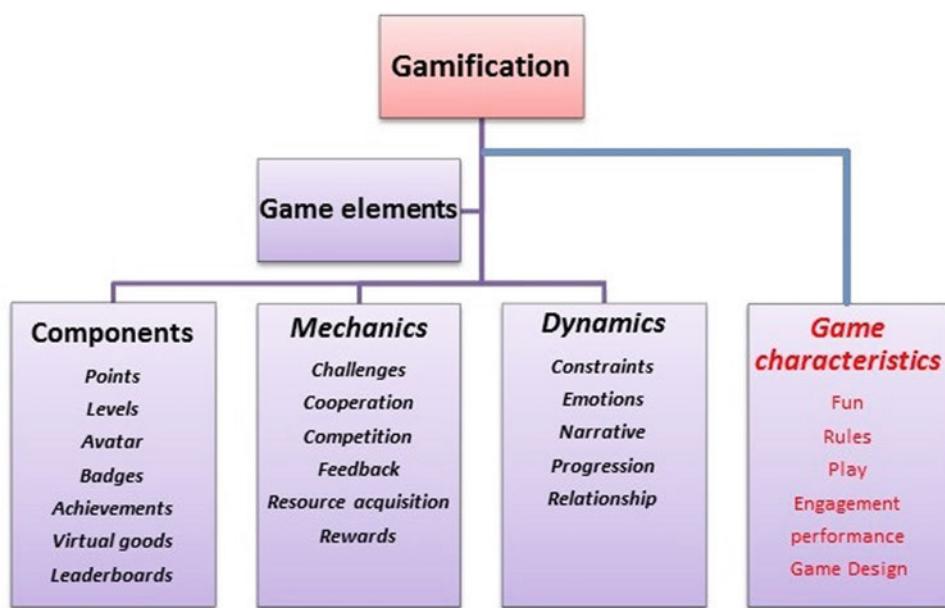
the use of gamification, but they do not guarantee that they will result in a better learning performance (Aparicio et al., 2019). In practice, a limited set of game elements are deployed in gamification applications such as points, leader boards, and badges (Rapp et al., 2019). There is a need to explore a different set of game elements and their mechanism that can create a difference in gamified applications.

4.1 Various Game Elements in Education

Gamification is a vast technology that can be transformed into various systems, viz. the incentivizing of user activities through the token of appreciation and reward systems in another trait of gamification which is also named as point system (Hanus Fox, 2015). Student response systems are becoming popular these days. It is of immense benefit that instructors can get instant feedback from students which may not be available with traditional systems. The author stated that when a Facebook like appearance and game-inspired paradigm was given to the students, they performed many exploratory activities. It was also identified that the richness and complexity of multifaceted open social learner modeling positively affect the user learning experience in terms of efficiency, effectiveness, and satisfaction (Shi Cristea, 2015).

Educational gamification aids in achieving teaching and learning goals that can be observed as the layout plan of applying game layout components in educational settings (Botra et al., 2014). The dynamics are applied to build the motive to accomplish the task manifested via mechanics in classification. The dynamics are the considerations associated with the task which is to be gamified. The methods which are used to drive the actions of the user are defined as mechanics. Mechanics are the components that are presented in the form of extrinsic reward points and response characteristics like badges, etc. (Toda et al., 2019). The game elements are different from game characteristics as mentioned in Fig. 1.

Fig. 1 Game elements are different from game characteristics

An important game element used in the learning process is required to inspire the student to progress with a given task. While considering the game design layout for the educational purpose, the primary key element which is required is the motivation and which can be achieved by leveraging the effective computing based on emotions to endorse the motivation aspect during the designing interfaces (Hakak et al., 2019). With the increasing trend in gamification, the present researches proposed that the specialists have keen attention of using gamification but due to various factors like lacking time or resources to apply the logic of alterations and resemblances to select and decide particular game elements among a variety of elements in the gamification system to use which are more appropriate to implement in a specific system (Mart´ı-Parren˜o et al. 2016). The various game elements like team activities, competition, and cooperation are highly ignored which indirectly forms the foundation of goal structures (Rapp et al., 2019). The various game elements used in the field of education are explored in Table 3.

Table 3 Taxonomy based on game element description and benefits

Elements	T	Description	Benefits
Points		This game element is also known as scores	The most common game element is used to encourage the contribution of the users
Badges	C	Badges are visual tokens in the form of logos or icons. Winning the badge is like attaining the virtual status symbol (Huang et al., 2019)	Indicates the performance of students
Levels	C	Players' expertise is judged from the level of their performance in the gamified framework (Legaki et al., 2020)	To track progress in terms of performing a particular activity and attaining a higher level step by step (Huang et al., 2019)
Feedback	M	Element to provide information to learners regarding their progress and understanding of the concept	Analyze and check their progress along with gain acknowledgment concerning positive conduct (Nand et al., 2019)
Collaboration	nM	Group activates to create a sense of relatedness and inculcate team learning ethics (Huang et al., 2019). It also enhances group exercises solitary than individual performance on a similar related topic	Collaboration leads to team formation, and there exists the mutual responsibility of teamwork (Dias, 2017)
Challenge	M	Something new and different for students to participate as z-generation is not interested in handling dummy illustrative problems (Dias, 2017)	A competitive environment enhances student interest and involvement

Table 3 (continued)

Elements	T	Description	Benefits
Leader boards	C	A scoreboard is used to foster social pressure to build learners' level engagement in an activity. It is used for the comparison between players' performance (Legaki et al., 2020)	Should be carefully used to project the best students' performance by considering the fact not to expose the students who are not doing well (Dias, 2017)
Progression	D	Momentum or a milestone used during the participation. It means splitting the process into more than one small progressive levels instead of overwhelming a bigger leap	It makes the task interesting, and randomness in any task acts as intrinsic motivators for players (Buckley and Doyle, 2017)
Co-operation	M	It is a process to achieve a common target collaboratively (Toda et al., 2019)	Teamwork or group formation that defines an intrinsic perception
Avatar	C	It is an appearance that depicts the virtual representations of the students optionally provided to choose their particular tutor to interact with the system (Mohamad et al., 2018)	Visual representation in the form of an icon or display picture to their profile act as a fun element (Buckley and Doyle, 2017)
Narration	D	It states the sequence of actions as they occur in the game via user experience (Toda et al., 2019)	Narration is also an intrinsic concept
Competition	M	The constructive competition takes place, when its orientation is based on fun and structured ways are designed to grow positive (Hanus and Fox, 2015)	Helps to explore hidden skills Increases the self-confidence
Emotions	D	Enjoyment, enticement, surprise	Emotions create a sense of gratitude, feeling of joy to perform a particular task
Constraints	D	Formulation of rules and guidelines creates a balanced environment	The boundaries of specific tasks are specified. On a wrong attempt, the defined penalty or action to be applicable as a liability
Virtual good	C	Virtual goods are a mode of incentivizing one's interest to earn reward points	Using points that the user collected overtime can be used to purchase virtual goods that are intangible items or non-physical objects (da Rocha Seixas et al., 2016)
Rewards	M	Like virtual goods, rewards are also tangible or intangible objects. After completion of a task, the user has presented rewards and can be earned on a repetitive progression	Rewards are one of the impactful extrinsic motivators

5 Challenges

Focus on intrinsic motivation: The presence of intrinsic motivation is required in the design methodology. Intrinsic motivation is the willingness of performing action irrespective of expecting any obvious external rewards which means that an individual performs the action because it is founded as interesting and joyful, instead of external pressure or incentives such as a reward or deadline to act upon it. Utilize the latest technology: Integration of the latest technologies in the education system inculcates interest and enhances the student enticement to perform a particular task. The use of mobile/ tabs in the form of quizzes or puzzles acts as an intrinsic motivator. Fun-based learning: As a part of the learning process, while performing the activities students consider them as fun to which executes engagement, passion, and motivation, and build inventive modes of learning. Identification of Elements: Usage of efficient game elements

results in ineffective results. Rewards/ badges should not overpower the actual essence of the gamified framework, and their use should be optimal. Classroom engagement: The main focus of the gamified framework is to enhance engagement among the players. The engagement should not be temporary; it should be a long-term engagement with a high level of enticement among the players.

6 Conclusion

Gamification, games, and game elements are different terminologies and make huge differences in the education system. The primary aim of this paper is to explore various gamification studies and explore a variety of games and game element opportunities that exist and can enhance the education system. Gamification has a great deal of perspective; however, some exertion is as yet required in the implementation and design of the user involvement to

enhance participation of the players to help and to motivate while enhancing engagement with the platform. The difference between the gamified environment and game-based learning is well elaborated, and it is stated that games are a subpart of gamified application. Usage of applicable game elements in the gamified application is still an open question. To enhance the education system, there is a need to explore new theories and implement new opportunities to enhance the engagement among the students toward classroom learning.

References

Akpolat, B.S., Slany, W. (2014). Enhancing software engineering student team engagement in a high-intensity extreme programming course using gamification. In: *2014 IEEE 27th conference on software engineering education and training (csee&t)*, pp. 149–153, IEEE.

Aparicio, M., Oliveira, T., Bacao, F., & Painho, M. (2019). Gamification: A key determinant of massive open online course (mooc) success. *Information & Management, 56*(1), 39–54.

Botra, A., Rerselman, M., Ford, M. (2014). Gamification beyond badges. In *2014 IST-Africa Conference Proceedings*. pp. 1–10. IEEE

Bouki, V., Economou, D., Kathrani, P. (2014). "Gamification" and legal education: A game based application for teaching university law students. In: *2014 International Conference on Interactive Mobile Communication Technologies and Learning (IMCL2014)*. pp. 213–216. IEEE.

Buckley, P., Doyle, E. (2017). Individualising gamification: An investigation of the impact of learning styles and personality traits on the efficacy of gamification using a prediction market. *Computers and Education , 106*, 43–55.

Cahyani, A. (2016). Gamification approach to enhance student's engagement in studying language course. In *MATEC Web of Conferences*. vol. 58, p. 03006. EDP Sciences.

Cardinot, A., Fairfield, J.A. (2019). Game-based learning to engage students with physics and astronomy using a board game. *International Journal of Game-Based Learning (IJGBL) , 9*(1), 42–57.

Clark, A., Ernst, J. (2009). Gaming research for technology education. *Journal of STEM Education, 10*(1) (2009)

Colteli, O., Grandi, X., Tosca, R., Latorre, P., S´anchez, J.S., Liz´an, L. V., Ros- Bernal, F., Mart´ınez-Cadenas, C. (2014). Designing serious games for learning support in medicine studies: A specific method to elicit and formalize requirements. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*. pp. 1–4. IEEE.

De Freitas, S. (2018). Are games effective learning tools? A review of educational games. *Journal of Educational Technology and Society, 21*(2), 74–84 (2018)

Deater-Deckard, K., Chang, M., & Evans, M. E. (2013). Engagement states and learning from educational games. *New Directions for Child and Adolescent Development, 2013*(139), 21–30.

Deterding, S., Dixon, D., Khaled, R., Nacke, L. (2011). From game design elements to gamefulness: defining" gamification". In: *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*. pp. 9–15.

Dias, J. (2017). Teaching operations research to undergraduate management students: The role of gamification. In: *The International Journal of Management Education, 15*(1), 98–111.

Gonzalez, C.S.G., Carren˜o, A.M. (2014). Methodological proposal for gamification in the computer engineering teaching. In *2014 International symposium on computers in education (SIIE)*. pp. 29–34. IEEE.

Hakak, S., Noor, N., Ayub, M., Affal, H., Hussin, N., Imran, M., et al. (2019). Cloud-assisted gamification for education and learning–recent advances and challenges. *Computers and Electrical Engineering, 74*, 22–34.

Halloluwa, T., Vyas, D., Usoof, H., Hewagamage, K.P., Sahama, T. (2016). Gamifying mathematics for primary students in rural sri lanka. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*. pp 1–4.

Hanus, M.D., Fox, J.: Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation social comparison, satisfaction, effort, and academic performance. *Computers and Education, 80,* 152–161.

Herbert, B., Charles, D., Moore, A., Charles, T. (2014). An investigation of gamification typologies for enhancing learner motivation. In: 2014 International Conference on Interactive Technologies and Games. pp. 71–78. IEEE (2014).

Huang, B., Hew, K., & Lo, C. K. (2019). Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement. *Interactive Learning Environments, 27*(8), 1106–1126.

Israel-Fishelson, R., & Hershkovitz, A. (2020). Persistence in a game-based learning environment: The case of elementary school students learning computational thinking. *Journal of Educational Computing Research, 58*(5), 891–918.

Jin, Y., Yang, X., Kula, R., Choi, E., Inoue, K., Iida, H. (2015). Quick trigger on stack overflow: a study of gamification-influenced member tendencies. In: 2015 IEEE/ACM 12th Working Conference on Mining Software Repositories. pp. 434–437 IEEE

Lavega, P., Alonso, J. I., Etxebeste, J., Lagardera, F., & March, J. (2014). Relationship between traditional games and the intensity of emotions experienced by participants. *Research Quarterly for Exercise and Sport, 85*(4), 457–467.

Legaki, N. Z., Xi, N., Hamari, J., Karpouzis, K., & Assimakopoulos, V. (2020). The effect of challenge-based gamification on learning: An experiment in the context of statistics education. *International Journal of Human-Computer Studies, 144,* 102496.

Lu¨ckemeyer, G. (2015). Virtual blended learning enriched by gamification and social aspects in programming education. In *2015 10th International Conference on Computer Science & Education (ICCSE)*. pp. 438–444. IEEE.

Mart´ı-Parren˜o, J., Segu´ı-Mas, D., Segu´ı-Mas, E. (2016). Teachers' attitude towards and actual use of gamification. In *Procedia-Social and Behavioral Sciences, 228,* 682–688.

Mohamad, S., Sazali, N., & Salleh, M. (2018). Gamification approach in education to increase learning engagement. *Int. J. Humanit. Arts Soc. Sci, 4*(1), 22–32.

Nand, K., Baghaei, N., Casey, J., Barmada, B., Mehdipour, F., Liang, H.N. (2019). Engaging children with educational content via gamification. *Smart Learning Environments, 6*(1), 6.

Rapp, A., Hopfgartner, F., Hamari, J., Linehan, C., Cena, F. (2019). Strengthening gamification studies: Current trends and future opportunities of gamification research.

da Rocha Seixas, L., Gomes, A. S., & de MeloFilho, I. J. (2016). Effectiveness of gamification in the engagement of students. *Computers in Human Behavior, 58,* 48–63.

Sailer, M., Sailer, M. (2020). Gamification of in-class activities in flipped classroom lectures. *British Journal of Educational Technology*.

Shi, L., & Cristea, A. I. (2015). Learners thrive using multifaceted open social learner modeling. *IEEE Multimedia, 23*(1), 36–47.

S¨obke, H., Broker, T., Kornadt, O. (2013). Using the master copy-adding educational content to commercial video games. In *The Proceedings of The 7th European Conference on Games Based Learning*. vol. 2, pp. 521–530.

The FunTheory: Piano stairs (accessed: 13–09–2016), https://www.youtube.com/watch?v2lXh2n0aPyw.

Toda, A. M., Klock, A. C., Oliveira, W., Palomino, P. T., Rodrigues, L., Shi, L., et al. (2019). Analysing gamification elements in educational environments using an existing gamification taxonomy. *Smart Learning Environments, 6*(1), 16.

A Taxonomy on Biometric Security and Its Applications

Aditya Bakshi and Sunanda Gupta

Abstract

In modern times, pioneering works in the field of face recognition have seen the new development in biometric technology. A greater spectrum with modalities such as iris, face, fingerprints, signature, or hand has been largely deployed, and highly accurate systems using these modalities have been designed too. Recently, a critical issue has been addressed that affects the path of technological evolution in biometrics, i.e., spoofing, which is very resistant to biometric technology through external attacks. Spoofing is different from other IT security solutions as it is a purely biometric vulnerability. With the help of a sensor, an illegitimate user fools the biometric system by treating it as a genuine one using a synthetic forged version refers to as spoofing. The researchers and developers of the biometric community have worked a lot in suggesting and emerging different security methods. The main objective of this paper is to deliver an inclusive outline of the emerging field of anti-spoofing that has been carried out over the last decade. The work covers concepts, procedures, or advanced techniques that largely positioned face modality and also explains the future aspect in the field of biometric security.

Keywords

Biometrics • Anti-spoofing • Face • Attacks • Security

A. Bakshi (✉) · S. Gupta
Department of Computer Science and Engineering, Shri Mata Vaishno Devi University, J and K, Katra, India
e-mail: addybakshi@gmail.com

S. Gupta
e-mail: sunanda.gupta@smvdu.ac.in

1 Introduction

For the last 40 years, revolutionary works on the face recognition system (i.e., automated system) have been done (Bledsoe, 1964; Kelly, 1970; Davis et al., 1952), and for developing an accurate biometric security system, a continuous progress has been done. Biometric traits such as iris, voice, and fingerprints modalities have been used for detection purposes nowadays. Every technology has its own time to prove its worth. For improving the performance of biometric systems (Jain et al., 2006), there are many areas such as image processing, computer vision, and pattern recognition in which researchers from different fields work for designing innovative new techniques. For example, the new security biometric paradigm can be designed as "forget about cards and passwords, you are your own key" (Guardian, 2013). Forensics, border and access control, surveillance, or online commerce are the diverse activities in biometrics too.

For the improvement in the recognition performance and scenario of constant expansion, a new area of concern is rising in biometric technology. The resilience against outside threats in biometrics has been developed that possess great challenges that have draws an attention by researchers. It is believed that airports, laptops, or mobile phones are not only examples of biometric security, but in day-to-day life, users become more familiar with this security mechanism. Therefore, in each year the deployment of biometric systems keeps growing as the general public easily understands the security weaknesses in their systems. Apart from the face, there are other biometric systems fingerprints or irises that fool users too because it is very easy to get the detailed guidance with tutorial videos on creating fake masks.

Many real operational applications have been designed as attacks cannot be restricted in the theoretical or academic sphere. The prime example for biometric security is new iPhone 5S fingerprint reader which is vulnerable to many attacks (Guardian, 2013). Other attacks such as face

recognition (Register, 2008; The CNN, 2010) attempt from hacking groups, from actual illegal cases (Tech Crunch, 2009), or even from security-specific conferences (Duc and Minh, 2009) where live demonstrations have been shown by the user for biometric security.

In literature, spoofing is well explained with low-cost and tech features publically which are shown in different ways, but these features are not vulnerable in all biometric modalities (Rasa, 2013; Galbally et al., 2011; 2011; Matsumo et al., 2002; Hennebert et al., 2007; Mjaaland et al., 2010; Chen et al., 2005; Alegre et al., 2012; Bin et al.. 2009; Akhtar et al., 2012). Therefore, for detection, necessary countermeasures can be incorporate to such an extent that systems are robust to these attacks (Tome et al., 2014). However, examples like encryption, digital signature, or watermarking are not effective in today's scenario as imitating these threats is not easy in security mechanisms. As a result, for detecting biometric systems, i.e., differentiate between fake and real samples, precise countermeasures have been required. A significant amount of research has been conducted in biometric security that is ensured in good publications in international journals and conferences. With the development of new anti-spoofing algorithms and systems, researchers make the system harmless for real-time applications. Face, fingerprints, and iris are the most popular and mature modalities that are the most of spoofing mechanism. At this moment, to explain the strong picture and advancements, a diverse and dedicated work in the anti-spoofing field is need for an hour today.

2 Background Study and Literature

The basic terminology used in the case for spoofing has not reached a general agreement by the biometric community. Therefore, lots of ongoing efforts and proposals have been explained for combined and consistent classification for vulnerabilities in spoofing. The ability of an illegitimate user that fools the biometric system and recognize as a genuine user by presenting in front of the sensor as a synthetic forged version of the original biometric user. These types of attacks are referred to as direct attacks. The process of impersonating different users to make a novel unpretentious personality using an artificial trait is referred to as spoofing.

Different scenarios for spoofing attacks that have been conceived on the type of biometric system are as follows (i) Verification system: In the best mutual incident, a duplicate copy of the true user is presented at the time of the authentication part. The registered actual pattern of the real user is acquired and matched in this phase. (ii) A closed set of Verification system/Identification system: Spoofing can be performed by producing a new identity for actual users that can be used by other users to enter the system later at the

enrollment stage too. (iii) Identification system in open set: Using the spoofing artifact, a new identity has been created in a watch list to avoid further loss of information.

2.1 State-Of-The-Art in Face Anti-Spoofing

The principal idea for selecting the face biometric as anti-spoofing survey is following:

- The group, i.e., International Biometric Group (IBG), tells face is the most organized biometric in terms of market quota right after at world level after fingerprints (International Biometrics Group, 2008). The most important ID documents such as pictures on biometric passport (Gipp et al., 2007) or national ID cards (2013). DNI Electronico, 2013) adopted the same pattern. The highest potential biometric traits nowadays are faces that impact the financial and societal point of view.
- Also very large amount of spoofing related published work has been conducted for face recognition together with the fingerprint trait.

In this section, common face spoofing techniques summary is presented. After that, a review of diverse mechanisms has been presented against spoofing security.
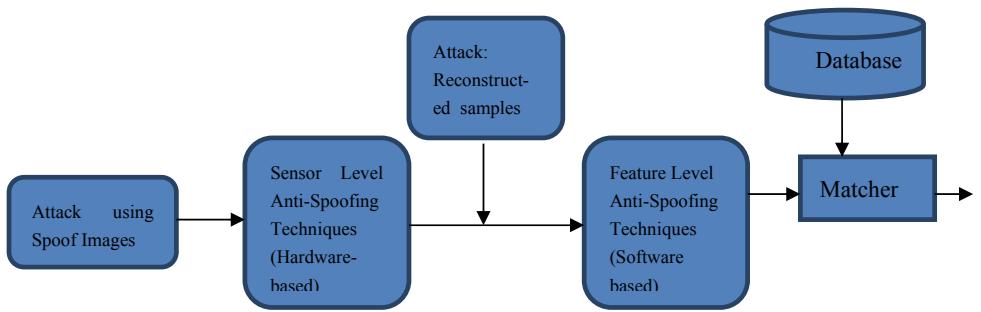
The three types of anti-spoofing techniques with biometric system block diagram is shown in Fig. 1.

2.1.1 Face Spoofing

In an enormous majority of recognized societies, the use of facial masks has been recognized for centuries. The trends to change one's self physical appearance are the most modern version used by the attackers. For example, the use of silicon artifacts or other methods is becoming more and more popular these days. These can be easily performed or implemented due to the availability of progressive expertise, its reasonable cost, and its swiftness. Although, many algorithms have been developed for robust facial surgery changes (Aggarwal et al., 2012; Sun et al., 2013). But, the problem of recognizing a person in automatic face authentication systems (Singh et al., 2010) is still an open challenge. Even, by wearing regular make-up (Dantcheva et al., 2013), face-based biometric systems may be outwitted. The three main types of attacks that have been used by the attackers to carry out spoofing attacks:

Photograph Attacks: In a photograph attack, a photograph of the genuine user is presented in front of the recognition system for attempting fraudulent access. The attacker captures a photograph of the user by himself using a digital camera. But most of the time, the attacker retrieved the user picture from the Internet which was taken by the attacker

Fig. 1 Block diagram of the biometric system with types (three) of anti-spoofing techniques

using a digital camera, or even retrieved from popular online social networks available today (Li et al., 2014). The image used for attack purposes may be from digital-photograph attacks (i.e., use of a digital device such as notepad and mobiles) or attacks from printed on a paper (Galbally, 2010a; Anjos and Marcel , 2011a). Photographic masks are the more innovative type of photograph attack these days. In these masks, eyes and mouth have been shown very clear as shown in high-resolution printed photographs. These help the imposters to attack on assured movements in the face such as eye blinking can be copied easily.

Video Attacks. Replay attacks are the other name of video attacks. Video attacks are a version of the spoofed photographs in a more sophisticated way. In this case, the attacker plays a video of the real client using mobiles, notebook, or laptop (Chingovska et al., 2012; Zhang et al., 2012) but does not use a still image. Furthermore, the development in face spoofing attacks is appeared frequently and detection is very difficult.

Mask Attacks. Mask attacks use 3D disguise of the real client's face for spoofing mechanism that increases the difficulty for accurate countermeasures. Moreover, the use of depth clues for finding a solution in the other two types of attacks becomes inefficient against a complete 3D face configuration. Although, it is a very great idea that has been circulating easily in the biometric system by copying the face mask of a different user but still (Kim et al., 2009) these attacks are not that much common than the previous two categories. With the attainment of the mask-specific datasets (Erdogmus and Marcel, 2013a; Kose and Dugelay, 2013), face-mask spoofing has been used thoroughly with different materials and sizes of masks (Erdogmus and Marcel, 2014; Erdogmus and Marcel, 2013b).

In today's generation, large databases of realistic masks posed great technical and economic difficulty that addressed the scarcity of research work in the field of face spoofing. But, recent emergence in most of the companies where 3D face models may be found for a rational value has lessened its difficulty.

2.1.2 Face Anti-spoofing

A physical insurgency under the ages of the TABULA RASA European project engrossed on the study of spoofing attacks in biometric systems. In the last three years, lots of experiments have been done in this technology which was out of the box for more than a decade. The achievement and circulation of numerous face spoofing databases motivate the researchers for the development of new security mechanisms against these attacks. For effective countermeasures, more emphasis is on the designing of a robust system, not on topics for data procurement which attracts the researchers (Li et al., 2014; Chingovska et al., 2012; Zhang et al., 2012; Kose and Dugelay 2013). This is the main reason that lots of recent publications were there for numerous methods in 2D face anti-spoofing. For face recognition systems (i.e., 3D structure) against attacks on mask, artifacts are a capable study for new security algorithms which is also initiated.

In the next sections, a review of face anti-spoofing and its challenges have been addressed. It is generally witnessed that when anti-spoofing approaches are verified under different circumstances for which they were considered, loss of accuracy is a significant issue across databases. The weaknesses of such methods are used by the strengths of others (Chingovska, et al., 2013) (Chakka et al., 2011) but by mixing many balancing algorithms usually give great results. Also, for the detection of video-based attacks, some liveness detection systems have been considered using the face analysis and context-based analysis with head poses of 2D images (Marsico et al., 2012; Wang et al., 2013). From different acquired samples, non-facial information has many advantages such as scenes with motion features, (Kim et al., 2011) recapturing process used for estimating the noise in an image (Silva Pinto et al., 2012), use of popular local binary patterns (LBP) for sequential evidence existing in series of videos (Freitas Pereira et al., 2012), etc. Table I shows the attacks on the face biometrics investigated.

Saha et al., (2012) presented a hardware-based computer vision algorithm using the Xilinx hardware development platform as well Mathworks Matlab and corresponding transmission crypto channel between multiple FPGA platforms for developing a hardware-software co-design

environment. As designs of application-specific integrated circuits (ASICs) and digital signal processors (DSP) have been successfully implemented by the engineers, but field programmable gate array (FPGA) combining the key advantages of ASICs and DSPs is a very powerful hardware device for rapid prototyping. Asaduzzaman, Abu, et al.. (Asaduzzaman et al.. 2015) proposed a CUDA-accelerated image processing method for loading of the pixel's bytes in a one-dimensional array with length equal to matrix width * matrix height * bytes per pixel which is the key step of an algorithm. Kaur et al.. (2012) presented distributed image processing algorithms using dynamic data for a particular application under various distributed environments. The performance analyses can also be done for a distributed image processing framework through distributed control. Akhtar, Zahid, et al., (2012) proposed robust multi-modal systems with serial and parallel fusion modes and their comparative analysis for spoofing attacks. As evaluation for the robust multi-modal system has not yet been investigated for serial fusion mode so for empirical investigation for finding the different vulnerability for real spoofing attacks.

3   Applications in Biometric Security

The exploitation of face videos (i.e., both spatial and temporal information) has shown very good results by dynamic anti-spoofing schemes. However, examples like applications for passport design, etc., these schemes cannot give fruitful results as there is only one face image of the user is present. Moreover, even getting the high accuracy for facial analysis with nonconsecutive frames, there are scenarios where detection cannot be done easily such as applications on video surveillance. This section explains different spoofing applications which are used by the illegitimate user for accessing the system in the field of biometric security.

One of the applications explained by the researchers is the physical entrance of the Indian currency. The economy of each country including India is affected by fake currency detection which is a very serious issue. It can be implemented either by changing its physical appearance or use of chemical properties (Rathee 2016). One of the security features of Indian currency is its authentication, but capturing various features such as security thread, intaglio printing

Table 1 Different face biometrics attacks

References	Feature type	Approach	Database
Galbally 2010b)	Face	Proposed a two face recognition systems for indirect attacks for testing the vulnerabilities based on Bayesian adaption using a hill-climbing attack algorithm	XM2VTS database
Kapur and Baregar 2013)	Face + SIFT	Presented the security of an image using image steganography and image stitching that can be achieved by using any electronic mode. Using k nearest method, parts are stitched together. The quality of the image is greatly improved by implementing SIFT features	Live database
Anjos and Marcel 2011b)	Face + Motion	The author presented a novel technique for spoofed identities such as photographs those by-pass 2D face recognition systems very easily. So, to find out the solution and designing a protocol, a motion-based algorithm that detects correlations between the scene context and the person's head movements is implemented	PRINT-ATTACK database
Chakka 2011)	Face	The author explained the competition of 2D face recognition systems for spoof identities, and a unique evaluation method is used by comparing the performance between different advanced algorithms on the similar database	Mask database
Hemalatha and Wahi 2014)	Face + liveness detection	Author presented a face recognition system against spoof attacks This paper explained the outline to the face biometric system, face spoofing attacks, and liveness detection that is helpful for identification (authentication) application	Live database
Pan 2011)	Face + color texture	Proposed a generalization of color texture-based face anti-spoofing mechanism for finding a robust face PAD solution for attack-specific and countermeasures based solely on color texture analysis	Replay attack database
Boulkenafet et al., 2018)	Face + eye blinking	Proposed an anti-spoofing face recognition system against photograph attack and a real-time liveness detection approach by explaining impulsive eye blinks which is a non-intrusive mechanism. The proposed model shows the effectiveness of our approach and after an extensive set of experimentation, it presents how it outperforms the cascaded Adaboost and HMM in the task of eye blink detection	Blinking video database

(continued)

Table 1 (continued)

References	Feature type	Approach	Database
Pan 2007)	Face	Proposed a continuous authentication mechanism for smartphone users using facial attributes. The author uses binary attribute classifiers for training that provides compact visual descriptions of faces	MOBIO and AA01
Samangouei et al. 2017)	Face + texture	Proposed countermeasures in the mask database that developed using both 2D data (texture images) and 3D data (3D scans). Moreover, the baseline technique for both 2D and 3D face recognition has already been used for analysis of mask spoofing	Mask database
Goswami and `Face recognition captcha.', 2012)	Face	Explored a face recognition-based CAPTCHA for potential high-level attacks. To understand the CAPTCHA, the complex background is inserted that can be placed with the same subject where clients can effectively discover one set of human face pictures	AR face database
Yu 2019)	Face + kernel features	Proposed a diffusion-based kernel matrix model for face liveness detection. As different verification systems and face recognition are vulnerable to video spoofing attacks, the proposed model uses anisotropic diffusion in a video to enhance the edges of each frame and extract the video features using diffusion kernel (DK) features	Replay attack database
Nguyen 2008)	Face	Proposed an automatic layer extraction method for face synthesis and editing and its applications. The human faces can be viewed as a composition of several different layers with different categories of objects too. The proposed method shows that the tasks such as beard removal (virtual shaving), beard synthesis, and beard transfer are explained very clearly	Live database
Galbally and `Hill-climbing attack to an eigenface-based face verification system.', 2009)	Face	Proposed an evaluation of Eigen face-based verification system using the XM2VTS database. The proposed hill-climbing attack algorithm of an Eigen face-based approach with Bayesian adaption is used to test the vulnerability for face recognition	XM2VTS database

(RBI logo), and documentation mark, different image processing procedures have been applied. So, the conclusive score of all the three features has been bonded to differentiate between actual and false currencies that make the system more robust and accurate.

Another application is also related to currency, i.e., counterfeit currency. Because of the rapid adoption and adaptation, forgers are becoming tougher to find (Ahmed 2014). So, one of the effective methods in terms of cost, reliability, and accuracy is easily available for the detection of fake user. This can be achieved by extracting existing features of banknotes such as micro-printing, optically variable ink (OVI), water-mark, iridescent ink, security thread, and ultraviolet lines using OCR (Optical Character recognition), contour analysis, face recognition, speeded up robust features (SURF) and Canny Edge & Hough transformation algorithm of Open CV.

The other application is protection against the use of low entropy passwords in consumer storage devices. Also, all the stored confidential information from a removable storage device can be easily retrieved by stolen passwords from the devices (Amin 2017). So, a common verification and key concession protocol have been implemented to protect the confidential information in the device of the user. An algorithm, i.e., Burrows-Abadi- Needham (BAN) logic is used for the security analysis.

Recently, the research and development community has gained considerable attention in the field of fog and mobile edge computing. The problems of security and privacy of biometric can be solved using edge computing that plays a vital role in saving critical private information. The information of software content that is easy to copy and distributed has been solved using zero-watermarking (Abdul et al., 2017). Also, data can be secured with visual cryptography that can be shared from multiple sources. So, a security mechanism for biometric face images has been developed which adversely impacts the visual quality of the image.

4 Future Scope

The problems and challenges that have been addressed in biometrics could help other researchers to work in this field. Although, detecting the recent developments and consequences from the different future models would show a path for different in future directions.

First, the absence of interoperability is the major shortcomings in existing anti-spoofing techniques that need to be examined in the future across databases. However, many algorithms have been designed to attain accuracy nearby 100% but when the difficult dataset is transformed their performance drops significantly. Therefore, it is clear that no superior anti-spoofing technique is designed to date. The results show a curious message that may be learned: No existing anti-spoofing system. The environment of the attack situations and acquisition settings has been changed from one particular protection method to another. Therefore, best fusion approaches have to be developed using liveness detection techniques to achieve greater performance over diverse spoofing information (Freitas Pereira et al., 2013; Galbally et al., 2014).

Second, the equilibrium between safety and suitability is another theoretical problem in spoofing field. The most reason for deploying and developing biometrics is its security dimension that cannot be denied. Fields related to forensics should also be considered that could impact the spoofing. It is also possible to include temporal information in systems that are working with face videos. Video attacks can also be used for video attack measures.

Renowned Sherlock Holme's short stories are prime evidence in fake fingerprint forensic. The possibilities of spoofing attacks in the coming future can be predicted effectively. In years to come, detection of spoofing can gain a lot of significance and assets.

5 Conclusion

Nowadays, in the next-generation system, the role of biometrics and its technologies has improved severely. So, a need for securing the system is an important aspect. It might be identified that in spoofing detection, lots of work and advancements have been done, but evolution of different offensive practices would make spoofing attacks more and more sophisticated. In this paper, a different aspect of biometric security has been explained with a background and literature survey for spoofing detection. Lots of application and future aspects of biometric security have also been covered. This will help to motivate the researchers to work in this field that helps the user to differentiate between fake and real users. So, protection against direct attacks is still a big challenge that energizes the new generation to enhance the work in designing secure biometric systems in the coming years.

References

Bledsoe W.W. (1964). *The model method in facial recognition*. Panoramic Res., Inc., Palo Alto, CA, USA, Tech. Rep. PRI:15,

Kelly, M.D. (1970). Visual identification of people by computer, Stanford AI Project, Stanford, CA, USA, Tech. Rep. AI-130.

Davis, K. H., Biddulph, R., & Balashek, S. (1952). Automatic recognition of spoken digits. *J. Acoust. Soc. Amer., 24*(6), 637642.

Jain, A. K., Ross, A., & Pankanti, S. (2006). Biometrics: A tool for information security. *IEEE Transformation Information Forensics Security, 1*(2), 125143.

The Guardian. (2013). *iPhone 5S Fingerprint Sensor Hacked by Germany's Chaos Computer Club*. (Online). Available: www.theguardian.com/technology/2013/sep/22/apple-iphone-ngerprint-scanner-hacked.

The Register. (2008). *Get Your German Interior Minister's Fingerprint Here*. (Online). Available: https://www.theregister.co.uk/2008/03/30/german_interior_minister_ngerprint_appropriated/

The CNN. (2010). *Man in Disguise Boards International Flight*. (Online). Available: https://edition.cnn.com/2010/WORLD/americas/11/04/canada.disguised.passenger/PRA Laboratory. (2013).

Fingerprint Spoofing Challenge, YouTube. (Online). Available: https://www.youtube.com/watch?v=vr0FmvmWQmM.

Discovery Channel. (2011). *Mythbusters: Fingerprints Cannot be Busted, YouTube*. (Online). https://www.youtube.com/watch?v=3Hji3kp-i9kChaos Computer Club Berlin. (2013).

Tech Crunch. (2009). *Woman Uses Tape to Trick Biometric Airport Fingerprint Scan*. (Online). Available: https://techcrunch.com/2009/01/02/woman-uses-tape-to-trick-biometric-airport-ngerprint-scan/ BBC News. (2005).

Malaysia Car Thieves Steal Finger. (Online). Available: https://news.bbc.co.uk/2/hi/asia-pacic/4396831.stm.

Duc, N. M., Minh, B. Q. (2009). *Your Face is NOT Your Password*. Face Authentication Bypassing Lenovo, Asus,Toshiba. San Francisco, CA, USA: Black Hat.

Tabula, R. (2013). *Tabula Rasa Spoofing Challenge*. (Online). Available: https://www.tabularasa-euproject.org/evaluations/tabula-rasaspoong-challenge-2013.

Galbally, J., Fierrez, J., Alonso-Fernandez, F., & Martinez-Diaz, M. (2011). Evaluation of direct attacks to fingerprint verification systems. *Telecommunication System, 47*(3–4), 243–254.

Galbally, J., et al. (2010a). An evaluation of direct attacks using fake fingers generated from ISO templates. *Pattern Recognition Letters, 31*(8), 725732.

Matsumoto, T., Matsumoto, H., Yamada, K., Hoshino, S. (2002). Impact of artificial gummy fingers on ngerprint systems. In *Proceedings on SPIE, Optical Security Counterfeit Deterrence Technology IV*, vol. 4677, pp. 275–289.

Hennebert, J., Loeffel, R., Humm, A., Ingold, R. (2007). A new forgery scenario based on regaining dynamics of signature. In *Proceedings IAPR International Conference Biometrics (ICB)*, pp. 366–375.

Mjaaland, B.B., Bours, P., Gligoroski, P. (2010). Walk the walk: Attacking gait biometrics by imitation. In *Proceedings 13th International Conference Information Security (ISC)*, 2010, pp. 361–380.

Chen, H., Valizadegan, H., Jackson, C., Soltysiak, S., Jain, A.K. (2005). Fake hands: Spoong hand geometry systems. In *Proceedings Biometrics Consortium Conference (BCC)*.

Alegre, F., Vipperla, R., Evans, N., Fauve, B. (2012). On the vulnerability of automatic speaker recognition to spoofing attacks with artificial signals. In *Proceedings European Signal Processing Conference (EUSIPCO)*, pp. 3640.

Bin, Q., Jian-Fei, P., Guang-Zhong, C., Ge-Guo, D. (2009). The anti-spoofing study of vein identification system. In *Proceedings International Conference Computer Intelligence Security (ICCIS)*, pp. 357360.

Akhtar, Z., Fumera, G., Marcialis, G.L., Roli, F. (2012). Evaluation of serial and parallel multi biometric systems under spoofing attacks. In *Proceedings IEEE 5th International Conference Biometrics, Theory, Application System (BTAS)*, pp. 287–288.

Tome, P., Vanoni, M., & Marcel, S. (2014). *"On the vulnerability of finger vein recognition to spoofing"*, *in Proc.* Biometrics Special Interest Group (BIOSIG): IEEE Int. Conf.

IBG. (2008). Biometrics market and industry report 2009–2014. *International Biometrics Group*, Virginia, USA, Tech. Rep.

Gipp, B., Beel, J., & Rössling, I. (2007). *ePassport: The World's New Electronic Passport*. Scotts Valley, CA, USA: CreateSpace.

Ministerio del Interior, Gobierno de Espana. (2013).DNI Electronico.

Aggarwal, G., Biswas, S., Flynn, P.J., Bowyer, K.W. (2012). A sparse representation approach to face matching across plastic surgery,'' in Proc. Workshop Appl. Comput. Vis. (WACV), pp. 118–119.

Sun, Y. Tistarelli, M., Maltoni, D. (2013). Structural similarity based image quality map for face recognition across plastic surgery,'' in Proc. IEEE Conf. Biometrics, Theory, Appl. Syst. (BTAS), Sep./Oct. 2013, pp. 1–8.

Singh, R., Vatsa, M., Bhatt, H. S., Bharadwaj, S., Noore, A., & Nooreyezdan, S. S. (Sep. 2010). Plastic surgery: A new dimension to face recognition. *IEEE Trans. Inf. Forensics Security, 5*(3), 441–448.

Dantcheva, A., Chen, C., Ross, A. (2013). Can facial cosmetics affect the matching accuracy of face recognition systems? In *Proceedings IEEE 5th International Conference Biometrics, Theory, Applicaion Systems (BTAS)*, pp. 391–398.

Li, Y., Xu, K., Yan, Q., Li, Y., Deng, R.H. (2014). Understanding OSN-based facial disclosure against face authentication systems. In *Proceedings ACM Asia Symposium Information Computer Communication Security (ASIACCS)*, pp. 413–424.

Anjos, A., Marcel, S. (2011). Counter-measures to photo attacks in face recognition: A public database and a baseline. In *Proceedings IEEE International Joint Conference Biometrics (IJCB)*, pp. 1–7.

Chingovska, I., Anjos, A., Marcel, S. (2012). On the effectiveness of local binary patterns in face anti-spoong. In *Proceedings IEEE International Conference Biometrics Special Interest Group (BIOSIG)*, pp. 1–7.

Zhang, Z., Yan, J., Liu, S., Lei, Z., Yi, D., Li, S.Z. (2012). A face antispoofing database with diverse attacks. In *Proceedings of IAPR International Conference on Biometrics (ICB)*, pp. 26–31.

Kim, Y., Na, J., Yoon, S., & Yi, J. (2009). Masked fake face detection using radiance measurements. *J. Opt. Soc. Amer., 26*(4), 760–766.

Erdogmus, N., Marcel, S. (2013). Spoofing in 2D face recognition with 3D masks and anti-spoofing with Kinect. In *Proceedings IEEE Biometrics, Theory, Application System (BTAS)*, pp. 1–6.

Kose, N., Dugelay, J.L. (2013). On the vulnerability of face recognition systems to spoong mask attacks. In *Proceedings IEEE International Conference Acoustics Speech Signal Process. (ICASSP)*, pp. 2357–2361.

Erdogmus, N., & Marcel, S. (Jul. 2014). Spoong face recognition with 3D masks. *IEEE Trans. Inf. Forensics Security, 9*(7), 1084–1097.

Erdogmus, N., Marcel, S. (2013). Spoong 2D face recognition systems with 3D masks. In *Proceedings International Conference Biometrics Special Interest Group (BIOSIG)*, pp. 1–8.

Chingovska, I., et al. (2013). The 2nd competition on counter measures to 2D face spoofing attacks. In *Proceedings IAPR International Conference Biometrics (ICB)*, pp. 1–6.

Chakka, M.M., et al. (2011). Competition on counter measures to 2-D facial spoofing attacks. In *Proceedings IEEE International Joint Conference Biometrics (IJCB)*, pp. 1–6.

de Marsico, M. M., Nappi, D. R. , Dugelay, J. (2012). Moving face spoofing detection via 3D projective invariants. In *Proceedings IEEE International Conference Biometrics (ICB)*, pp. 73–78.

Wang, T., Yang, J., Lei, Z., Liao, S., Li, S.Z. (2013). Face liveness detection using 3D structure recovered from a single camera. In *Proceedings IEEE/IAPR International Conference Biometrics (ICB)*, pp. 1–6.

Kim, Y., Yoo, J.H., Choi, K. (2011). A motion and similarity-based fake detection method for biometric face recognition systems. In *Proceedings IEEE International Conference Consumer Electronics (ICCE)*, pp. 171–172.

da Silva Pinto, A., Pedrini, H., Schwartz, W., Rocha, A. (2012). Video based face spoofing detection through visual rhythm analysis. In *Proceedings 25th Conference Graphics Patterns Images (SIBGRAPI)*, pp. 221–228.

de Freitas Pereira T., Anjos, A., de Martino, J.M., Marcel, S. (2012). LBP-TOP based countermeasure against face spoofing attacks. In *Proceedings International Workshop Computer Vis.ion Local Binary Pattern Variants (ACCV)*,pp. 1–12.

Saha, Sangeet, Satyabrata Maity, and Suman Sau. "A brief experience on journey through hardware developments for image processing and its applications on Cryptography." arXiv preprint arXiv:1212.6303 (2012).

Asaduzzaman, A., Martinez, A., Sepehri, A. (2015). A time-efficient image processing algorithm for multicore/manycore parallel computing. SoutheastCon 2015. IEEE.

Kaur, S., Manisha, B. *Review Paper on Image Processing in Distributed Environment*.

Akhtar, Z. (2012). Evaluation of serial and parallel multibiometric systems under spoofing attacks. In *2012 IEEE Fifth International Conference on Biometrics: Theory, Applications and Systems (BTAS). IEEE.*

Galbally, J. (2010). On the vulnerability of face verification systems to hill-climbing attacks. *Pattern Recognition, 43*(3), 1027–1038.

Kapur, J., & Baregar, A. J. (2013). Security using image processing. *International Journal of Managing Information Technology (IJMIT), 5*(2), 13–21.

Anjos, A., Sébastien, M. (2011). Counter-measures to photo attacks in face recognition: a public database and a baseline. In *2011 international joint conference on Biometrics (IJCB). IEEE.*

Murali Mohan, C. (2011). Competition on counter measures to 2-d facial spoofing attacks. In *2011 International Joint Conference on Biometrics (IJCB). IEEE.*

Hemalatha, S., Amitabh, W. (2014). A study of liveness detection in face biometric systems. *International Journal of Computer Applications, 91*(1).

Pan, G. (2011). Monocular camera-based face liveness detection by combining eyeblink and scene context. *Telecommunication Systems, 47*(3–4), 215–225.

Boulkenafet, Z., Komulainen, J., & Hadid, A. (2018). On the generalization of color texture-based face anti-spoofing. *Image and Vision Computing, 77,* 1–9.

Pan, G. (2007). Eyeblink-based anti-spoofing in face recognition from a generic webcamera. In *2007 IEEE 11th International Conference on Computer Vision. IEEE.*

Samangouei, P., Patel, V. M., & Chellappa, R. (2017). Facial attributes for active authentication on mobile devices. *Image and Vision Computing, 58,* 181–192.

Goswami, Gaurav, "Face recognition captcha." 2012 IEEE Fifth International Conference on Biometrics: Theory, Applications and Systems (BTAS). IEEE, 2012.

Yu, C. (2019). Diffusion-based kernel matrix model for face liveness detection. *Image and Vision Computing, 89,* 88–94.

Nguyen, M. H. (2008). *Image-based shaving*. Computer graphics forum. Vol. 27. No. 2. Oxford, UK: Blackwell Publishing Ltd.

Galbally, J. (2009). Hill-climbing attack to an eigenface-based face verification system. In *2009 First IEEE International Conference on Biometrics, Identity and Security (BIdS). IEEE.*

Rathee, N. (2016). Feature fusion for fake Indian currency detection. In *2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom). IEEE.*

Ahmed, Z. (2014). Image processing based Feature extraction of Bangladeshi banknotes. In *The 8th International Conference on Software, Knowledge, Information Management and Applications (SKIMA 2014)*, IEEE.

Amin, R. (2017). A software agent enabled biometric security algorithm for secure file access in consumer storage devices. *IEEE Transactions on Consumer Electronics, 63*(1), 53–61.

Abdul, W., et al. (2017). Biometric security through visual encryption for fog edge computing. *IEEE Access* 5 (2017): 5531–5538.

de Freitas Pereira, T., Anjos, A., De Martino, J.M., Marcel, S. (2013). Can face anti-spoong countermeasures work in a real world scenario? In *Proceedings IEEE International Confw Biometrics (ICB)*, pp. 1– 8.

Galbally, J., Marcel, S., & Fierrez, J. (Feb. 2014). Image quality assessment for fake biometric detection: Application to iris, ngerprint, and face recognition. *IEEE Transactions on Image Processing, 23*(2), 710–724.

Computer-Aided Diagnostic System for Diabetic Retinopathy Using Convolutional Neural Network

Sanket Saxena, Shivam Sinha, and Shruti Jain

Abstract

An ongoing advancement in the condition of craftsmanship innovation assumes an imperative job in the picture handling applications, like biomedical, satellite picture preparing, artificial intelligence, object recognizable proof, diabetic retinopathy (DR), etc. DR is an eye disease found in people having high blood sugar. It can lead to loss of vision, if it is not treated properly. There is an increase in number of patients in comparison with ophthalmologists. The seriousness of the DR depends upon nearness of microaneurysms, hemorrhages, exudates and neovascularization. Specialists arrange diabetic retinopathy into five stages, namely ordinary, gentle, moderate, non-proliferative DR (NPDR) or proliferative DR (PDR). Convolutional neural network (CNN) results in high accuracy in classifying these diseases by spatial analysis. A CNN is progressively mind-boggling engineering construed more from the human visual perspective. A previous study done on DR suggests the use of CNN but with a different approach. Among other managed calculations involved, the proposed arrangement is to locate a superior and advanced way to classify the fundus picture with little pre-preparing techniques. Different fundus image databases available have been discussed. In this paper, different parameters used for the evaluation of developed systems have been presented.

1 Introduction

Diabetic retinopathy is one of the most prominent diseases found in the human eye. The problem with DR is its detection which requires very highly skilled medical facility. The main reason for a person to get contracted with diabetic retinopathy is diabetes. Diabetes occurs when the body is either not capable of producing sufficient insulin (known as Type 1 diabetes) or cells that cannot utilize which is produced by pancreas (Type 2 diabetes). Factors that are responsible for the increase in diabetes are obesity, urbanization, diabetes is population growth, aging, and reduced physical activity. As per the statistics from the International Diabetic Federation (IDF), the number of people with diabetes over the world in 2015 was 415 million, and by 2040, it will be 642 million. For Southeast Asia, it was 78.3 million in 2015 and will be 140.2 million in 2040. In India alone, there are 69.18 million cases of diabetes (http://www.ubcieee.org/events/signal-processing-cup-2015). If proper care is not taken, diabetes will lead to complications in the eye, kidney, skin, heart, foot, etc. An eye is an essential part of the human visual system which operates as a receptor organ. The eye is an exceptionally perplexing and stunning organ. It is roughly one inch wide and profound, and 0.9 inches tall. Natural eyes permit people to value all the superiority of the world. The natural eye is enveloped by three layers of tissue. There are just about 80 million individuals in India living with sight misfortune, counting around 3,60,000 individuals who are enlisted as visually impaired or incompletely located. Sight undermining maladies, for example, macular degeneration and diabetic retinopathy (DR) have added to the 40% expansion in outpatient attendances in the most recent decade yet are agreeable to early location and checking. With right on time and proper mediation, visual impairment might be forestalled in numerous cases (https://www.mayoclinic.org/diseases-conditions/retinal-diseases/symptoms-causes/syc-20355825). The retinal ailment is getting basic in the creating scene.

S. Saxena · S. Sinha · S. Jain (✉)
Jaypee University of Information Technology, Solan, India
e-mail: jain.shruti15@gmail.com

Treatment of retinal conditions is improving and might be financially savvy, even in eye clinics. One of the diabetes complexities is DR which harms the eye. It mainly harms the veins of light-touchy tissue which is at the back of the eye (retina). Ophthalmic training ought to plan eye laborers not just for the difficulties they will confront today, yet besides for future turns of events. This implies that we need all the more creating world ophthalmologists with sub-claim to fame preparing in retinal ailment who can prepare people in the future of eye workers (https://www.mayoclinic.org/diseases-conditions/diabetic-retinopathy/symptoms-causes/syc-20371611; https://www.eatonrapidseyecare.com/eye-health/diabetic-retinopathy/h). The standard eye tests, great control of our glucose and circulatory strain, and early interception for vision issues can assist with forestalling extreme vision misfortune. The complications in the eye can be glaucoma, cataracts and DR. About 40% of diabetic people are affected by DR. About 10% of the DR patients have the chance of completely losing the vision (https://www.mayoclinic.org/diseases-conditions/retinal-diseases/symptoms-causes/syc-20355825). DR is the entanglement that affects the eyes. It mainly harms the veins of delicate tissues of the eye.

Diabetic retinopathy is an eye disease found in people having high blood sugar. It can lead to loss of vision if it is not treated properly. There is an increase in the number of patients in comparison with ophthalmologists. In this scenario, there is a need for a system to aid the ophthalmologists for faster and easy diagnosis. Among other existing managing calculations, the majority of them require more pre-handling or post-preparing stages for recognizing various phases of the DR. Likewise, different calculations obligatorily require manual element extraction stages to order the fundus pictures. DR is the intricacy of diabetes and a leading reason for blindness in the world. The layer that covers the eye is the retina (https://www.nature.com/articles/s41746-019-0172-3). The retina is profoundly sensitive to light. It changes over any light that hits the eye into signals that can be deciphered by the mind. Signal manages to examine and handle uncomplicated and computerized signals and helps in removing other signals (http://www.ubcieee.org/events/signal-processing-cup-2015). These signs incorporate transmission signals, sound or voice signals, picture signals and different signs. DR damages the tissue which is in the retina and further makes it to excrete liquid and misshape sight which is shown in Fig. 1 (https://expertsystem.com/machine-learning-definition/). DR may cause no side effects or just mellow vision issues, and it causes the loss of eyesight.

DR affects the blood vessels in the retina. The inner side of an eye opposite to the lens forms the *fundus* of the eye (https://machinelearningmastery.com/what-is-deep-learning/; https://verhaert.com/use-artificial-intelligence-valuable-new-solutions/value-add-strategies-verhaert-nl/). As the situation gradually increases, diabetic retinopathy indications have spots in our vision, unfocused vision, and vary vision, unpaired color vision, black or blank areas in vision loss. DR is categorized into two parts, namely proliferative DR (PDR) and non-proliferative DR (NPDR). NPDR is the first phase of the DR. The extra fluid and some amount of blood start leaking from the retina into the eye. Sometimes, deposits of fats or cholesterol from the blood might seep out into the retina (https://www.eatonrapidseyecare.com/eye-health/diabetic-retinopathy/h). PDR is an advanced stage of DR, thereby precluding the flow of blood leading to block the vision. In response, the retina grows new blood vessels. However, they do not supply blood flow (https://www.geeksforgeeks.org/python-language-introduction/; http://news.mit.edu/2017/explained-neural-networks-deep-learning-0414). Also, these sometimes have scar tissue that can cause the retina to wrinkle or detach. When the tiny blood vessels, leaking blood and other fluids, forming features such as *microaneurysms*(MAs), *exudates, hemorrhages,* and *cotton wools* distorts vision as shown in Fig. 2. The presence of microaneurysms is an indication of mild NPDR. Moderate NPDR is identified by the presence of hemorrhages. Severe NPDR is depicted by the presence of exudates in the retina (https://www.kaggle.com/sid321axn/regularization-techniques-in-deep-learning; https://www.kaggle.com/sohaibanwaar1203/diabetic-rateinopathy-full). PDR can be in the form of vitreous hemorrhages. This blocks the light rays to arrive the retina. It can cause retinal detachment or neovascular glaucoma (https://modernod.com/articles/2019-june/the-four-stages-of-diabeticretinopathy?c4src=article:infinite-scroll; Santhakumar et al. 2016; Chandrakumar et al. 2016).

Fig. 1 Comparison between normal eye and diabetic eye. (https://expertsystem.com/machine-learning-definition/)
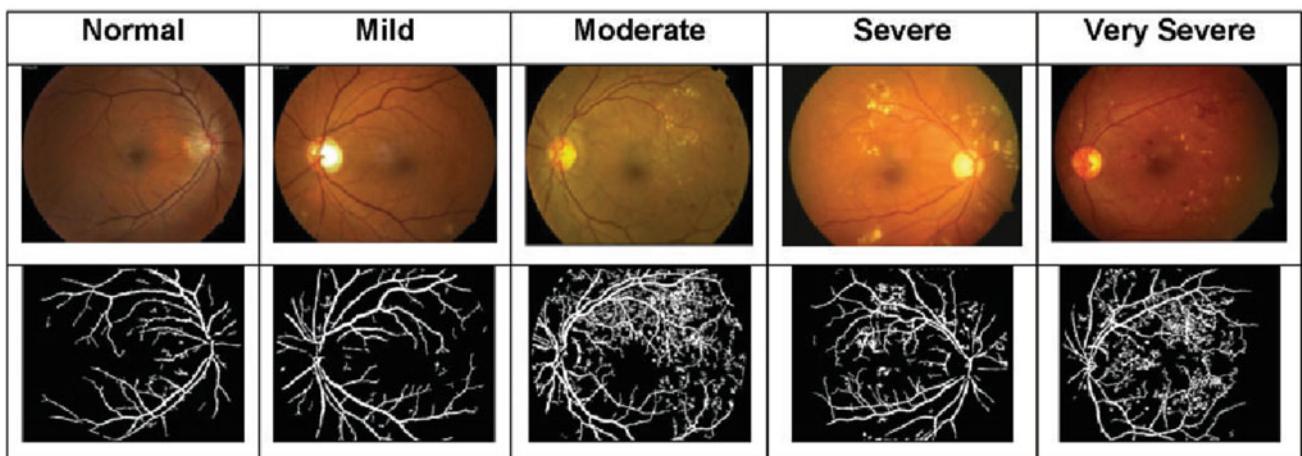
Fig. 2 Different DR stages

The patients with normal eyes have no findings in the eye images. The patients with only microaneurysm can be classified in the mild category, with at least one microaneurysm or retinal hemorrhage can be placed under moderate category and with greater than 20 microaneurysm are of severe type. Patients with neovascularization are of very severe category (Santhakumar et al. 2016). It has been realized that there are just about 80 million individuals in India who are experiencing sight loss or some other eye diseases. One of the significant tests is the forecast of the eye ailments accurately and by observing the statistical data points, and before expectation issues, it has been chosen to construct a program by which we can support the individuals and the specialists everywhere throughout the world to effectively and precisely foresee the retinal sicknesses (Chandrakumar and Kathirvel, 2016).

The objective of this paper is to develop software that can more accurately and efficiently predict diabetic retinopathy and help people and doctors all over the world to accurately predict retinal diseases. Initially, a basic neural network or algorithm requires a hand featured algorithm. In this paper, convolution neural networks which do not require hand-engineered features are used. Artificial intelligence (AI) intellectual advances can make it much progressively viable in preparing huge volumes of data that prompt profound learning. Profound learning, a subset of AI, uses various levels of counterfeit neural systems to do the procedure of AI. Machine learning revolves around the progress and improvement of PCs software and programs that can have the information and further use it to learn and grow (https://expertsystem.com/machine-learning-definition/).

This paper consists of the following: Sect. 2 explains the methodology for the images using CNN, Sect. 3 explains experimental results and discussion, of the proposed algorithm on images followed by a conclusion.

2 Proposed Methodology

In recent times, the majority of the picture handling specialists enjoyed the improvement of AI, particularly profound learning. Our proposed approach firmly developed dependent on the key parts of infection seriousness arrangement from the fundus pictures. To accomplish the most extreme exactness from the picture dataset, the proposed engineering of DCNN comprises various advances to be specific data augmentation, pre-handling, initialization of networks and *convolution neural network (CNN) classification* as shown in Fig. 3. The main reason for choosing CNN was that they have taken inspiration from animal's visual cortex. The CNN is considered over NN because fewer features are required in CNN which in turn helps in reducing overfitting problem in the proposed model.

Data augmentation: The fundus images are attained by different cameras and by changing its field of views, angles, clarity and ratio collected from different datasets. Data augmentation consists of different steps: flipping images, contrast adjustment and brightness adjustments which are made (Wang et al. 2019; https://www.flatworldsolutions.com/data-science/articles/7-applications-of-convolutional-neural-networks.php).

Pre-processing: Resizing is the primary step of the pre-processing. Before nourishing into the architecture for classification, the images are converted to gray scale and afterward to the *L* model. It is a monochrome image that is utilized to emphasize the MAs and vessels in the fundus images and helps in flattening the images in a single dimension for further dealing.
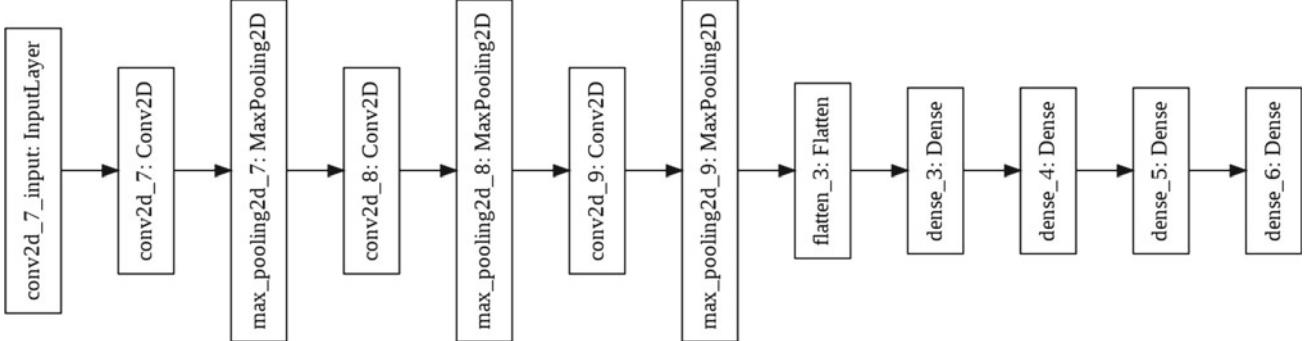
Fig. 3 Methodology for detection of various stages of DR. (https://verhaert.com/use-artificial-intelligence-valuable-new-solutions/value-add-strategies-verhaert-nl/)

CNN Classification: A CNN is a kind of feed-forward counterfeit neural system wherein the network design between its neurons is propelled by the association of a creature's visual cortex. In profound learning, (http://news.mit.edu/2017/explained-neural-networks-deep-learning-0414; https://www.kaggle.com/sid321axn/regularization-techniques-in-deep-learning), the convolutional neural system utilizes unpredictable engineering made out of stacked layers which is especially very much adjusted to characterize the pictures. Convolutional layer, pooling layer, rectified linear unit (ReLU) layer, dropout layer, fully associated layer and classification layer are various layers of the CNN model. The *convolutional layer* includes the fraction of channels. Each channel is convolved and focuses by framing another layer or initiation map. Every enactment map contains some critical highlights or trademark of the information image (Wang et al. 2019; Rodtook and Chucherd 2019). In the convolutional layer, $m \times m$ channel is tangled with the $N \times N$ input neuron layer that results in the size of $(N - m + 1) \times (N - m + 1)$. *The pooling layer* is one of the most noteworthy layers that assist the system from avoiding overfitting by lessening the boundaries and calculation in the system. It is only a scale back to the pixels with highlights. $N \times N$ input layer will yield a layer of $N/K \times N/K$ (Poplin et al. 2018). *ReLU layer* is an actuation work communicated by Eq. (1).

$$F(x) = \max(0, x) \tag{1}$$

where x is a contribution to the neuron and is a slope. A smooth estimate to the rectifier is the expository capacity. This actuation work initiates the insufficient condition of the concealed units. Additionally, it has been indicated that sigmoid and calculated relapse actuation work cannot be prepared productively contrasted with the profound neural systems. *The dropout layer* is the crucial piece of the CNN considering boundaries created from each stacked layer extensively that cause overfitting. To overcome this issue,

dropping out of certain neurons in the layer can be done. The feed-forward activity of the dropout layer network (https://www.geeksforgeeks.org/python-language-introduction/) depicts using Eq. (2).

$$r_{j}(n) \sim Bernoulli(p) \tag{2}$$

Fully connected layer is used after the normal/max-pooling layer. All neurons in the past layer from the max-pooling layer are taken by a completely associated layer and associated with each neuron (Pratt et al. 2016). After the stacked or profound different layers, the last layer which stacked toward the end for ordering the fundus picture is a softmax layer (*classification layer*).

Ophthalmologists use fundus images for diagnosis of DR. They visually inspect the image for detecting the lesions. These include microaneurysms, vitreous hemorrhages exudates and cotton wools. Classification is the categorization of the features into the predefined classes. For this, the feature inputs to the classifier must be representative of the object of interest. Once the pre-processing of the image is done, the objective of feature extraction is to select the features required from this image. The techniques are broadly classified into two types. The first one uses textural features from the pre-processed image, and the second one is based on anatomical structures.

3 Experimental Results and Discussion

Different fundus image databases are publically available for study purposes. Researchers have made some databases available through a hospital or ophthalmologist (Pratt et al. 2016). DIARETDB0 is a Standard Diabetic Retinopathy database. It has 130 images, out of which 110 have signs of DR and 20 are normal. The resolution of images is 1500×1152, and field of view (FOV) is 50° (https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53). DIARETDB1 consists of 89

images with five normal images and 81 with signs of DR. It is obtained with ground truth collected from experts following an evaluation protocol (https://adeshpande3.github.io/A-Beginner%27s-Guide-To-Understanding-Convolutional-Neural-Networks/). The DRIVE database has 40 images. The camera is CR5 3CCD with a FOV of 45° and a resolution of 768 × 584 [30].STARE is introduced by Michael Goldbaum at the University of California. It consists of 81 fundus images with 31 normal images and 50 with signs of DR. The camera is TopCon-50 with a resolution of 605 × 700 (https://medium.com/@RaghavPrabhu/understanding-of-convolutional-neural-network-cnn-deep-learning-99760835f148). Retinopathy Online Challenge (ROC) is introduced by Michael D Abramoff, Bram van Ginneken and Meindert Niemeijer at the University of Lowa. It consists of 50 images in which 22 images are with 768 × 576 pixels, three images are with 1059 × 1061 pixels and 25 images are with 1389 × 1388 pixels (https://www.flatworldsolutions.com/data-science/articles/7-applications-of-convolutional-neural-networks.php).

For the experimentation, data is collected from Kaggle software or manually written digit acknowledgment, for example, the MNIST dataset. CNN multi-layer profound engineering is actualized utilizing Theano and Lasagne libraries. Straightforward datasets are dealt with the equipment Intel i5 @3.20 GHz, 8 GB RAM Ubuntu 14.04 Theano API Python libraries are utilized. For dealing with an enormous Kaggle dataset, a graphics processing unit is required. Amazon EC2 web administration occurrence is utilized. In this paper, the deep neural network technique is designed to classify the DR disease in different grades (0, 1, 2, 3 4).

Initially, data is augmented using the *Image editor tool* which also helps in color balance adjustment, rotation, color adjustment, etc. At the pre-processing stage (Bhardwaj et al. 2020a,b), *num py* package is used for resizing and monochrome conversion. The data frame file is created which includes all the information of images. Images were of dimensions 224 × 224 × 3, which were resized to 50 × 50 × 3 dimensions using MATLAB 2018b software. The images were converted into the matrix which is of unit eight data types; authors have converted into the double type or vector of dimension 7500 as shown in Fig. 4.

The DNN is implemented, and the authors observed a cost curve as shown in Fig. 5.

The cost curve tells about the performance of our algorithm for a particular iteration. The X-axis denotes the number of iterations our model had been trained on. Y-axis represents the probabilistic cost that our model has on a certain dataset. Lower cost corresponds to better performance and vice versa. Authors have observed after training deep neural networks indicates cost has gone down which means that our network is fitting data more accurately after whole training. Peaks are seen between the cost curves which indicates the non-convex nature of optimization. Moreover, the peaks may be present due to the learning rate that was chosen; if the learning rate is high, it is gonna maximize the function instead of minimizing it.

From the curve shown in Fig. 6, it is seen that after each epoch, the cost is decreasing. To overcome this problem, a mini-batch gradient descent approach is used in comparison with stochastic gradient descent. The advantage of mini-batch gradient descent is that it provides an advantage in the speed of learning. And it can be seen from the curve

Fig. 4 Matrix of image

Fig. 5 Cost curve

Fig. 6 Learning rate versus iteration

|	Iterations (in 100′s)	Cost
Table 1 Table depicting the cost after every 100 iteration	4300	1.06
	4400	0.58
	4500	0.37
	4600	1.83
	4700	0.51
	4800	0.87
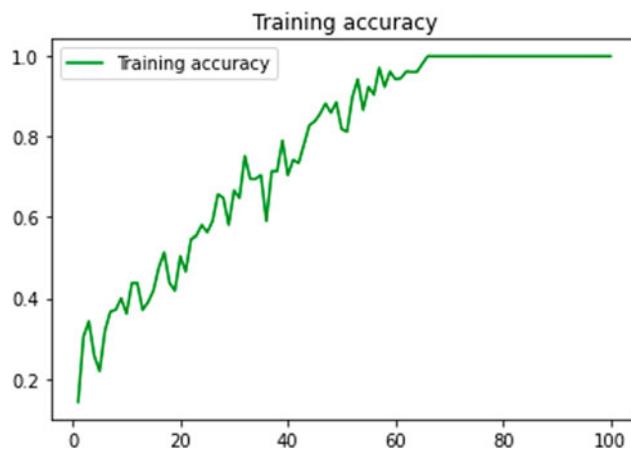
Fig. 7 Training accuracy vs epochs

Fig. 8 Output of neural network

Table 2 Comparison table depicting various features of both network and its outputs.

	Neural network	Convolutional neural network
Learning rate	0.05	0.009
Probability	0.419	0.101
Time(ms)	7.46	5.62

that cost is decreasing as the number of epochs is increasing. Table 1 shows the cost values for every 100 iterations from 4300 to 4800. As the cost first decreases slowly in the beginning, we decided to mention cost from 4300 iterations so that the decrease in cost can be easily viewable to the readers.

From Fig. 7, it can be seen that training accuracy of our model has reached very close to 100% on the training data. The model had been trained on 100 epochs, and model converges to global optima of the cost function. Later, output of neural network has been observed, and the result is shown in Fig. 8.

This output shows the probability of an image of being of a certain severity. The maximum probability is 0.4194 which is present at index 4. This signifies that the image which was fed to the deep neural network is of the severity of level 4. The same simulations were carried out using conventional NN, and the results are compared and given in Table 2.

The output shows the probability of an image of being of a certain severity. The maximum probability of 0.101 is achieved. From Table 2, it has been observed that with each iteration, our cost is going down which means that our network is fitting data more accurately after every iteration in the neural network, while, on CNN, it has been observed from the curve that cost is decreasing as the number of epochs is increasing. Also, the time on CNN is less as that in the neural network.

4 Conclusion

In this research paper, CNN is a healthy way to deal with all degrees of diabetic retinopathy stages. Manual highlight extraction stages are required. Our system design with dropout procedures yielded huge characterization exactness. Genuine positive rates are likewise improved. Elevated-level illustrations handling unit for preparing high goal pictures when the degree of layers stacked more are required inferable from the complex and calculation escalated nature of our system design. The medical statistics are a clear indication that the ratio of patients to ophthalmologists is over a lakh, and hence, an efficient automation system is highly desirable for mass screening of DR, particularly in rural areas where the situation is more alarming. In the automation system, the pre-processing stage is a critical one, as all further processing depends on it. The green component of the color image is more popularly used as it provides the best contrast. Also while detecting the dark lesions, utmost care is to be taken concerning blood vessels as they have similar intensity. Similarly, while detecting bright lesions, great care must be taken about OD. Though there are many techniques and algorithms developed for the extraction of dark and bright lesions, still there is room for research. Care must be taken to select only the relevant features from all the features identified. It is seen that different classifiers have been used for classification with some hybrid classification methods.

References

https://www.ubcieee.org/events/signal-processing-cup-2015.

https://www.mayoclinic.org/diseases-conditions/retinal-diseases/symptoms-causes/syc-20355825.

https://www.mayoclinic.org/diseases-conditions/diabetic-retinopathy/symptoms-causes/syc-20371611.

https://www.eatonrapidseyecare.com/eye-health/diabetic-retinopathy/h.

https://www.nature.com/articles/s41746-019-0172-3.

https://expertsystem.com/machine-learning-definition/.

https://machinelearningmastery.com/what-is-deep-learning/.

https://verhaert.com/use-artificial-intelligence-valuable-new-solutions/value-add-strategies-verhaert-nl/.

https://www.geeksforgeeks.org/python-language-introduction/.

https://news.mit.edu/2017/explained-neural-networks-deep-learning-0414.

https://www.kaggle.com/sid321axn/regularization-techniques-in-deep-learning.

https://www.kaggle.com/sohaibanwaar1203/diabetic-rateinopathy-full.

https://modernod.com/articles/2019-june/the-four-stages-of-diabeticretinopathy?c4src=article:infinite-scroll.

Santhakumar, R. ,Tandur, M., Rajkumar, E.R., Geetha, K.S, Haritz, G., Rajamani, K.T. (2016). Machine Learning Algorithm for Retinal Image Analysis [[978–1–5090-2597–8/16] 2016 IEEE Region 10 Conference (TENCON), vol. 2, pp. 62–65.

Chandrakumar, T., Kathirvel, R. (2016). Classifying Diabetic Retinopathy using Deep Learning Architecture. *International Journal of Engineering Research & Technology (IJERT)* , *5*(06),122–125.

Wang, L., Zou, B., Zhao, R.C., Chen, Y., He, Y.,Zhou, M.J. Clinical interpretable deep learning model for Glaucoma diagnosis. *IEEE Journal of Biomedical and Health Informatics* , *4*, 15–19. https://doi.org/10.1109/JBHI.2019.2949075

Rodtook, A.,Chucherd, S. (2019). *Automated Optic Disc Localization Algorithm by Combining A Blob of Corner Patterns, Brightness and Circular Structures Models 2019 Association for Computing Machinery ITCC 2019*, August 16–18, 2019, Singapore vol. 7, pp. 45–52.

Poplin, R., Varadarajan, A.V., Blumer, K., Liu,Y., McConnell, M.V., Corrado, G.S., Peng, L., Webster, D.R. (2018). Prediction of cardiovascular risk factors from retinal fundus photographs via deep learning. *Nature Biomedical Engineering, 2*, 158–164.

Pratt, H., Coenen, F., Broadbent, D.M., Harding, S.P., Zheng, Y. (2016). Convolutional Neural Networks for Diabetic Retinopathy. In *International Conference On Medical Imaging Understanding and Analysis 2016,* MIUA 2016, vol. 6, pp. 15–19 6–8, July 2016, Loughborough, UK.

https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53.

https://adeshpande3.github.io/A-Beginner%27s-Guide-To-Understanding-Convolutional-Neural-Networks/

https://medium.com/@RaghavPrabhu/understanding-of-convolutional-neural-network-cnn-deep-learning-99760835f148

https://www.flatworldsolutions.com/data-science/articles/7-applications-of-convolutional-neural-networks.php

Bhardwaj, C., Jain, S., Sood, M. (2020a). Diabetic retinopathy severity grading employing quadrant based inception-V3 convolution neural network architecture, *International Journal of Imaging Systems and Technology*, 1–17. https://doi.org/10.1002/ima.22510

Bhardwaj, C., Jain, S., & Sood, M. (2020b). Hierarchical Severity Grade Classification of Non-Proliferative Diabetic Retinopathy. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-020-02426-9.

Role of IoT in Enhancing Smart Agriculture System

Mandeep Kaur, Parma Nand, Nitin Rakesh, and Sudeep Varshney

Abstract

Internet of things (IoT) has shown a different research direction in the domain of farming and agriculture. Smart agriculture has reduced the farmer's effort and improved their capability in managing their crops, soil, water, field monitoring, pesticide control, etc. IoT-based solutions have increased the farmer's attention toward humidity, temperature, pH value and environment conditions that are the most important concern in agriculture. The unique features of Internet of things like faster access to application and data, reduced human efforts, efficient communication and the global connectivity through different devices have made it a fast-growing technology in providing agriculture solutions. This paper explored various IoT smart agriculture systems and the challenges faced in deploying these systems.

M. Kaur (✉) · P. Nand · N. Rakesh · S. Varshney
Department of Computer Science and Engineering, School of Engineering and Technology, Sharda University, Noida, Uttar Pradesh, India
e-mail: drmandeepkaur10@gmail.com

P. Nand
e-mail: parmaastya@gmail.com

N. Rakesh
e-mail: nitin.rakesh@gmail.com

S. Varshney
e-mail: sudeep149@gmail.com

1 Introduction

The Internet of things (IoT) is viewed as sanguine technology that is a combination of the objects and the data spread over the World Wide Web. These objects use the data and make intelligent and smart collaborations among them, which are available anywhere and anytime. The main focus of IoT is to reduce the human intervention by implementing the automation. Different devices and technologies such as actuators and sensors, for sensing and collecting the data, controllers for processing the data, Internet and cloud computing used as infrastructures for communication, completes the process of automation (Dlodlo and Kalezhi, 2015; Madushanki et al., 2019). The basic model of IoT is shown in Fig. 1 which encompasses a variety of devices or things, which are smart in nature such that they can connect in the network; these smart things are capable enough to accumulate the information about themselves, other devices and environments and transfer the same information to various other devices and connected systems through Internet (Lakhwani et al., 2019).

The applications of IoT include smart transport system, smart agriculture, environment monitoring, promotions, marketing, healthcare system and infrastructure monitoring (Venkatesan and Tamilvanan, 2017). In agriculture, the goal of IoT is to automate different aspects of farming and agri-business and to make the agricultural methods more effective and efficient. Still, there are many areas in which there is a high human intervention which is needed; one of them is cattle heat detection system, which is not fully automated (Arvind et al., 2017; Zhao et al., 2017; Sagar et al., 2017; Saraf and Gawali, 2017; Rama Chidambaram and Upadhyaya, 2017). Many researchers have focused on different areas of agriculture and farming to make more productive, efficient by controlling various parameters and make them automated such as smart irrigation system, smart insects detection system and smart fire detection system etc. with the help of IoT (Vaishali et al., 2017; Rajkumar et al., 2017; Rau
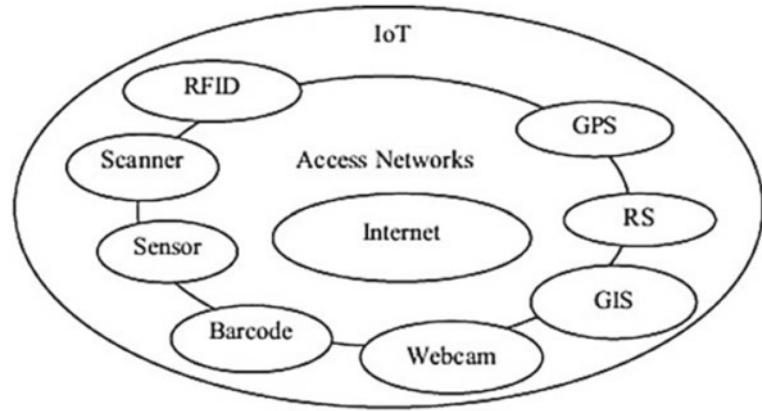
Fig. 1 Basic model of IoT

et al., 2017; Salvi et al., 2017). The primary focus of this exposition is to explore and analyze the use and the challenges of Internet of things as technology in agriculture system. More specifically, the paper is organized in four more sections: Sect. 2 explains the traditional agriculture methods and system in India. Section 3 describes the role of Internet of things (IoT) in agriculture. Then, Sect. 4 discusses various challenges of deployment of IoT in agriculture. Section 5 gives the concluding remarks of this paper.

2 Traditional System of Agriculture

The traditional Indian agriculture system is one of the ancient methods in agriculture. The traditional method reflects the complete manual method for analyzing different parameters of agriculture. In this system, the farmers use manually find and confirm all the parameters. They analyze and calculate the readings based on those found parameters (Vyavahare et al., 2020). Although agriculture is one of the important work professions of Indian financial system, the farmer generally used traditional methods for crop selection, harvesting, irrigation, etc. The farmers are totally dependent upon their experience about the agriculture. The crop obtained generally relies upon climate situations such as rainfall patterns, which generally influence the irrigation. So, the traditional techniques of farming or agriculture are not pleasing the farmers as they are not so cost effective, and moreover, the output is comparatively low. So, this is the necessity of farmers and agriculturalists to have some solutions, based on the previous data, weather forecasting and other parameters to maximize the crop.

3 Role of IoT in Agriculture

Agriculture has always been a crucial role in any country's economy. It became a strong backbone of the Indian economy. For any developing country like India, the role of technology is growing at vast for food, nutrition, farming and agriculture. This section discusses the new technologies, methods and systems that are getting popularity with IoT in the present scenario. The irrigation and crop field monitoring system, organic farming system, modified crop system, food production system, soil temperature and moisture monitoring system are few examples (Alam, 2014).

Such systems help in improving the food quality, better crop production, crop disease prediction and management, etc. Among all the existing solutions available, Internet of things (IoT) is providing lot of unique solutions which has transformed agriculture along with many other industries. IoT has given rise to smart agriculture. Smart agriculture using IoT is proving to be best for managing agriculture + business-like farm management, precision /smart farming, back-end analytics—AI, smart dairy, etc. (Mundada, 2016).

The methodical approach of agriculture + business using IoT has gradually changed the viewpoint of farmers and users. The concept of IoT in agriculture has grown to fulfill the need of users or farmers and to take advantage it provides from managing labor productivity using smart harvesting, monitoring of lands using drones, predicting crop health and disease using crop monitoring system and predicting weather using weather data system, understanding and decision making of soil sciences like temperature,

nutrients, pH value and humidity using soil management system. The adaptability to the smart agriculture or IoT-based solutions for agriculture has increased the anticipation of farmers and users toward (Mundada, 2016; Naveen Balaji et al., 2018a).

IoT for agriculture has evolved over time as shown in Fig. 2 in order to fulfill the need of farmers. In agriculture, tractors as product, tool or machine have played a crucial role and became friends forever for farmers. The first evolution confirms the connectivity of these tools with technology like connecting tractors with GPS to optimize routes which will reduce fuel consumption to make the next level of smart product. Then, the deployment of sensors and its connectivity with smart product defines another level. The sensors have different roles in performing the tasks related to agriculture. The deployment of sensors initiates precision agriculture. The next level transforms the smart, connected product to product system like farm equipment system, crop management system, water management system, irrigation system, etc. The next level of evolution shows the connectivity from a digitized product to a platform where all the mentioned systems are connected (Naveen Balaji et al., 2018a) (García et al., 2020). This scenario offers the integrated systems of systems solution (Khanna and Kaur, 2019).

Internet of things as technology has a huge potential for developing the applications in the agriculture field. Table 1 describes the role of Internet of things (IoT) technology in agriculture. Here, IoT-based solution systems developed for the respective application and its outcomes are discussed.

From Table 1, the survey showed around 12 IoT-based agriculture and farming subareas. According to the results obtained, the topmost area was water management (25%) shown in Fig. 3.
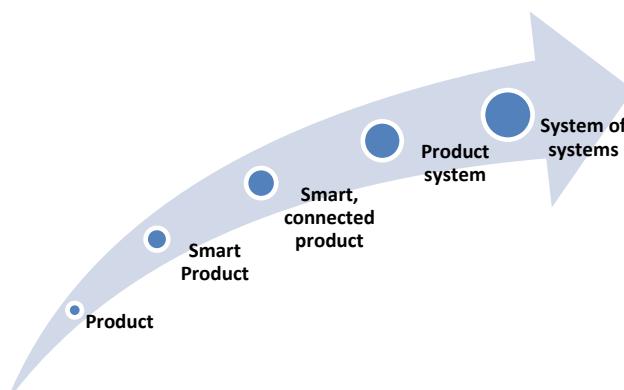
In addition, Fig. 4 shows different parameters for which sensors are being used to collect the data. It is concluded that the temperature sensor is the most commonly used sensor in agriculture.

4 Challenges of IoT Deployment in Smart Agriculture

This section discusses the challenges in deploying different IoT-based solution applications for smart agriculture. Smart agriculture is the way of providing and reaching to end farmer through IoT-based solution application. Although IoT has offered plenty of potential solutions (discussed in Sect. 3) to farmers and users, still there are many challenges in deploying these applications. In India, the major challenge faced by farmers and users is the Internet availability, Internet connectivity and lack of infrastructure. These challenges sometimes become obstacle for the adoption of IoT-based solutions for smart agriculture. But, in general, the challenges are the mainly concerned with the kind of application and its implementation issues. With the use of huge number of sensors, the large volume of data is produced. Data management becomes the major concern for such applications. The integration of such applications with other devices is further very challenging. In addition to this, as shown in Fig. 5, poor infrastructure for Information and Communication Technology, fear of new technology, untrained workforce, understanding of policies, coverage and connectivity, high investment, lack of knowledge and lack of awareness of Information and Communication Technology infrastructure are the major challenges that are faced while deploying the IoT-based solutions (Nayyar and Er. Vikram Puri, 2016; Ali et al., 2017; Dr et al., 2018; Naveen Balaji et. al., 2018; Swarna Krishnan et al., 2020).

5 Conclusion

In agriculture, farmers use their experience to check the maturity level of soil, take harvesting decision, identifying the crop disease, manage the water quantity, protect fields from animals, etc. With the evolution of Internet of things, plenty of solutions have been provided that have minimized the farmer or user effort. IoT-based solutions for agriculture have given rise to smart agriculture. This paper discusses the traditional system of agriculture and role of IoT in agriculture. Various IoT-based solution applications have been discussed that has not only reduced the effort of the farmers

Fig. 2 Evolution of IoT for agriculture

Table 1 Role of IoT in agriculture

Focus area	Sustainable solution for	Task supported for IoT enabled farming	Outcome
Smart Farming (Jayaraman et al., 1884)	1. Scalable sensor data acquisition 2. Analysis and visualization platform	1. Support virtually any IoT devices 2. Rapid ingestion and visualization of IoT data using zero-programming effort 3. Virtual laboratory environment for visualization and sharing of study data 4. Scalability of the SmartFarmNet platform	Performance of SmartFarmNet with the real-time analysis is twofold better than without real-time analytics
GPS based remote controlled robot (Gondchawar and Kawitkar, 2016)	1. Solution to field activities, irrigation problems and storage problems using remote-controlled robot 2. Smart irrigation system and a smart warehouse management system	1. Weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance 2. Smart irrigation with smart control and intelligent decision making, smart warehouse management	1. Automatically, start cooling fan in auto mode 2. Automatically, start water pump
IoT Agriculture Stick Monitoring (Nayyar and Vikram Puri, 2016)	1. Live data (temperature, soil moisture) 2. Increase overall yield and quality of products	Data of soil moisture, environment temperature at very low cost	1. Increasing agriculture yield and take efficient care of food production 2. Accurate live feed of environmental temperature 3. Soil moisture with more than 99% accurate results
Agriculture Productivity Enhancement System (Satish et al., 2017)	1. Predict various diseases affecting the crop growth and to inform the farmer 2. Ratio of pesticides to be used to reduce the risk caused by excessive usage of pesticides both on human health and environment	1. Improve plant productivity 2. Identify the diseases depending on environment 3. Achieve efficient utilization of the pesticides using supervised machine learning algorithm	Informs the farmer, the proportion of pesticides to be used to enhance the agricultural growth and productivity and reduce the damage done by pests on a large scale
Precision agricultural system (Ali et al., 2017)	1. Optimize crop yields 2. Reduce the waste of resources 3. Minimizing the environmental impact of farming	Achieve Green Internet of Things technologies in agriculture which can be deployed, which will help to conserve the energy and utilize the agriculture resources effectively	1. Precision agriculture applications based on IoT 2. Overcome the existing challenges and the future road maps
Crop Monitoring System (Naveen Balaji et al., 2018b)	1. Secures the crops by the deployment of sensor 2. Prevents intrusion of animals using image processing technique	To monitor the crop water requirements, temperature and humidity of the cultivating land	Increases the crop yield which will not be harmful to the cultivation as well as to the animals
Automated irrigation system (Ramachandran and Ramalakshmi, 2018)	Optimization model for reducing the water usage	Optimization model to compute the optimal irrigation rate which are automated using a solenoid valve controlled using an ARM controller	1. Reduction in water utilization 2. Increase in data availability, and visualization
Automatic Monitoring and Irrigation System (Dr et al., 2018)	Automated irrigation and crop field monitoring system is used to optimize the use of water resource for agriculture	Monitor the soil moisture, temperature, humidity, color and water level	Improving the agricultural fields yield by providing a monitoring system with effective and efficient usage of water resource
Crop monitoring system (International Journal of Scientific Research in Computer Science, Engineering and Information Technology 2018)	Proposed a method for efficient crop monitoring for agricultural field by deploying sensors in the field to sense the water requirement of the soil and provides irrigation automatically	Monitor the soil characteristics, weather conditions, moisture and temperature	Improve the crop productivity efficiently by monitoring soil characteristics

Table 1 (continued)

| Focus area	Sustainable solution for	Task supported for IoT enabled farming	Outcome
Remote monitoring system (Smart Agro Mobile Application) (Naveen Balaji et al., 2018)	Proposed a system that collect data from multiple nodes, and using this sensor data, the farmers is able to control the operations on the agricultural field wirelessly and remotely anytime	Allow the farmers to have complete wireless connectivity for their agriculture farm	Improve economy steadily
Remote Monitoring System (Agraj et al., 2018)	To gather continuous information of farming generation condition that gives simple access to horticultural offices, for example, alarms through Short Messaging Service (SMS) and advices on climate design, crops and so on	To monitor temperature, soil moisture and humidity	Decrease the dirt disintegration and wastage of water
WSNs application to watering crops (Anusha et al., 2019)	To design and develop a control system using node sensors in the crop field with data management via smart phone and a Web application	Control the crop watering, monitor soil moisture, humidity and temperature and collect other data of crop and agriculture field	To improve crop yields, improve quality and reduce costs
Centralize monitoring and control system (Muangprathub, 2019)	The proposed system saves water and vitality by utilizing dribble water system technique and to screen the plants by keeping up the ideal temperature	To collect data automatically about fertilization, soil, irrigation and environment	To assess and compute crop forecast, performance and recommendations
Suitable Crop Prediction System (Dhawale and Dr. 2019)	1. Low-cost IoT-enabled smart agricultural system 2. Predict which crop is best for that land based on the data collected from local conditions of that land varying from humidity to soil moisture content	Analysis and prediction of type of crops best to grow in the particular agricultural field	Cost effective
Real time monitoring system (Sidhanth Kamath et al. 2278)	1. Develop real-time monitoring system for soil properties 2. Crop disease identification using image analysis and SMS-based alerts	1. Detecting the field conditions like soil moisture content, temperature condition, intruder detection 2. Leaf disease at the earlier stage as soon as it occurs on the leaf	Improve the yield of the efficient crops
GPS based robot (Vijayalakshmi, 2019)	1. Perform tasks like weeding, spraying, moisture sensing, bird scaring, keeping vigilance 2. Provide smart irrigation with smart control to give best decision making based on accurate real-time data	GPS-based controlling robot which can work both manually and automatically for doing weeding, seeding and harvesting	To improve crop quality
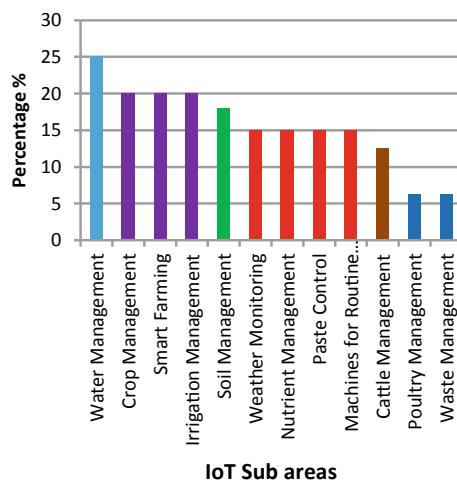
**Fig. 3** Agriculture and farming subareas
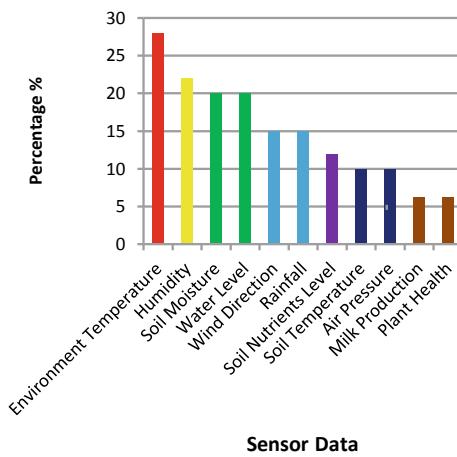
Fig. 4 Utilization of sensors for collecting the data
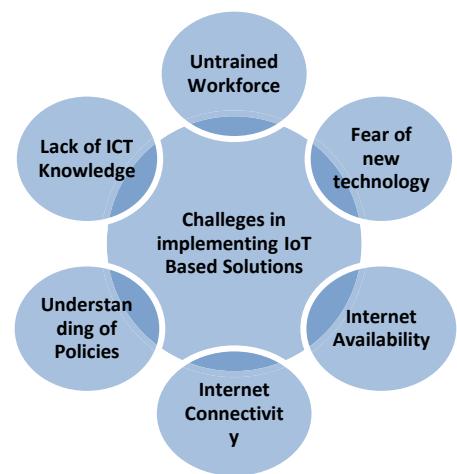

Fig. 5 Challenges in implementing IoT-based solutions

but also helped in making better decisions. Smart agriculture has given a successful platform to farmers to take corrective measures for their field or soil, crop, water, storage, pesticide, etc. The paper also discussed the major challenges that can arise while deploying IoT-based solutions in agriculture. This can help the farmers in providing more awareness about the existing IoT-based solutions and their deployment challenges.

References

Aher, A., Kasar, J., Ahuja, P., Jadhav, V. (2018). Smart agriculture using clustering and IOT. *International Research Journal of Engineering and Technology (IRJET), 05*(03). e-ISSN: 2395–0056.

Alam, A., Hasan Rizvi, A., Verma, K., Gautam, C. (2014). The changing scenario in indian agriculture: a review. *International Journal of Scientific Research in Agricultural Sciences, 1*(7), 118–127.

Ali, T.A.A., Choksim, V., Potdar, M.B. (2017). Precision agricultural monitoring systems using IoT. *International Journal of Innovative Research in Science, Engineering and Technology, 6*(11).

Anusha, A., Guptha, A., Sivanageswar Rao, G., Tenali, R. K. (2019). A model for smart agriculture using IOT. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8*(6). ISSN: 2278–3075.

Arvind, G., Athira, V., Haripriya, H., Rani R., Aravind, S. (2017). Automated irrigation with advanced seed germination and pest control. In *IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR)*

Ayaz, M., et al. (2019). *Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk, New Technologies for Smart Farming 4.0: Research Challenges and Opportunities*, vol. 7, pp. 129551–129583. (Published in: IEEE Access).

Dhawale, K.N., Bawane, N. (2019). IoT based smart agriculture system. *IOSR Journal of Engineering (IOSRJEN), 09*(5), 04–09.

Dlodlo, N., Kalezhi, J. (2015). The internet of things in agriculture for sustainable rural development. In: *2015 international conference on Emerging trends in networks and computer commununication (ETNCC)*, pp. 13–18.

García, L., Parra, L., Jimenez, J.M., Lloret, J., Lorenz, P. (2020). IoT-based smart irrigation systems: an overview on the recent trends on sensors and IoT systems for irrigation in precision agriculture. *Sensors, 20*, 1042.

Gondchawar, N., Kawitkar, R.S. (2016). IoT based smart agriculture. *International Journal of Advanced Research in Computer and Communication Engineering, 5*(6).

International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 4(5). ISSN: 2456–3307.

Jayaraman, P. P. et al. (2016). Internet of things platform for smart farming: experiences and lessons learnt. *Sensors, 16*, 1884.

Khanna, A., & Kaur, S. (2019). Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture. *Computers and Electronics in Agriculture, 157*, 218–231.

Lakhwani, K., Gianey, H., Agarwal, N. and Gupta, S. (2019). Development of IoT for smart agriculture a review. In *Emerging Trends in Expert Applications and Security*, pp. 425–432, Springer, Singapore.

Madushanki, A.R., Halgamuge, M.N., Wirasagoda, W.S., Syed, A. (2019). *Adoption of the Internet of Things (IoT) in agriculture and smart farming towards urban greening: A review*

Muangprathub, J., et al. (2019). IoT and agriculture data analysis for smart farm. *Computers and Electronics in Agriculture, 156,* 467–474.

Mundada, R. (2016). *IoT—A Perspective for Indian Agriculture Sector Keynote Speech, Indian Technology Congress—2016 Excellence in Engineering Practice: Networking and Collaboration.*

Naveen Balaji, G., et al. (2018). OT based smart crop monitoring in farm land. *Imperial Journal of Interdisciplinary Research (IJIR),4* (1). ISSN: 2454–1362.

Naveen Balaji, G., Nandhini, V., Mithra, S., Naveena, R., Priya, N. (2018). Advanced crop monitoring using internet of things based smart intrusion & prevention in agricultural land. *International Journal of Trend in Scientific Research and Development (IJTSRD),* 2(2), 1348–1352.

Naveen Balaji, G., Nandhini, V., Mithra, S., Naveena, R., Priya, N. (2018). Advanced crop monitoring using internet of things based smart intrusion & prevention in agricultural land. *International Journal of Trend in Scientific Research and Development (IJTSRD),* 2(2).

Nayyar, A., Vikram Puri, E. (2016). Smart farming: IoT based smart sensors agriculture stick for live temprature and moisture monitoring using Arduino, Cloud Computing & Solar Technology. In *Proceedings of International Conference on Communication and Computing Systems (ICCCS-2016).* https://doi.org/10.1201/9781315364094-121.

Rajkumar, M., Abinaya, S., Kumar, V. (2017). *Intelligent irrigation system—An IOT based approach International Conference on Innovations in Green Energy and Healthcare Technologies (IGEHT).*

Rama Chidambaram, R.M., Upadhyaya, V. (2017). Automation in drip irrigation using IOT devices. In *Fourth International Conference on Image Information Processing (ICIIP).*

Ramachandran, V., Ramalakshmi, R., Srinivasan, S. (2018). An automated irrigation system for smart agriculture using the internet of things. In *2018 15th International Conference on Control, Automation, Robotics and Vision (ICARCV),* Singapore.

Rau, A., Sankar, J., Mohan, A., Das Krishna, D., Mathew, J. (2017). *IoT based smart irrigation system and nutrient detection with disease analysis IEEE Region 10 Symposium (TENSYMP).*

Sagar, S., Kumar, G., Xavier, L., Sivakumar, S., Durai, R. (2017). *Smart irrigation system with flood avoidance technique in Third International Conference on Science Technology Engineering & Management (ICONSTEM).*

Sanket, S., Pramod Jain, S.A., Sanjay, H.A., Harshita, T.K., Farhana, M., Jain, N., Suhas, M.V. (2017). *Cloud based data analysis and monitoring of smart multi-level irrigation system using IoT International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC).*

Saraf, S., Gawali, D. (2017). IoT based smart irrigation monitoring and controlling system. In *2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT).*

Satish, T., Bhavani, T., Begum, S. (2017). Agriculture productivity enhancement system using IOT. *International Journal of Theoretical and Applied Mechanics,* 12(3), 543–554.

Sidhanth Kamath, B., et al. (2019). IoT based smart agriculture. *International Journal of Science, Engineering and Technology Research (IJSETR),* 8(4). ISSN: 2278-7798.

Swarna Krishnan, K., et al. (2020). Self-automated agriculture system using IoT. *International Journal of Recent Technology and Engineering (IJRTE),* 8(6). ISSN: 2277–3878.

Vaishali, S., Suraj, S., Vignesh, G., Dhivya, S., Udhayakumar, S. (2017). *Mobile integrated smart irrigation management and monitoring system using IOT International Conference on Communication and Signal Processing (ICCSP).*

Venkatesan, R., Tamilvanan, A. (2017). *A sustainable agricultural system using IoT in International Conference on Communication and Signal Processing (ICCSP).*

Vijayalakshmi, M. M. (2019). IoT based smart farming in a agriculture. *International Journal of Trend in Scientific Research and Development (IJTSRD),* 3(2).

Vyavahare, N., Ingle, S., & Jorvekar, P. P. (2020). Digital Agriculture System for Crop Prediction and Disease Analysis Based on Machine Learning. *CLIO an Annual Interdisciplinary Journal of History,* 6(4), 92–101.

Yuvaraju, M., Priyanga, K.J. (2018) An IOT based automatic agricultural monitoring and irrigation system. In *International Conference on New Horizons in Science Engineering Technology (NHSET-2018).*

Zhao, W., Lin, S., Han, J., Xu, R., Hou, L. (2017). *Design and implementation of smart irrigation system based on LoRa, IEEE Globecom Workshops (GC Wkshps)*

Speech Recognition Employing MFCC and Dynamic Time Warping Algorithm

Meenakshi Sood and Shruti Jain

Abstract

Speech has been an integral part of human life acting as one of the five primitive senses of the human body. As such any software or application based upon speech recognition has a high degree of acceptance and a wide range of applications in defense, security, health care, and home automation. Speech is a waffling signal with varying characteristics at a high rate. When examined over a very short scale of time, it can be considered as a stationary signal with very small variations. In this paper, authors have worked upon the detection of a single user using multiple isolated words as speech signals. For designing the system, feature extraction using Mel-frequency cepstral coefficients (MFCCs) and feature matching using dynamic time warping (DTW) are considered as the designing of the system because of its simplicity and efficiency. Short-time spectral analysis is adopted which is the main part of the MFCC algorithm used in feature extraction. To compare any two signals varying in speed or having phase difference between them, DTW is used. Since two spoken words can never be the same, the DTW algorithm is best suited to compare two words.

Keywords

Speech recognition • Feature extraction and matching • Dynamic time warping • Mel-frequency cepstral coefficients

M. Sood
Department of CDC, NITTTR, 160019 Chandigarh, India
e-mail: meenakshi@nitttrchd.ac.in

S. Jain (✉)
Department of ECE, JUIT, Solan, 173234, Himachal Pradesh, India
e-mail: jain.shruti15@gmail.com

1 Introduction

Speech recognition refers to identifying voice and executing the required task as specified by the system in which the recognition is being used. The main task of the whole process is to make the computer or the device to understand human language. Any technology utilizing speech has been an integral part of computer science and other domains of science that study about the characteristics of human speech. But the words spoken by an individual vary every time, depending on accent and dialect. As such speech recognition and perfect accuracy are very difficult to perform (Shaikh et al., 2017).

Many word detection techniques and methodologies have been developed over the years. Mansour et al. proposed a technique for voice recognition utilizing the dynamic time wrapping method (Mansour et al., 2015). The speaker's voice signal and the pre-stored voice signals are compared for this purpose. The MFCC is used for speaker voice signal extraction which is one of the important factors to achieve high recognition accuracy. Y Afrillia detailed the well-known anagram technique to the chanting of Al-Quran verse recognition using MFCC (Afrillia et al., 2017). The Nagham Al-Quran pattern's characteristics are much more complex as compared to the Makhraj and tajwid pattern. The sound wave has more variation in Nagham which implies a higher level of noise. The real-time recording was taken for the implementation and the evaluation of the system. To measure the accuracy of the system, it is necessary to give more data learning process with more variation or modify the MFCC. Anggraeni et al. describes an implementation of speech recognition to pick and place an object using a robot arm (Anggraeni et al., 2018). The MFCC technique is utilized to extract the features of the speech signal. Riyaz et al. proposed an automatic speaker recognition system to recognize the identity of the users using Urdu utterances (Riyaz et al., 2019). This system utilized the MFCC and hidden Markov model (HMM). The most popular feature extraction

approach is MFCC which extracts the features with human auditory behavior. The use of HMM makes the recognition process simple and realistic. The 250 isolated Urdu words uttered by twenty speakers are utilized for performance evaluation of the proposed technique. The performance of the proposed technique is 96.4% better as compared to other existing models in terms of accuracy. Guillaume Plouffe and Ana-Maria Cretu proposed a novel algorithm to identify the first pixel on the hand contour to improve the scanning time (Plouffe and Cretu, 2015). A directional search algorithm and k-curvature algorithm allow for the identification of the hand contour and to locate the fingertips over the contour. To select gesture candidates and to recognize gestures, dynamic time warping (DTW) is used. Static and dynamic gestures are used simultaneously, and an average of 92.4% recognition rate is achieved over 55 static and dynamic gestures. Zhao et al. detail the new speaker feature, gammatone frequency cepstral coefficients (GFCCs), which reveals better noise toughness in comparison with MFCC (Zhao and Wang, 2013). The speaker identification experiments are designed to systematically analyze their differences and similarities of GFCC relative to MFCC.

Generally, the human voice conveys a large magnitude of information such as gender, emotions, and identity of the speaker. This paper uses MFCC and DTW to accomplish speech recognition of an individual. Firstly, utterances are converted into digitalized samples using an audio recorder. Then, the MFCC algorithm is employed over the obtained samples to obtain feature matrix (Shaikh et al., 2017) corresponding to the spoken word. The database is created by storing these features in a file. During the identification process, the DTW algorithm is used to find a pattern between spoken word and the words stored in the database.

The main motivation behind this research work is to compare the difference in recognition of spoken English alphabets with their recorded version, which help in recognition of speech. This paper uses MFCC and DTW to accomplish speech recognition of an individual and is considered effective for isolated word recognition (Shaikh et al., 2017). Compared to other available techniques, MFCC and DTW are efficient for the implementation of speech recognition in physical systems (Muda et al., 2010). The speech signal contains a lot of noise, and it has been observed that the Savitzky–Golay filter produces the best results for noise removal and maintaining an adequate SNR (Azami et al., 2012). However, MFCC alone cannot ensure high efficiency of matching when variation in the speaker characteristics is considered (Plouffe and Cretu, 2015). It has been observed that the error rate in the speaker-independent system is greatly reduced using hidden Markov models.

This system aids the users with an efficient method of authentication system for speech recognition. The initial sections of the paper deal with feature extraction describing the steps undertaken in the MFCC algorithm. Section 2 deals with methodology adopted for feature extraction, DTW algorithm which accomplishes the feature matching, followed by Sect. 3 detailing results and finally followed by conclusion.

2 Methodology

Noise filtering, pre-emphasis, windowing, energy calculations, and Mel filter bank are the sub-modules used in the speech recognition system. These are utilized for the MFCC extraction which is the main step for spoken word recognition. The steps listed from noise filtering until MFCC coefficients come under the category of the feature extraction process. All these sub-modules of the MFCC process are used for the extraction of Mel coefficients. Feature matching is the next part of the system where comparisons are done between the input and the pre-recorded alphabet. The flowchart for the methodology adopted in this work is depicted in Fig. 1.

2.1 Feature Extraction

The feature extraction is the first and main step in speech recognition which is accomplished using the MFCC technique. MFCC is based upon human auditory perception. Our auditory system does not follow a linear behavior. Human listening behavior is linear only up to 1000 Hz and becomes nonlinear as the frequency is increased beyond 1000 Hz. The prominent steps in the MFCC algorithm undertaken are explained in the following section.

Noise Filtering

The first step carried out over the signal before any other processing is noise filtering. The noises such as wind and breath corrupt the input voice signal, and the extracted feature contains less information. So, there is a need to employ
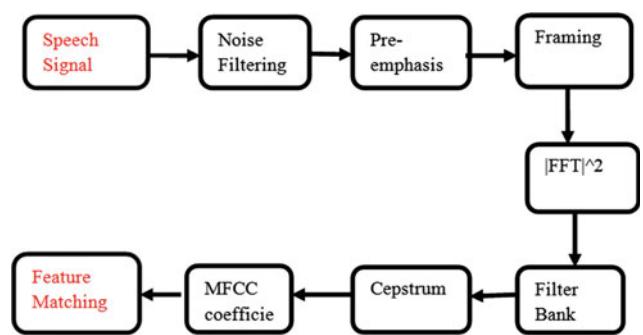

Fig. 1 Flowchart of the proposed model for recognition of words

a filter to remove such noises without compromising original signal loss. Savitzky–Golay filter (Azami et al., 2012) is considered to remove the unwanted noise signals from the speech signal. Speech signal generally contains additive white Gaussian noise (AWGN), thermal noise, etc., due to which the signal-to-noise ratio (SNR) of the processed signal is low which degrades the coefficients of MFCC. For creating an approximating function, the Savitzky–Golay filter is used to capture an important pattern in the signal dataset. This leads to an increment of SNR without introducing time delay, and it is the major advantage of this filter.

Pre-emphasis

Considering the energy spectrum of the speech signal, it is discovered that with an increase in frequency, the energy of the waves decreases rapidly. The majority of the energy is contained in a lower frequency spectrum, whereas the distinction between any two signals is given by higher frequency components. Also, the higher frequency component contains important information for spoken commands recognition (Shaikh et al., 2017). This process is used to enhance the high-frequency components of the speech signal energy. The speech signal's value is raised using Eq. (1).

$$Y[n] = x[n] - \alpha * X[n-1] \tag{1}$$

where $\alpha = 0.9$ to 1.0 (Shaikh et al., 2017).

Framing

The signal obtained after pre-emphasis is divided into several smaller frames. Framing of the signal is done using the Hamming window (Brown et al. 1983). This process is executed so that complexity of analyzing the signal is reduced dramatically. For our case, the frame size may vary from 20 to 40 ms. Most of the speech signal after sampling is not periodic. To reduce this, the discrete Fourier transform (DFT) is performed by multiplying the speech signal with the windowing function. The authors have opted for a Hamming window for the work because the energy of the side lobes in this window decreases rapidly. The response of the Hamming window is given by Eq. (2).

$$W[n] = 0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right) \tag{2}$$

Fast Fourier Transform (FFT)

The frequency spectrum of the signal stores any information that is required for comparing two signals. FFT is used for the conversion of time domain ($X[n]$) speech signal to frequency domain ($X(k)$) using Eq. (3) considering N as 512.

$$X(k) = \sum_{n=0}^{N-1} X[n]\, e^{-j2kn\,\pi/N} \tag{3}$$

where $k = 0$ to N. Computational complexity is greatly reduced by using FFT. The energy of the signal is also calculated (Brown et al., 1983).

Mel Filter Bank

MFCC revolves around the listening behavior of a user and is one of the important concepts to plan the normal frequency spectrum of a signal. After performing the fast Fourier transform, the output spectrum is very wide, and also, the speech signal does not follow a linear scale. Thus, a set of filters is used to match the characteristic of human voice signal (Shaikh et al., 2017). These filters are known as Mel filter banks. The equation for the filter bank is represented by Eq. (4)–(6).

$$H_m(k) = 0 \quad if\ 0 \le k \le f_c(m-1) \tag{4}$$

$$H_m(k) = \frac{k - f_c(m-1)}{f_c(m) - f_c(m-1)} \quad if\, f_c(m-1) \le k < f_c(m) \tag{5}$$

$$H_m(k) = \frac{k - f_c(m+1)}{f_c(m) - f_c(m+1)} \quad if\, f_c(m-1) \le k < f_c(m+1) \tag{6}$$

where 'm' = number of filters required, $f\,()$ = list of $M + 2$ Mel-spaced frequencies. Equation (7) is used for the calculation of Mel frequencies.

$$F_{mel} = 1125 \times \log_e\left[1 + \frac{f(linear)}{700}\right] \tag{7}$$

where f (linear) represents linear frequencies. The auditory perception is linear till 1 kHz, and subsequently, it is nonlinear.

Mel-Frequency Cepstral Coefficient

The cestrum reduces the active range of the values and results in reducing the required storage space. The coefficients are used as the MFCC algorithm is based upon the human hearing anatomy. These coefficients are calculated using the above-described step after which discrete cosine transform (DCT) of the filter banks outputs is calculated whose output comes out in the form of a matrix, which is known as feature matrix. This matrix is used to calculate the similarity between the spoken words. DCT is represented by Eq. (8).

$$DCT = \sum_{m-1}^{k} \log f_{bc} \cos n(m-1)\frac{\pi}{k} \qquad (8)$$

where $n = 1, 2, 3,\ldots..k$ (k is the number of filters used which will be determined in the above process) and 'f_{bc}' is the FFT coefficients after passing from filter bank (Shaikh et al. 2017).

2.2 Feature Matching

The next important step of speech recognition is feature matching. The similarity between the stored signals in the database is compared and evaluated which is known as matching. The degree of correlation between the features depends on factors like surrounding noise, the speaker's pitch and frequency condition, and the speed at which the speaker pronounces the words.

Dynamic Time Warping Algorithm

Dynamic time warping is an algorithm implemented for feature matching. The whole process is seen as a function of the signal's nonlinear warping. A more intuitive similarity measure is generated by nonlinear alignment which allows similar signals/shapes to match even if they are out of phase in the time axis. In this paper, we use the DTW algorithm that helps in calculating cosine distance that is based on the similarities between two sequences that vary in speed or time (Dhingra et al. 2013; Mohan and Babu 2014).

The whole process is a function of nonlinear warping between the signals. Even if the signals/ shapes are out of phase in the time axis, a nonlinear alignment produces a more intuitive similarity measure to match these signals. Euclidean distance is the normal distance calculation between any two points which does not account for phase difference or time variations between two signals. For the feature matching process, it acts as a poor measure of similarity. Twice Euclidean distance does not suffice for feature mapping as voice signal changes at a very fast rate and is never steady. The first step of DTW process is to calculate the distance between the two temporal sequences which gives out a distance matrix. From the distance matrix, the least weighted path is calculated.

3 Results and Discussion

The size of the frame is defined by the amount of frequency and time information that will be included in the particularized frame. The frame comprises about 15–25 ms of the entire signal. It limits the size of the frame by ensuring the stationery property of the stored signal in the frame. The size of the frame decides the size of the matrix of features after the extraction process. Figures 2 and 3 show the pre-emphasis results of the alphabet 'A' and 'B,' respectively. If the size of the frame is decreased further, the information extracted will be meaningless. If the size of the frames is increased beyond the upper range of about 25 ms, the accuracy of the MFCC will decrease considerably as the signal will cease to be stationery.

Figure 4 represents the proposed designed filter bank for the MFCC algorithm comprising initial filters spaced linearly. These filters are trailed by the triangular filters with nonlinear spacing, by which the energy in its designated region is calculated.

Mel scale is used to map filter response on the frequency axis. The Mel scale follows a nonlinear behavior mapping the entire frequency axis (Das et al., 2012).

After performing the steps proposed in the methodology, the outcome is Mel coefficients, obtained for each frame, and then clubbed together to get a feature matrix.

37 Mel coefficients are obtained by the algorithm for the entire feature extraction process out of which the first 12 coefficients are identified as *cepstral coefficients* and the next 12 coefficients are called *delta coefficients*. The cepstral coefficients stores the information found in the spectral domain of the signal, and delta coefficients describe the rate of change in the formants and the cepstral coefficients. The next 12 numbers are *double delta coefficients* which are obtained by calculating the slope of change in delta coefficients. In the end, an energy function is also used apart from the above three categories. The energy function calculates the energy and helps in recognizing a signal together with these coefficients. These multiple sets of coefficients obtained from the whole MFCC algorithm are together an ensemble to form a feature matrix. This matrix is further employed for feature matching purposes as input for the DTW algorithm.

Fig. 2 Pre-emphasis results of alphabet 'A'
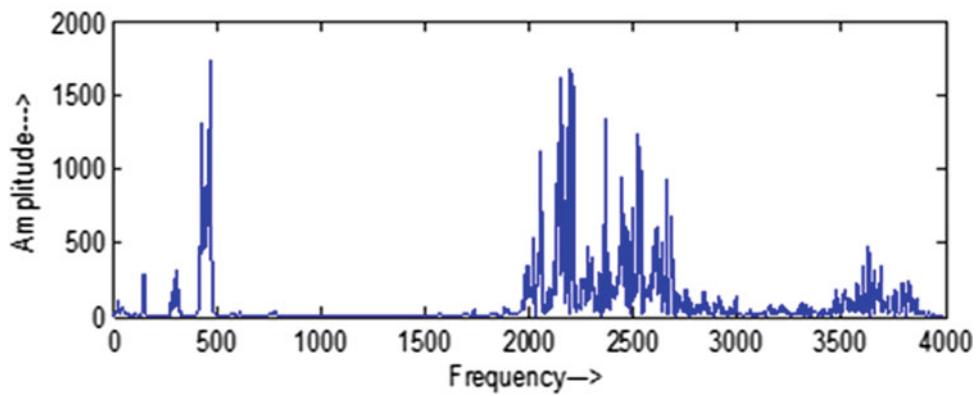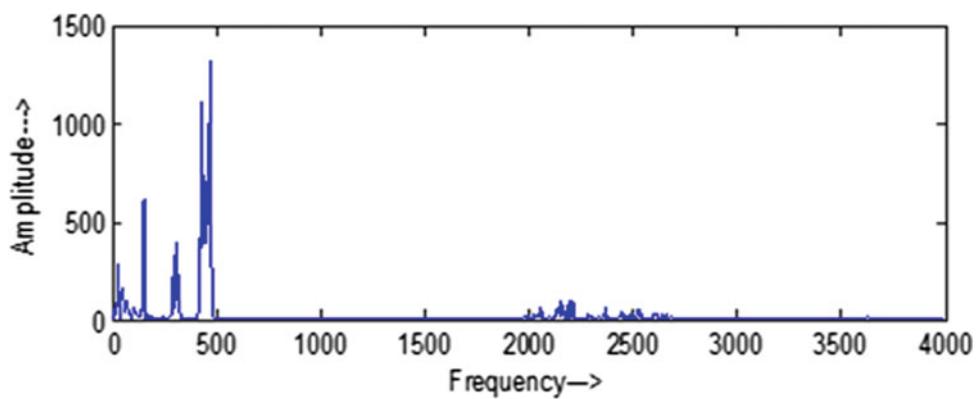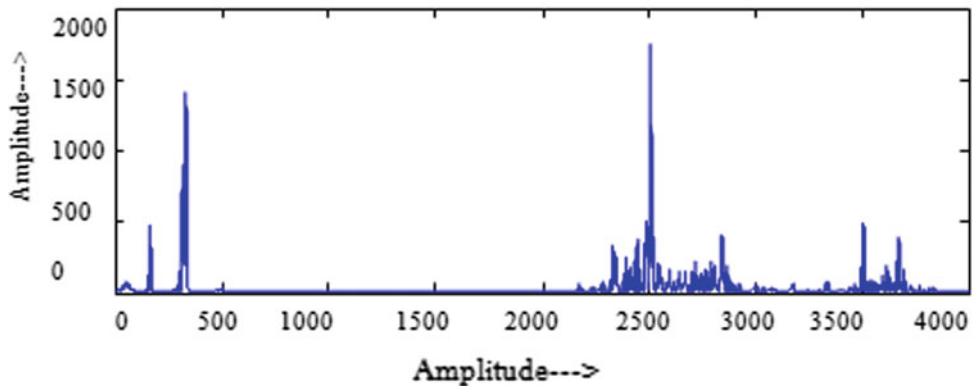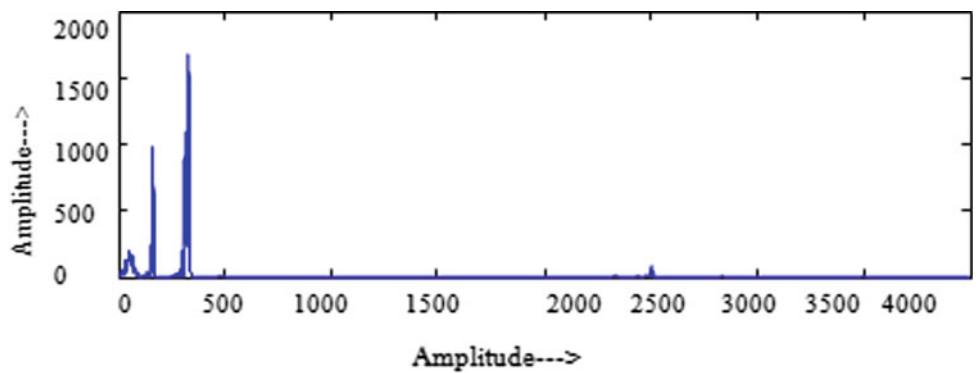


Fig. 3 Pre-emphasis results of alphabet 'B'
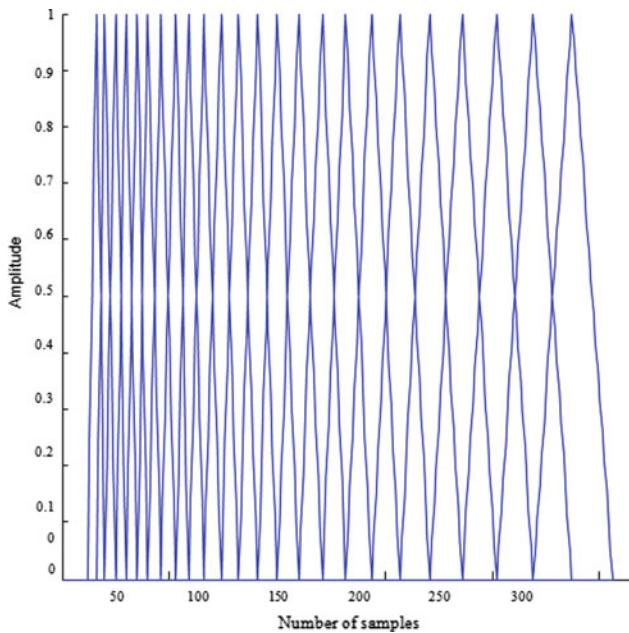
Fig. 4 Filter bank at 8 kHz

3.1 Recognıtıon Results

The results of recognizing alphabets using the MFCC and DTW algorithms are depicted and are shown in Table 1. The sampling frequency of 8 kHz was taken, and the comparison threshold was kept around 1.5. The extent of matching between two time series is measured in terms of distance factor between points ai and bj of two time sequences. Euclidean distance is used to measure distance between features of input sample and saved template.

The initial database contains the coefficient matrices of 25 alphabets 87 as each of the alphabets was recorded 5 times. The spoken alphabet was compared with the first five instances, followed by averaging giving out the comparison

parameter. The results of the comparison of different alphabets concerning recorded and spoken words are shown in Table 1. The reference value of the comparison parameter is taken as 1.3; if the comparison parameter value is less than 1.3, then the alphabet is considered to be perfectly recognized with high accuracy.

The problem associated with MFCC is that the cepstral is a matrix. If constant window spacing is used, the input and stored signals are unlikely to be similar to each other; moreover, the alphabets which have similar phonemes will have a larger degree of similarity, for example, alphabet 'C' and 'D' have similar phonemes; hence, we are getting the value of comparison parameter comparatively close for such alphabets (Huang et al., 1993). Table 2 depicts the accuracy results of recognition for three different commands, left–right, and down.

To sample the signal, 8 kHz frequency was chosen and a frame of 256 points which accounts for 32 ms in the time domain. The overlap size was considered as 100 points resulting in 12.5 ms in the time domain. Each of the commands had three instances, and the comparison parameter was calculated by averaging the comparison output (five times) of the three stored signals. Table 3 depicts the results with the frame size of to 512 points from 256 points, with a sampling frequency of 8 kHz (64 ms) and overlap between frames as 100 points.

From the results, it is observed that the accuracy of the system degrades as the size of the frame is increased, the reason being the change in the time limit of each frame. An increase in frame size increases the time duration from 32 to 64 ms. MFCC algorithm applies to the signal that follows stationary behavior. Hence, the clipped out signal cannot be approximated as a stationary signal. In large time duration of 64 ms, the properties' frequency of the signal varies to a large extent, and thus, MFCC algorithm efficiency decreases.

A higher sampling frequency is utilized for higher framing size, but it increases the redundancy. The range of

Table 1 Values of comparison parameter

Recorded						
Spoken	Alphabet	a	b	c	d	e
	a	**1.05**	3.43	2.81	7.5	1.64
	b	3.36	**1.012**	2.9	1.67	1.7
	c	3.33	3.6	**1.11**	2.64	1.62
	d	3.1	1.83	2.01	0.6	1.85
	e	2.58	3.2	1.83	4.003	**0.511**

Table 2 Commands recognition 256 point framing

Commands	Left	Right	Down
Left	**0.904**	2.825	4.97
Right	7.884	**2.137**	4.87
Down	9.01	8.08	**1.924**

Table 3 Commands recognition 512 point framing

Commands	Left	Right	Down
Left	**1.02**	3.29	3.83
Right	4.42	**1.84**	5.44
Down	1.50	6.90	**0.73**
Accuracy (%)	80	60	80

3.5–4 kHz of maximum frequency is produced by the average human, justifying the Nyquist criteria, at a sampling frequency of 8 kHz.

The results shown in Fig. 5 shows that alphabet B is perfectly matched with itself. When alphabet B is matched with alphabet C, no matching is observed as represented in Fig. 6. The distance between two signals, vectors 1 and 2, is shown by the red line. A straight diagonal line signifies that the signals are highly correlated. Two signals are different from each other if the line follows a zigzag pattern.

Similarly, these graphs can be obtained for different alphabets, straight-line perfect matching, and zig zag line showing perfect mismatch (Singh et al. 2019).
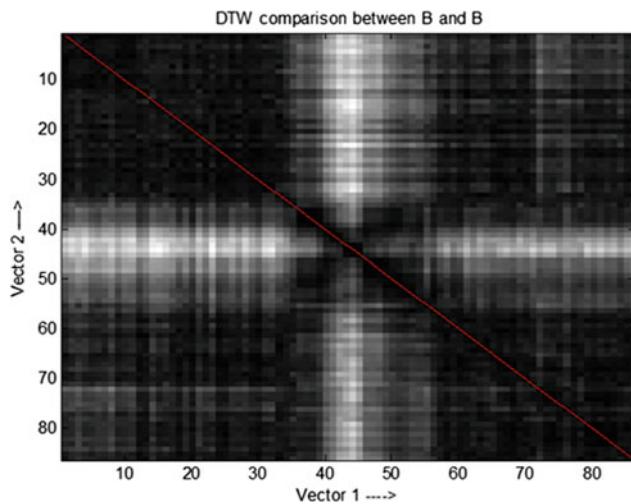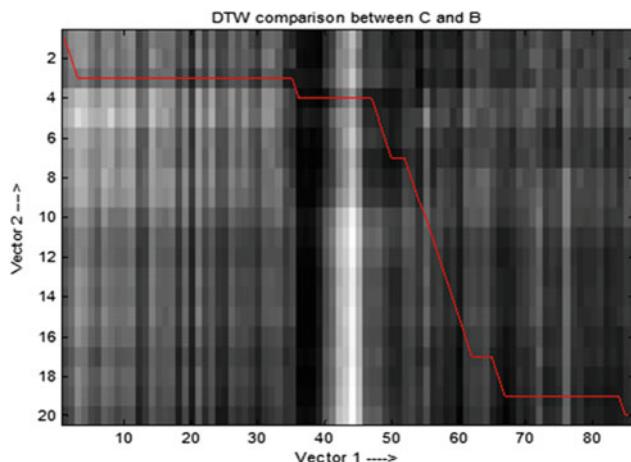
4 Conclusion

The performance of the voice recognition system depends on various factors such as background noise, delivery source, recording media, speaking rate, and speaker voice specifications. The accuracy in the speech recognition system comes from the quality of voice signal issued by the speaker and the similarity of the rate at which the speaker has spoken while recording the database for analysis. The signal analysis using MFCC favors the work that authors have done as it converts the speech signal according to the hearing perception of a human being. The DTW algorithm applied gives results of great accuracy.

When the frame size and windows are limited to 15–25 ms, the MFCC algorithm generates efficient results. Four commands are used to successfully control the robotic model, and the accuracy has been described in results and discussions. From different available windows, the Hamming window gives comparably better results. Despite MFCC's efficient results, it has some setbacks for implementing the concept of speech recognition. Primarily, any signal other than the ones stored in the database will not be recognized as it depends on a database for recognizing speech signals. Secondly, the MFCC algorithm depends upon the clarity of the signal being stored, so it is prone to noise interference. To give good and accurate results, an ideal recording for the algorithm is required. Lastly, it is a user-dependent as the commands of only those individuals are recognized whose voice signals have been stored in the database. So with the same database, it cannot recognize the voices of multiple users. Shortly, for human–machine interaction, speech processing has a huge potential in becoming an important factor. A speaker-independent speech recognition system employed artificial neural networks and MFCC can be proposed for better performance. For better accuracy, a combination of recurrent neural network and probabilistic neural network followed by MFCC can be used.

Fig. 5 DTW comparison between 'B' and 'B'

Fig. 6 DTW comparison between 'C' and 'B'

References

Afrillia, Y., Mawengkang, H., Ramli, M., & Fhonna, R. P. (2017). Performance measurement of mel frequency ceptral coefficient (MFCC) method in learning system of Al-Qur'an based in nagham pattern recognition. *Journal of Physics: Conference Series IOP Publishing., 930*(1), 1–6.

Anggraeni, D., Sanjaya, W. S. M., Solih, M. Y., & Munawwaroh, M. (2018). The implementation of speech recognition using mel-frequency cepstrum coefficients (MFCC) and support vector machine (SVM) method based on python to control robot arm. *Annual Applied Science and Engineering Conference, 2,* 1–9.

Azami, H., Mohammadi, K., Bozorgtabar, B. (2012). An ımproved signal segmentation using moving average and savitzky-golay filter. *Journal of Signal & Information Processing, 3*, 39–44.

Brown, P. F., Lee, C.H., Spohr, J. C. (1983). Bayesian adaptation inspeech recognition. *IEEE International Cont on Acoustics, Speech, and Signal Processing, 8*, 761–764.

Das, B. P., & Parek, R. (2012). Recognition of isolated words using features based on LPC, MFCC, ZCR and STE with neural network classifiers. *International Journal of Modern Enginnering Research, 2*(3), 854–858.

Dhingra, S., Nijhawan, G., Poonam, Pandit. (2013). Isolated speech recognıtıon usıng MFCC And DTW. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 2*(8), 4085–4092.

Huang, X., & Lee, K. (1993). On speaker-independent, speaker-dependent and speaker-adpaptive speech recognition. *IEEE Transaction on Speech and Audio Processing, 1*(2), 150–157.

Mansour, A. H., Salh, G. Z. A., & Mohammed, K. A. (2015). Voice recognition using dynamic time warping and mel-frequency cepstral coefficients algorithms. *International Journal of Computer Applications., 116*(2), 34–41.

Mohan, B., Babu, R .: Speech recognition using MFCC and DTW. In *ICAEE Conference paper.* https://doi.org/10.1109/ICAEE.2014.6838564.

Muda, L., Begam, M., & Elamvazuthi, I. (2010). Voice recognition algorithms using mel frequency cepstral coefficient and dynamic time warping techniques. *Journal of Computing., 2*(3), 138–143.

Plouffe, G., & Cretu, A. M. (2015). Static and dynamic hand gesture recognition in depth data using dynamic time warping. *IEEE Transactions on Instrumentation and Measurement, 65*(2), 305–316.

Riyaz, S., Bhavani, B. L., & Kumar, S. V. P. (2019). Automatic speaker recognition system in Urdu using MFCC & HMM. *International Journal of Recent Technology and Engineering (IJRTE), 7*, 109–113.

Shaikh, H., Mesquita, L., Das, S., & Araujo, S. (2017). Recognition of isolated spoken words and numeric using MFCC and DTW. *International Journal Engineering Science and Computing., 7*(4), 10539–10543.

Singh, P. K., Kar, A. K., Singh, Y., Kolekar, M. H., Tanwar, S. (2019). *Proceedings of ICRIC Recent Innovations in Computing*, vol. 597. Springer Nature.

Zhao, X., & Wang, D. (2013). Analyzing noise robustness of MFCC and GFCC features in speaker identification. *IEEE International Conference on Acoustics, Speech and Signal Processing* 7204–7208.

IoT and Smartphone-Based Remote Health Monitoring Systems

Chimdessa Assaba and Shilpa Gite

Abstract

As people age, their body tissues and organs begin to fail. This causes a number of diseases that can quickly destroy a person's life. Thus, as long as they are alive, daily or weekly monitoring of the physiological body is an issue. To do this physically by visiting a hospital can be very difficult. IoT and smartphone-based systems are one subset of new technologies that focus on shifting in-hospital treatment to out-hospital treatment, therefore avoiding having to go to hospital to know his/her health status physically. The system collects real-time data from the patient's body without burdening their daily activities. The practical implementation of the system is improved by taking five patients as a sample, and data acquired from each sensor is analysed by calculating the error rate. The advancement of information communication and technologies in mobile technology not only provides a calling service but provide services in health monitoring activities. This paper describes how advanced smartphones and wearable sensors play important functions in remote health monitoring. Wearable sensors can obtain data from the patient's body, while smartphones can obtain the patient's parameters (data) from wearable sensors through Bluetooth communication technology, and then send the data to a database (Cloud) through a wide area network (WLAN) technology for future access.

1 Introduction

Internet of Things (IoT) technology using mobile smartphones plays many tasks around the world at this time. The advancement of these technologies is not limited to a number of specific areas. It is possible for health care providers to deliver remote health monitoring activities by using modern technology IoT (wearable sensors + communication modules like Bluetooth and WLAN) and mobile smartphones (Lomotey et al., 2017). This means health and medicine collage is an area where IoT technology play a great role (Pang, 2013).

Researchers have shown (O'Neill & Peoples, 2017) that IoT plays a great role in smart cities, traffic congestion, waste management, structural health, security, emergency services, industrial control, and health care. IoT should be available over the entire country. With IoT technology unconnected things can be connected to each other for the processing and completing of tasks: sending, receiving, processing, storing, securing. In the IoT general concept, visible and invisible objects are not simply objects but smart objects. Not all objects establish communication with each other without IoT technology, and the concept is much greater than other technologies because it is a domain of all fields, include wireless networks: RFID, WLAN, LAN, Bluetooth, etc., machine learning, Cloud technologies and so on.

The traditional health monitoring systems require users to visit medical care centers and to get balanced treatments. This is especially so for rural populations. In urban and rural areas, accessing medical health care physically consumes many resources—such as time and budget, and also faces additional problems while accessing.

C. Assaba
Department of Computer Science, Wollo University, Dessie, Ethiopia
e-mail: chimdesaasebe7@gmail.com

S. Gite (✉)
Department of Computer Science, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune, India
e-mail: shilpa.gite@sitpune.edu.in

As some researchers (Islam et al., 2015; Rahmani et al., 2015; Sebestyen et al., 2014) have said, health and medicine application is a place where IoT technology can be applied to many services providing monitoring and processing functions. The new system developed from the IoT and mobile computing will perform a continuous remote monitoring of the patient, highlighting vital signs effectively while consuming fewer resources (Wood et al., 2008). To remotely know the health condition of users, the sensors we use have ability to provide information frequently (Krish et al., 2011). IoT and mobile-based health care systems provide remote health monitoring, store recorded data, establish communication with health care givers and access medical health centers. However, the follow-up date will be established with specialists and patients, for giving and receiving treatment after the patient's vital signs are collected and processed (Yan et al., 2010).

In this study, we will look at some of the physiological sensors worn by the user which able to collect patient vital sign. These different sensors: ECG, body temperature and pulse heart rate sensors are comfortable and easy to wear and use (Lee & Chung, 2009). These sensors collect physiological data and forward values to the Arduino microprocessor. Smartphones are used to show the results of the processed gathered data from the microcontroller and then send it to a health care database storage and an authorized person for further processing. Before using such devices, knowing their advantages, disadvantages, battery life time, availability and cost must all be considered.

The developed system in this paper performs the following functions in the health and medicine departments:

1. The system provides real-time data and feedback; it means that at the same time that wearable sensors obtains vital signs from patients, the next process is based on values compared with the threshold values; normal physiological patient values are displayed from a local database which is an Android built-in database, while in case of abnormal vital signs, the system will display alert dialog messages to patients and send these to a remote server to be accessed by an authorized body.
2. The system provides AES security algorithms to protect each patient data from theft.
3. The system uses Bluetooth wireless communication to send and receive information—RFCOMM is the Bluetooth wireless communication protocol.
4. The system provides permissions to ensure who is authorized for accessing patients' data.

2 Problem Statement

In the current health providers' departments, the system they are using is uncomfortable for both patients and health providers. In a greater number of health providers, beyond giving real-time treatment it is a burden for data storing and accessing. There are more people who are discharged from health centers for getting real-time services. To get services for their health case status, they have to pay out expensive money, they are queued for a long time, they face shortage of commitment and inadequate medical facilities and professionals to provide patients with intensive care in emergency units and other healthcare departments.

These listed problems lead to:

- a health care system that does not support the easy monitoring of the health of patients;
- puts the burden on patients to make their treatment and to return for follow-up visits;
- find and pay for transport;
- high costs incurring.

Moreover, in developing countries, in rural areas, there is no system that gives a solution for solving these problems and monitoring self-health remotely.

3 Related Literature

3.1 Sensors and Wearables

Wearable sensors are electronic devices that any user can wear on their body and are capable of doing expected processes in convenient ways. Recent advances in security, industries, health, home life, microelectronics and data analysis techniques have been possible for using wearable technology to achieve more benefits and a health outcome. In the past years, the size of health care monitoring electronics used in medical centers made them too difficult to use. In recent years, such difficult electronics have been replaced by wearable sensor devices to gather human physiological data, providing strong security, improving human life style and to gathering movement data. Now, wearable sensors can now be deployed in digital health monitoring systems with circuits, wireless data communication protocols, and microcontrollers.

In the mid-2000s, wearable sensors, watches, clothes, shoes, umbrellas, etc., with wireless communication technology are fully integrated as a complete device used in medical (hospitals) for monitoring medical care.

Advanced wearable technology used to collect and measure the physiological signals and human movement has the potential impact on physical medicine and rehabilitation (Bonato, 2005).

Researchers have (You et al., 2017) developed mobile-based physiological data monitoring systems that perform monitoring and analysis of tasks regarding human physiological vital signs value. The system combines the wireless communication technology and wearable sensors worn on the human body to obtain physiological data. The system performs classification and analysis activities for individual patient records and stores it from where authorized persons are able to access the data for future tasks. The main problem of this system is delay time during data classification and analysis.

Researchers (Kantoch, 2013) also developed a system for patient management in medical centers. The system can transfer data via Bluetooth technology and sensors which patients wear on their body to obtain physiological data. For future purposes, data will be stored in an external server. Physical experiments are done for a number of groups. In this experiment, the system shows 95% absolute correct value when compared to the certified medical devices.

Experimental tasks took place on the group of people after they worked any activities and the result shows 95% is absolutely correct when compared to certified medical health devices. Researchers (Kakria et al., 2015) developed real-time cardiac monitoring systems in wearable sensors and smartphones in order to monitoring cardiac patients remotely. The system acquires the patient data with a zephyr sensor and stores data in online MySQL database via GPRS, Wi-Fi, and 3G from a smartphone.

3.2 Smartphone Issues

Smartphone is a device that allows communication technology in data from sender to receiver via any devices that support wireless protocol having no fixed physical link connected. Mobile computing technology involves: mobile communication, which is any infrastructures used in communication services put in place and ensures that seamless and reliable communication is establishing or going on. These would include devices such as protocols, services, bandwidth, and portals necessary to facilitate and support the stated services. Mobile hardware is another involvement in mobile computing, which is hardware we use in wireless communication: including devices such as smartphones, tablets, laptops, palmtops. Mobile software is the third one, which is a software that run on any mobile and controls any operations going in it. Researchers (Yi & Saniie, 2013) have developed smartphone-based health monitoring remotely systems. The system involves sensors that acquire data from

the human body and uses wireless communication to transferred sensed data and uses a smartphone to send data to Cloud. Researchers (Jovanov, & Zhang, 2004) developed a mobile health system which is a transition of desktop telemedicine to mobile computing to monitor human signals generated from the body. The related patient data will be stored at a remote location via a wireless transmission technique.

3.3 Safety Monitoring Issues

The advancement of wearable sensors and smart mobile phones is not limited to specific areas, it involved many areas. Some of the systems developed with the IoT technology are for safety monitoring and issuing alarm messages to a user. Researchers (Lyder et al., 2012; Lemly, 2004) are using the best technology designed for safety monitoring in hospitals. These have the ability to wirelessly relay an alarm message to the patient and to describe the clinical and demographic character of hospitals to individuals. Researchers (Lee et al., 2017) using ZigBee technology developed a smart bridge safety monitoring system on the IoT base. This system consists of: (1) sensors in the bridge; (2) communication devices which connect the bridge monitoring devices (sensors) and the Cloud-based server; (3) a database that stores bridge environment-condition data; and (4) a Cloud-based server that calculates and analyses data transmitted from the monitoring devices. This system can monitor and analyse in real-time the conditions of a bridge and its environment, including the water levels nearby, pipelines, air and other safety conditions. The detected data and images are transmitted to the server and database for users to have real-time monitoring of the bridge conditions via mobile telecommunication devices. Researchers (Jutila et al., 2014) presented a prototype wearable vest keeping the safety and wellness of children in places. The system is developed with use of Lilypad Arduino and Adafruit Flora platforms and with wearable sensors, GPS and wireless communications. The developed system gathers and picks up the children's location and has the ability to send the notification to carers.

3.4 The Power Consumption Issue

Whenever we desire to use any devices or sensors, we have to consider their battery lifetime. This is one concept that every researcher will know. Each device may consume different powers of energy while in the operation process; while some devices consume less power others consume high power. For example Bluetooth consumes low power while ZigBee consumes high power. To keep the battery life of
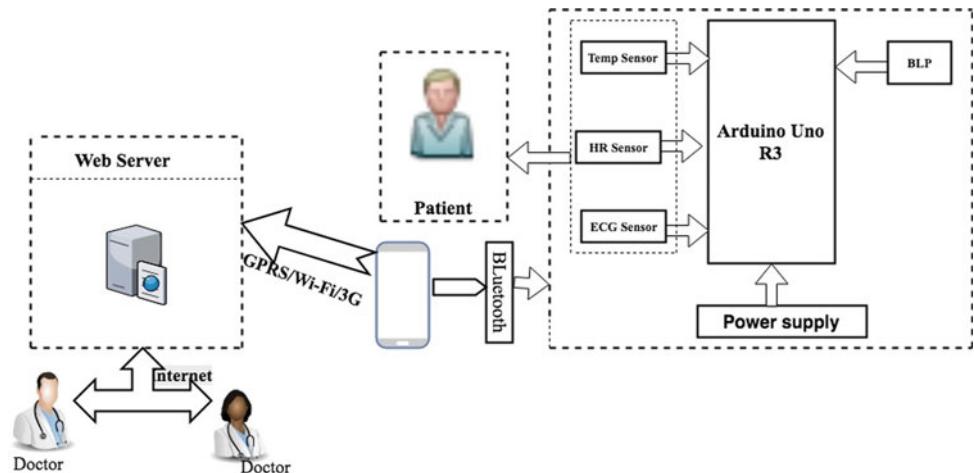
medical sensors should be ensured during operation. Researchers (Wu et al., 2017) presented how to enhance the battery life of connected devices during operation. The system uses harvesting solar power to keep the batteries of sensors connected. After experiments have taken place, the wearable sensor devices work well when powered by the solar system. The proposed system with solar energy harvesting demonstrates that long term continuous medical monitoring based on WBAN is possible provided that the subject stays outside for a short period of time in a day.

4 IOT and Smartphone-Based Remote Health Architecture

This section studies the overall picture of the system functions, components and working flows. IoT and smartphone-based remote health systems have four functions: (i) sensing function (ii) communication function, (iii) security and (iv) storing functions. Sensing function is acquiring a set of patient physiological data with the help of worn wearable sensors. Communication function is delivering of gathered physiological data to patients directly and might be to a gateway device through transmission protocols. Security function applied on the data obtained from sensors is a mechanism employed for data protection from unauthorized bodies. Data storing function represents both local and remote server for collecting and safe data. The IoT and smartphone-based remote health monitoring architecture in Fig. 1 combines two systems, such as: WBANS and the persistent storage system.

The WBANS provides two functions, sensing patient vital sign and forwarding data to a smartphone device. Then information is stored in a SQLite database and in the remote health care storage-MySQL storage from where authorized persons access and diagnose the patient's physiological status.

The system makes it easy to acquire medical related data parameters: heart rate, body skin temperature and electro-cardiograms at the same time. These parameters help to avoid, or detect, cardiac diseases such as hypothermia, fever, pathological tachycardia and pathological bradycardia with automatic feedback relying on threshold range values restricted. The system has two interfaces: the patient interface and the doctor/families' interface. The patient interface involves sensors which collect vital signal data of patients and transmit it to an Android app through Bluetooth and then forward data to a web server. To login into the web, doctors/families should have a user ID and password. Then to access and make diagnosis for patients, an authorized user can use Bluetooth ID and patient ID. Figure 1 shows the system architecture.
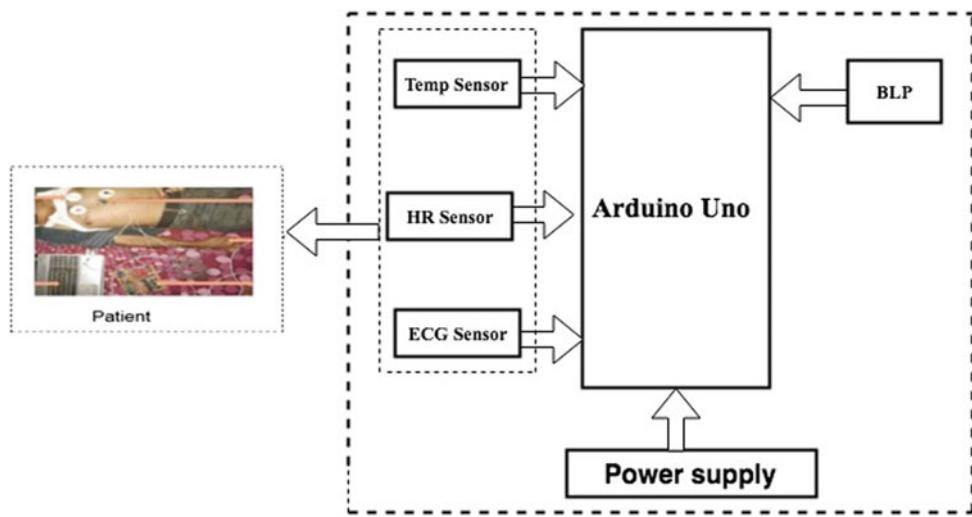
4.1 Wireless Body Sensor Network System

WBSNS can contain a great number of WBSN. Here, each of WBSN shown in Fig. 2 has three wireless physiological sensors which obtain patient body physiological data. Then physiological data is sent to a middleware smartphone through Bluetooth communication.

4.2 Persistent Storage System (PS)

PS is a storage system where patient-related data is held in an electromagnetic or optical form for access later. However, if a container goes to off, or crashes, the data is already stored and does not get lost. The system stores data which is sent from a smartphone via Wi-Fi in MYSQL persistent storage where an authorized person accesses the data, and also data is classified in this system. Each data sent from a smartphone should be expected under its classification.

**Fig. 1** IoT and smartphone-based remote health care general architecture

Fig. 2 Hardware design of WBANS

4.3 Sensors Issues

In the medical health field, the sensors are classified into two types: (i) intrusive—which measure a patient's physiological data intradiscally; and (ii) non-intrusive—which measures a patient's body data without intrusiveness. Body temperature sensors, pulse heart rate sensors and ECG sensors are non-intrusive sensors placed at the proper position for the purpose of accurately measure physiological data.

4.4 Data Security Issues

In daily life, the prevalent problem associated with enhancing data safety is data security, privacy, confidentiality, integrity and availability (Forouzan & Mukhopadhyay, 2011). The developed system also provides AES algorithms to protect the patient data from theft while storing it in a remote server. Encryption is the most important technology for protecting sensitive patient data from theft. There are two types of encryption: asymmetric and symmetric. The system focuses on symmetric encryption AES which uses the same key to encrypt and decrypt data. The comparison between asymmetric and symmetric encryption is that asymmetric encryption is not well used and not powerful enough to secure data in a database, while symmetric encryption is very common in database frameworks. Twofish, Blowfish, DES and AES are some common symmetric encryptions. The system keeps the patient-related data safe on remote sites by applying AES algorithms which provides excellent security and is more energy efficient (Daemen & Rijmen, 2002; Diffie & Hellman, 2006; Thangavel et al., 2015) (Fig. 3).

This algorithm is one type of symmetric key cryptosystem that is very easy to use and implements in security deployments. Unlike other symmetric key cryptosystems such as: 3DES, RC6 and Blowfish and all asymmetric type of cryptosystem the AES algorithm has high speed in data encryption and decryption processing. This algorithm processes a symmetric block cipher data with the three different keys length "AES-128", "AES-192", and "AES-256". In other words AES comprises three block ciphers such as: AES-128, AES-192 and AES-256. Each cipher encrypts and decrypts data in blocks of 128 bits using cryptographic keys of 128-, 192- and 256-bits, respectively. The main problem in this algorithm is exchanging the shared secret key (Mahalanobis, 2005) over an unsecure way. Figure 4 show AES design.

4.5 Configuration of Bluetooth Module and Arduino Uno

When we talk about wireless communication, we know Bluetooth is one method of a popular communication between devices. Today many smartphones have the integrated Bluetooth chip and have the capability to communicate using it. This is useful on many projects whose system requires a wireless communication protocol. The main issue here is to explain how to wire the Bluetooth module with Arduino and how to make it send and receive data to and from another device wirelessly. Figure 5 depicts the wiring of the Bluetooth module with Arduino.

The communication for data exchange between the Android device and Arduino starts after connectivity is established via the Bluetooth module. The Bluetooth module and Arduino microcontroller are connected in Fig. 3 and the Android app communicates with the connected devices in order to send and receive data. If the Android app sends the letter "T" or "H" or "E" to the Arduino, the Arduino will

**Fig. 3** AES encryption algorithm structure
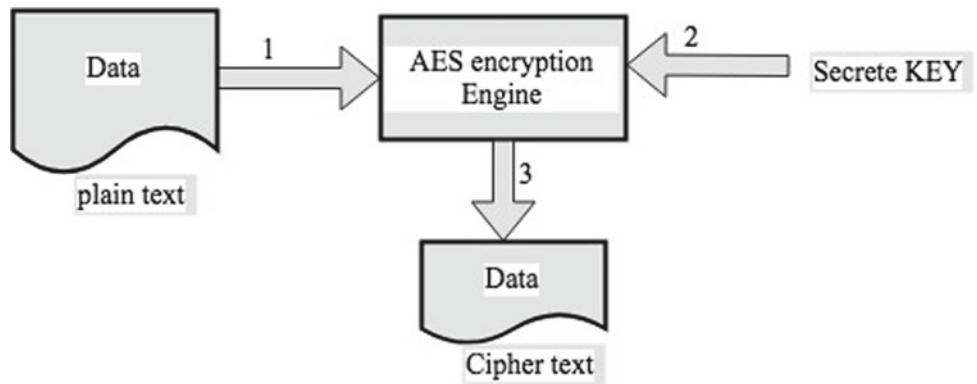

Fig. 4 AES algorithm diagram
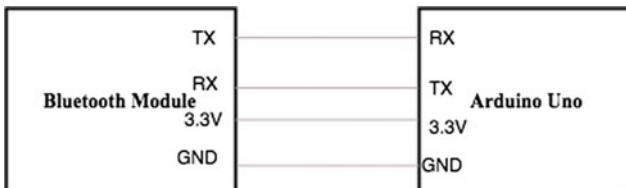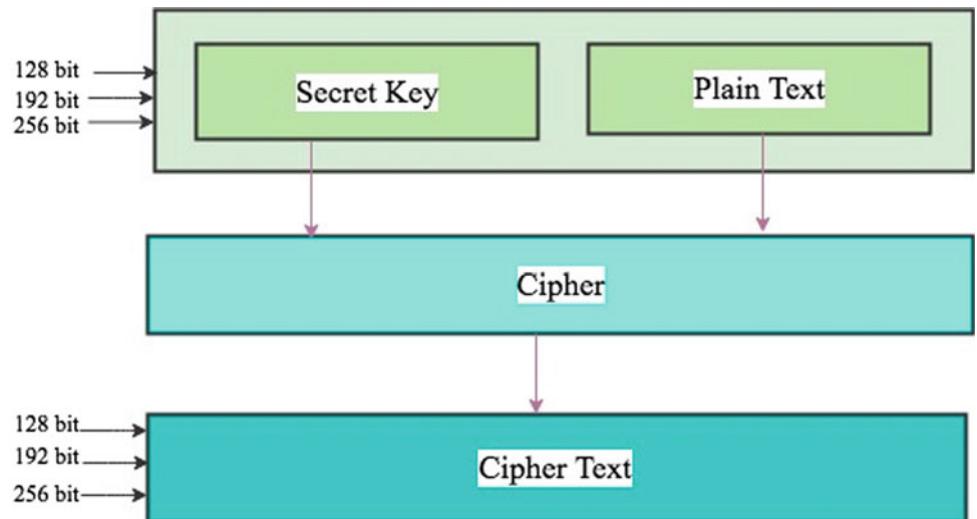
Fig. 5 Bluetooth and Arduino connectivity

send the data obtained from sensors via the outstream of the Bluetooth module.

4.6 The Working Flow of Bluetooth

The working flow of Bluetooth is illustrated in Fig. 6. In this section, several seamless functions are performed before the data is transmitted and received data via Bluetooth. Here, first ensure that an Android device supports Bluetooth and if it supports it, Bluetooth must be turned on. Then, the smartphone will be paired and connected with the Bluetooth module on the Arduino. Finally, the Android sends and

receives data through the same shared channel RFCOMM protocol between both devices.

4.7 Smartphone Working Flow

In this system, a smartphone is used as BS. The working flow is showed in Fig. 6. A patient's data which will be send from a smartphone has four attributes: patient ID, patient name,
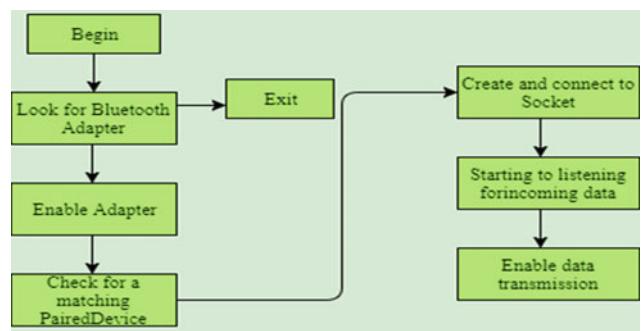

**Fig. 6** Bluetooth working flow diagram
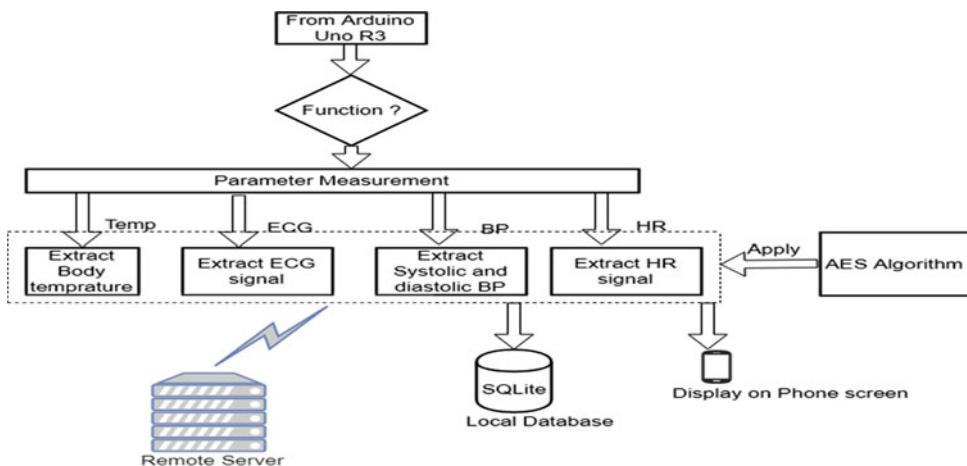
Fig. 7 Smartphone working flow diagram

Bluetooth ID and physiological data. After it receives physiological data it packets it to a third-party body-database server, a SQLite local server, doctors in the SMS message with all its fields. When global network is unavailable, patient data will be stored in the SQLite database. In order to make an alarm system, comparison functions of data will be processed in the smartphone, based on threshold value setting (Fig. 7).

4.8 Alarm Systems

The proposed system has the capability of issuing an alarm to notify health care personnel in cases of an emergency happening on patient vital signs. The alarm system is on threshold data values comparison (Sim et al., 2012; Goldberger et al., 2008) (Fig. 8; Table 1).

5 Simulations

The effectiveness of the system is measured after the simulation of the system is completed.

To achieve the result in order to take diagnoses, we have threshold value for normal and abnormal physiological sign values. This setting helps the smartphone to sound alerts to health care when the value is out of range. For individual patients, any collected data can be stored in his/her local storage-SQLite and removed from it. The packet which has a
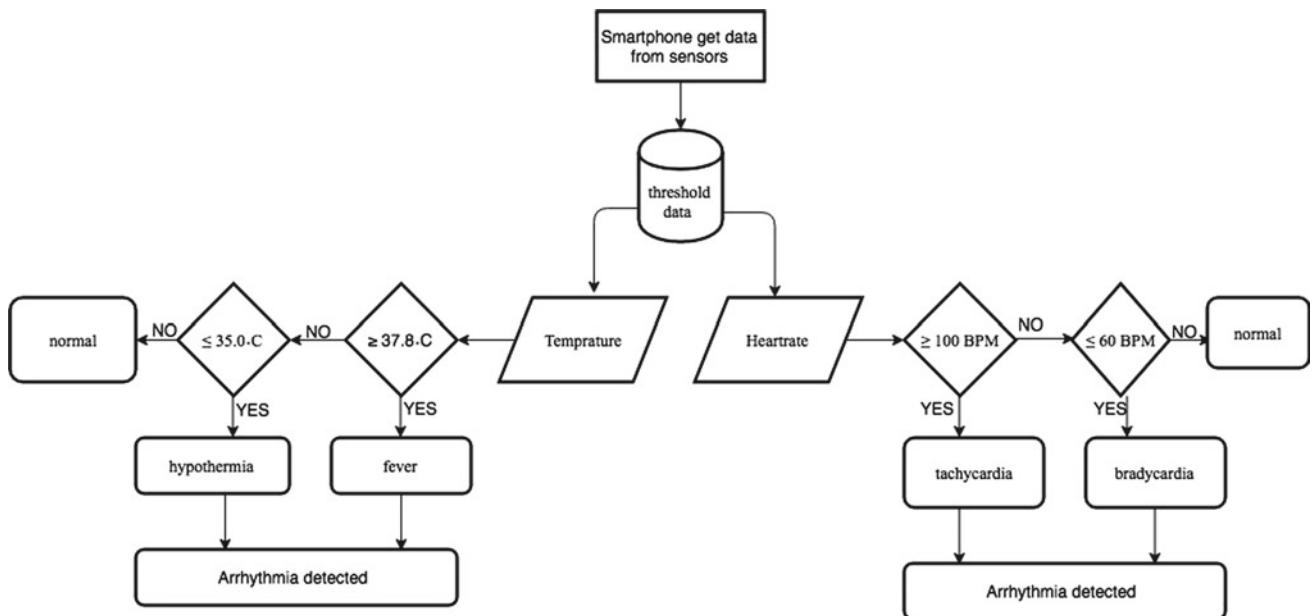

Fig. 8 Flow chart of alarm mechanism

Table 1 Threshold values of heartrate and body temperature, adult person, for alarm mechanism

Sinus rhythm type	Threshold value of body temperature	Threshold value of heart rate
Normal	36.5–37.5 °C	$60 \leq HR \leq 100$ BPM
Hypothermia	≤ 35.0 °C	
Fever	≥ 37.8 °C	
Pathological tachycardia		$HR \geq 100$ BPM
Pathological bradycardia		$HR \leq 60$ BPM

**Fig. 9** The combination of a smartphone and body sensors
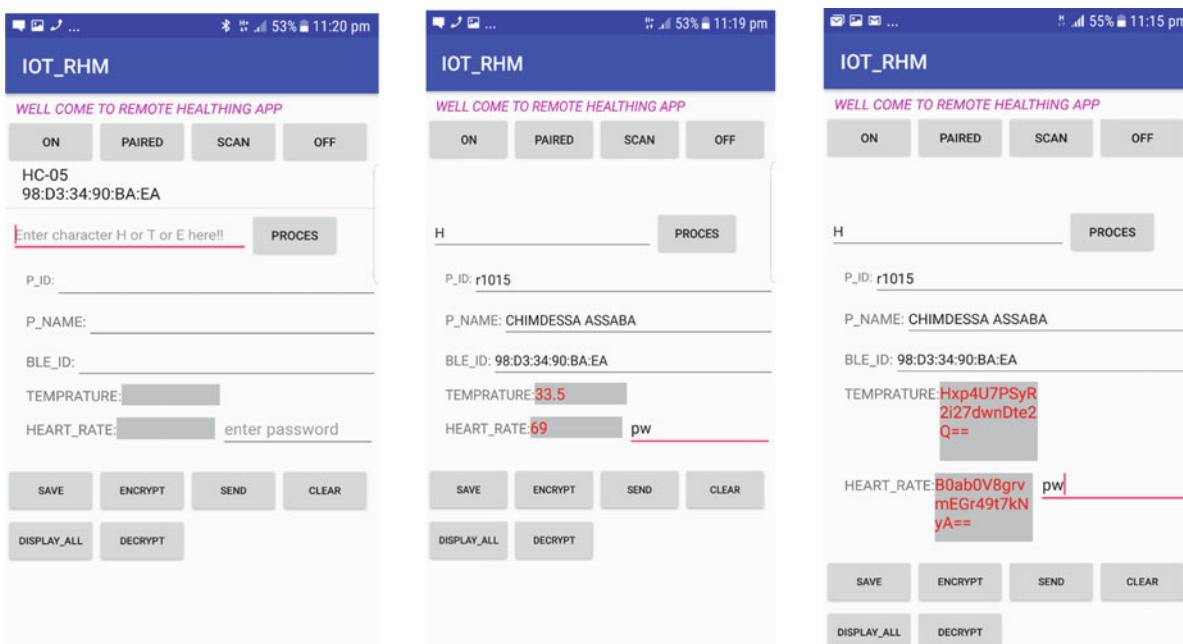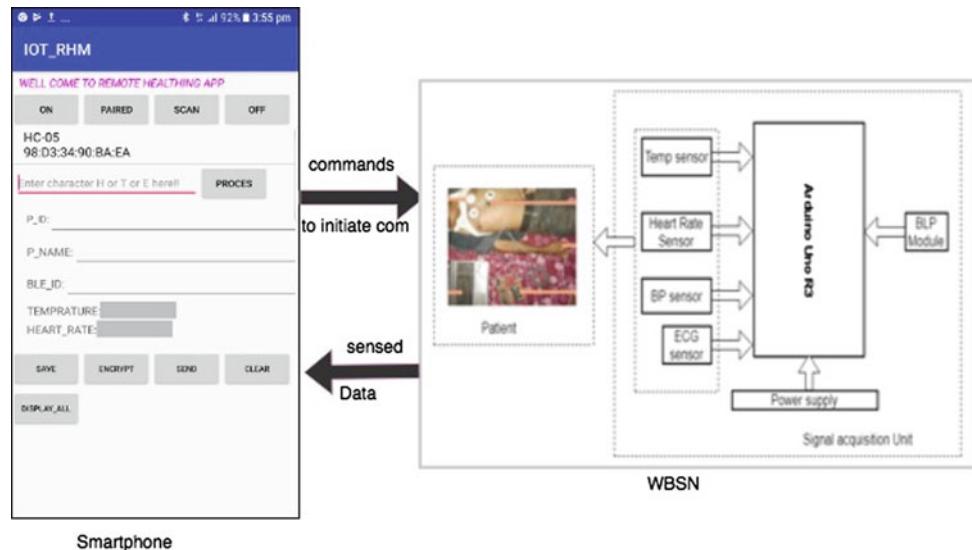
Fig. 10 Demonstration of IoT and smartphone-based remote health monitoring system Android application
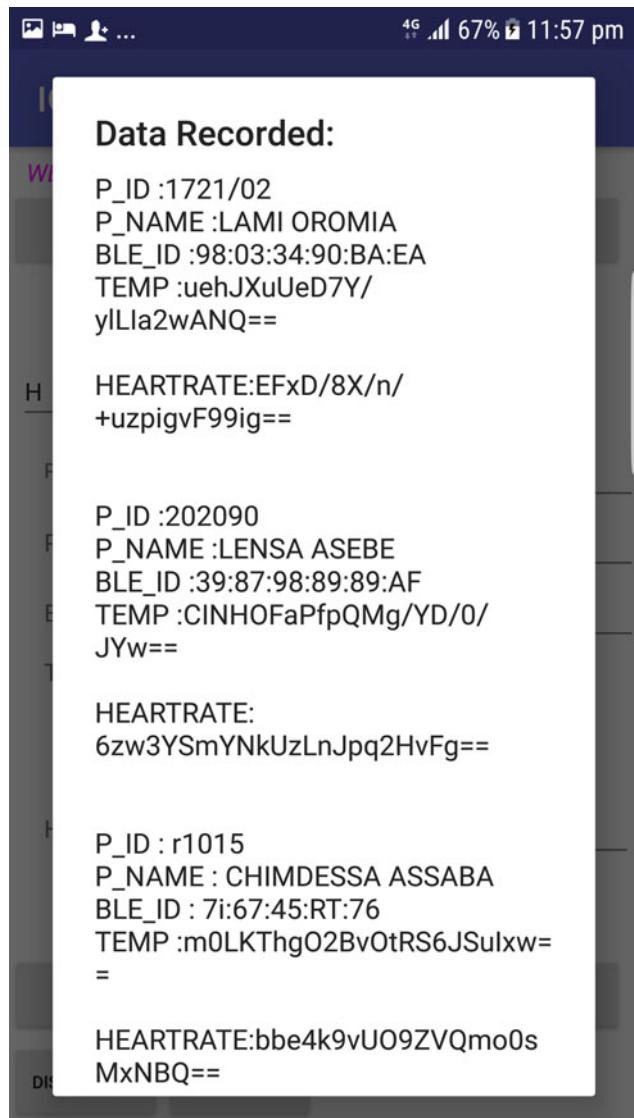
Fig. 11 SQLite local database recorded data screen on simulation device

permission to be sent via Wi-Fi to a remote server can be stored in the MYSQL server. This permission avoids the complexity and business of the server (Figs. 9 and 10).

Every patient can do the necessary tasks on the data obtained from the sensors and visited on their mobile phone. He/she can be sent, store, save, clear, secure and display their own information. They can be stored locally or remotely for every patient with their unique other information to identify them from other patients (Fig. 11; Table 2).

6 Results and Analysis

In this study, the IoT and smartphone-based remote health monitoring system is developed for monitoring cardiac parameters such as heart rate, temperature and ECG and are being obtained using worn sensors attached on the patient's body. The Android application has been developed to receive, store and transfer patient-related data to a remote server using wireless communication. From the remote server, a privilege is given for authorized doctors/family to know the medical status of a patient and deliver the treatments for patients.

The practical implementation of IoT and a smartphone-based remote health monitoring system is examined to determine the accuracy, ability, compatibility, usability and performance of the system by calculating the error rate of the patient's vital signs.

The practical implementation process of the system involves the participation of five patients with different ages. Before going to use the developed system, we have to record patients' vital signs by using certified medical health devices used in hospital as actual data; then each patient wears wearable sensors, and we are use the system to acquire medical information. With the approach presented in the paper (Islam et al., 2020) states that health related parameters are measured by the healthcare assistants which is a manual method that can be automated with our approach. Hence human load can be reduced. The error rate is less than 5% for all patient's medical information, this means the rate of success between the actual data and observed data is approximately greater than 95% for all cases of the developed remote health monitoring system (Tables 3 and 4).

Table 2 MYSQL database containing data recorded

Table 3 The statistical summarization of body temperature data obtained by a standardized machine used in hospital (actual data) and temperature sensor used in the system (observed data) in degree Celsius °C

Patients	Actual data (°C)	Observed data (°C)	Error data (%)
P_1	31	30	3.2
P_2	25	24	4
P_3	38.4	37.7	1.8
P_4	36.9	37.5	1.6
P_5	38.2	37	3.14

Table 4 The statistical summarization of pulse heart rate data obtained by a standardized machine used in hospital (actual data) and pulse heart rate sensor used in the system (observed data) in BPM

Patients	Actual data (BPM)	Observed data (BPM)	Error data (%)
P_1	67	68	1.49
P_2	73	72	1.36
P_3	70	73	4.28
P_4	80	83	3.75
P_5	75	73	2.66

7 Conclusions and Future Works

When people age their bodily strength dramatically decreases, but on the opposite side, health care costs, and queues for health in getting services are increasing. For these reasons, an urgent solution is needed with advanced technologies to handle the health services problems.

Here, we have developed the system which is potentially an essential in the medicine and health fields and which is more effective for both costs and services. The value of employing smartphones and wearable sensors is applied in this system. The IoT and smartphone-based health monitoring system integrates wearable sensors, smartphones, wireless body area networks and the storage system.

The future work of the system is with smaller and more effective sensors that can be embedded within soldiers' uniform cloths, to be used in the government military forces areas for monitoring soldiers' body hydration, heart beat and body temperature. The main problem in the developed system is a delay time. Because of the data stored in the Cloud the time required to process is long. So, for our future work we shall solve this problem by Fog technologies.

References

Bonato, P. (2005). Advances in wearable technology and applications in physical medicine and rehabilitation. *Journal of neuroengineering and rehabilitation, 2*(1), 2.https://doi.org/10.1186/1743-0003-2-2.

Daemen, J., & Rijmen, V. (2002). *The design of Rijndael: AES—The advanced encryption standard*, ser. Information Security and Cryptograph- ph. Springer.

Diffie, W., & Hellman, M. (2006). New directions in cryptography. *IEEE Transactions of Information Theory, 22*(6), 644–654.

Fang−Yie, L., Chia−Yin K., You, I., Choo, K. K. R., & Ho, C. L. (2018). A smartphone-based wearable sensor for monitoring

real-time physiological data. *Computers & Electrical Engineering, 65*, 376–392. ISSN 0045-7906. https://doi.org/10.1016/j.compeleceng.2017.06.031.

Forouzan, B. A., & Mukhopadhyay, D. (2011). *Cryptography and network security (Sie)*. McGraw-Hill Education.

Goldberger, J. J., Cain, M. E., Hohnloser, S. H., Kadish, A. H., Knight, B. P., Lauer, M. S., Stevenson, W. G., et al. (2008). American Heart Association/American College of Cardiology Foundation/Heart Rhythm Society scientific statement on noninvasive risk stratification techniques for identifying patients at risk for sudden cardiac death: A scientific statement from the American Heart Association Council on Clinical Cardiology Committee on Electrocardiography and Arrhythmias and Council on Epidemiology and Prevention. *Heart Rhythm, 5*(10), e1–e21.

Islam, M. M., Rahaman, A., & Islam, M. R. (2020). Development of smart health care monitoring system in IoT environment. *SN Computer Science, 1*(3).

Islam, S. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The internet of things for health care: A comprehensive survey. *IEEE Access, 3,* 678–708.

Jovanov, E., & Zhang, Y. T. (2004). Introduction to the special section on M-Health: Beyond seamless mobility and global wireless health-care connectivity. *IEEE Transactions on Information Technology in Biomedicine, 8*(4), 405–414.

Jutila, M., Rivas, H., Karhula, P., & Pantsar-Syväniemi, S. (2014). Implementation of a wearable sensor vest for the safety and well-being of children. *Procedia Computer Science, 32,* 888–893.

Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015). A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors. *International Journal of Telemedicine and Applications, 2015,* 8.

Kantoch, E. (2013, September). Technical verification of applying wearable physiological sensors in ubiquitous health monitoring. In *Computing in Cardiology Conference (CinC), 2013* (pp. 269–272). IEEE.

Lee, J. L., Tyan, Y. Y., Wen, M. H., & Wu, Y. W. (2017, May). Development of an IoT-based bridge safety monitoring system. In *2017 International Conference on Applied System Innovation (ICASI)* (pp. 84–86). IEEE.

Lee, Y. D., & Chung, W. Y. (2009). Wireless sensor network based wearable smart shirt for ubiquitous health and activity monitoring. *Sensors and Actuators B: Chemical, 140*(2), 390–395.

Lemly, A. D. (2004). Aquatic selenium pollution is a global environmental safety issue. *Ecotoxicology and Environmental Safety, 59*(1), 44–56.

Lenert, L. A., Kirsh, D., Griswold, W. G., Buono, C., Lyon, J., Rao, R., & Chan T. C. (2011). Design and evaluation of a wireless electronic health records system for field care in mass casualty settings. *Journal of the American Medical Informatics Association, 18*(6), 842–852. https://doi.org/10.1136/amiajnl-2011-000229

Lomotey, R. K., Pry, J., & Sriramoju, S. (2017). Wearable IoT data stream traceability in a distributed health information system. *Pervasive and Mobile Computing, 40,* 692–707.

Lyder, C. H., Wang, Y., Metersky, M., Curry, M., Kliman, R., Verzier, N. R., & Hunt, D. R. (2012). Hospital-acquired pressure ulcers: Results from the national medicare patient safety monitoring system study. *Journal of the American Geriatrics Society, 60*(9), 1603–1608.

Mahalanobis, A. (2005). *Diffie-hellman key exchange protocol, its generalization and nilpotent groups*. Florida Atlantic University.

O'Neill, D., & Peoples, C. (2017). A web-based portal for assessing citizen well-being. *IT Professional, 19*(2), 24–30.

Pang, Z. (2013). *Technologies and Architectures of the Internet-of-Things (IoT) for Health and Well-being* (Doctoral dissertation, KTH Royal Institute of Technology).

Rahmani, A. M., Thanigaivelan, N. K., Gia, T. N., Granados, J., Negash, B., Liljeberg, P., & Tenhunen, H. (2015, January). Smart e-health gateway: Bringing intelligence to internet-of-things based ubiquitous health care systems. In *Consumer Communications and Networking Conference (CCNC), 2015 12th Annual IEEE* (pp. 826–834). IEEE.

Sebestyen, G., Hangan, A., Oniga, S., & Gál, Z. (2014, May). eHealth solutions in the context of Internet of Things. In *2014 IEEE International Conference on Automation, Quality and Testing, Robotics* (pp. 1–6). IEEE.

Sim, S. Y., Lee, W. K., Baek, H. J., & Park, K. S. (2012, August). A nonintrusive temperature measuring system for estimating deep body temperature in bed. In *2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 3460–3463). IEEE.

Thangavel, M., Varalakshmi, P., Murrali, M., & Nithya, K. (2015). An Enhanced and secured RSA key generation scheme (ESRKGS). *Journal of Information Security and Applications, 20,* 3–10.

Wood, A. D., Stankovic, J. A., Virone, G., Selavo, L., He, Z., Cao, Q. Stoleru, R., et al. (2008). Context-aware wireless sensor networks for assisted living and residential monitoring. *IEEE Network, 22*(4).

Wu, T., Wu, F., Redouté, J. M., & Yuce, M. R. (2017). An autonomous wireless body area network implementation towards IoT connected health care applications. *IEEE Access, 5,* 11413–11422.

Yan, H., Huo, H., Xu, Y., & Gidlund, M. (2010). Wireless sensor network based E-health system-implementation and experimental results. *IEEE Transactions on Consumer Electronics, 56*(4), 2288–2295.

Yi, W. J., & Saniie, J. (2013, May). Smart mobile system for body sensor network. In *2013 IEEE International Conference on Electro/Information Technology (EIT)* (pp. 1–4). IEEE.

Empirical Evaluation of the Revised Technology Acceptance Model for Lean Six Sigma Approach—A Pilot Study

Slawomir Switek, Ludoslaw Drelichowski, and Zdzislaw Polkowski

Abstract

Effectiveness of the implementation of the hybrid lean six sigma (LSS) approach depends on the acceptance of the employees affected by this change. This context is crucial for changes in the organization of radical technological and innovative nature. McLean et al., (2017). Failure of continuous improvement initiatives in manufacturing environments: a systematic review of the evidence. Total Quality Management and Business Excellence, 28(3–4), 219–237.) indicate based on analysis of 72 journal articles selected; it is evident that continual improvement initiatives can fail due to a multitude of individual variables; hence, their implementation effectiveness is very important and of the moment from the point of view of management practice.The direct inspiration to use the TAM model to test the acceptance of the lean six sigma conception was its frequent use in the implemented ERP class systems (Bobek and Sternad, (2012). End user's knowledge issues in ERP solutions use, Studies and Proceedings of Polish Association for Knowledge Management, no. 58, pp. 129–141. (It should be added at this point that the issue of supporting the lean six sigma concept by ERP class systems has been discussed in a paper presented at a conference scored by Springer—3rd International Conference on Microelectronics and Telecommunication Engineering ICMETE 2019 28 and 29 September New Delhi NCR Campus Ghaziabad India, the tile of the paper was—How much integrated ERP/MES/SCADA/ HMI systems support implementation of lean six sigma management concept? S. Świtek, L. Drelichowski, Z. Polkowski)), which are an example of information technology where the acceptance among users and the consolidation of employees' attitudes are changes in cultural internal factors, including interactions in the field of external factors influencing an organization. The conducted pilot study allowed to define nine factors influencing acceptance for lean six sigma. They will be utilized in the main study, which will be elaborated in next paper.

1 Introduction

Contemporary challenges in the management processes of a company, whose activities are carried out in turbulent, complex and constantly changing environmental conditions, have forced the introduction of adequate changes in the theory and practice of management. A frequently exposed goal of a company's activity is profit maximization, while a modern company, wishing to survive and develop, is forced to pursue a bundle of goals—economic, social, technological, etc.

Although this type of data is still rarely published, the newly released monograph concerning 16 years of experience in implementing six sigma at the American corporation Cummins Inc., specializing in the design and production of diesel engines for construction machinery and locomotives, summarizes the business results of implementing the program six sigma in 1999–2015. Total savings of 45,000 completed projects amounted to $5.5 billion. This had an impact on the value of the stock, which increased by 1400% (from $9.56 in January 2000 to $144.17 in 2014) (Strodtbeck and Tatikonda 2020).

S. Switek (✉)
WSG University, Bydgoszcz, Poland
e-mail: s.switek@gazeta.pl

L. Drelichowski · Z. Polkowski
Jan Wyzykowski University, Polkowice, Poland
e-mail: ludoslaw.drelichowski@byd.pl

Z. Polkowski
e-mail: z.polkowski@ujw.pl

The implementation of concepts such as six sigma, however, requires radical actions in companies, from embedding these concepts into the corporate strategy of the company. For the first time, M.E. Porter places operational efficiency programs (in business practice, more often known as operational excellence programs) in his research work, showing them as a necessary part of the company's strategy.

A company facing the challenge of implementing this concept should ask itself the question to what extent is it prepared for its application. In the literature on the subject, the concept of readiness (Watson 2003) or acceptance for the six sigma conception appears here (Eckes 2001a). Acceptance itself is a concept broader than readiness and concerns the cultural aspect. It can be obtained if employees adopt the assumptions of the LSS approach, start using its techniques and tools, and through this practice of application, they change their attitudes and habits (Eckes 2001b).

In the context of the cited sources, it can be stated that the acceptance of the six sigma conception will evolve over time along with the introduction of six sigma-specific practices in the daily operations of the company, and its level would be systematically diagnosed (Eckes xxxx). Therefore, for the enterprise itself, which has taken implementation measures or is at a certain stage after implementation, it is crucial to diagnose this "soft" acceptance factor, decisive for the success of the implementation or the need to remove any obstacles.

Usually, the work of management practitioners dealing with the implementation of six sigma (George 2002a, b; Gardner 2014) is based on implementation models resulting from the theory of change management, assuming that following them will bring a financial effect of change through the impact on Key Process Indicators (KPIs) and this effect should be measured to confirm the ongoing change.

The aim of the work is to identify external (exogenous) factors having an influence on the acceptance for LSS management conception and take into account the factors resulting from perceiveness of an individual.

Although there are many papers published on utilization of technology acceptance model (TAM), there is a dearth of literature connecting lean six sigma implementation with individual perception theories related to the model.

2 Theoretical Background

Attitudes adopted by an employee are sets of beliefs and feelings in relation to specific ideas, situations or other people (Griffin 2017). They are the mechanism by which an employee expresses his feelings. The attitude is considered a latent variable or a hypothetical construct. Due to the fact that it cannot be directly observed, it has to be inferred from other measurable factors, and because of the nature of the construct, these factors should reflect either a positive or negative assessment of the object against which the attitude is taken. Attitudes have three components—affective, cognitive and intentional (Diagram 1).

The affective element of an attitude reflects an individual's feelings and emotions triggered by a specific situation or object. The cognitive element of an attitude results from the person's knowledge of the situation. The cognitive element of an attitude refers to beliefs, thoughts and attributes that are associated with the object towards which the attitude is taken. The intent element of an attitude reflects the way a person expects to behave in a certain situation or towards an object. It is a tendency or intention to behave in a certain way toward an object in the short or long term.

Fishbein and Ajzen found, however, that the term attitude defines a general attitude (evaluation) toward an object, and the three elements mentioned should be treated as conceptually separate precursors or consequences of a given attitude (Ajzen, 1989). The works of Fishbein and Ajzen postulate a causal chain in which behavior is determined by the intentions of showing a certain behavior, intentions result from general assessments or attitudes, and these attitudes are a function of beliefs related to a given individual.
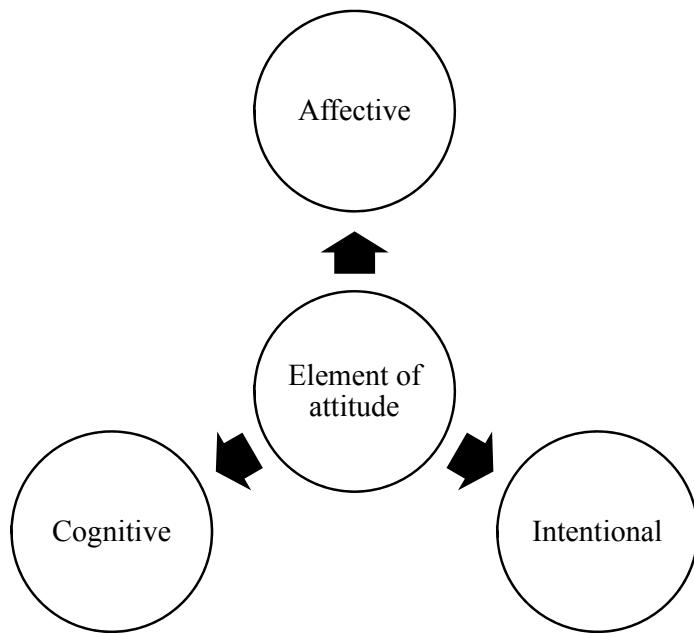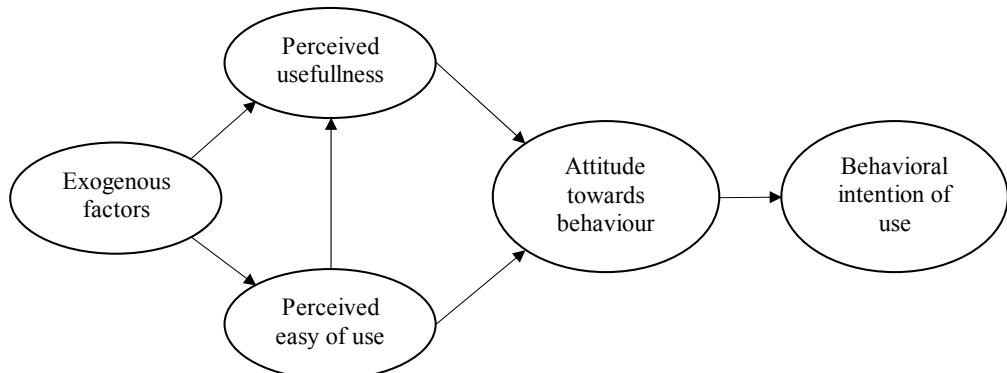
It should be emphasized that on the basis of these considerations, Ajzen formulated the theory of planned behavior (TPB), which is an extension of the theory of reasoned action (TRA), graphically explained by the technology acceptance model.

The author of the TAM model—Davis identified two key beliefs that played a central role in his model—perceived usefulness and perceived ease of use. The former belief is defined as the degree of user's belief that using a particular system will increase his/her work efficiency, and the latter determines the degree of user's belief that using a particular system will be easy (Davis et al., 1989) (Diagram 2).

3 Conceptual Model and Research Question

A research question naturally arises as to whether the substantive process, described by general theories related to the perception of the individual (Ajzen, 1991) in organizational conditions, is a process that can describe the adopted attitudes and, as a result, the acceptance or lack of it for the six sigma conception. The conducted literature review did not allow to identify studies that would propose model solutions for acceptance of the LSS approach, based on theories related to the perception of an individual—the theory of reasoned action (Banas, 2010) and the theory of planned behavior.

Six sigma, as a management conception, is a complex one, requires many assumptions as to the way the organization operates (e.g., it assumes previously implemented

**Diagram 1** Elements of attitude. *Source* own work

Diagram 2 Technology acceptance model (TAM I). *Source* own work

process management), technical and substantive knowledge regarding both the processes subject to improvement and the improvement techniques themselves, and strongly refers to employee involvement and attitudes.

According to P. Lowe, technology is the systematic application of scientific principles and practical knowledge to physical facts and systems (Lowe, 1995). The Deming cycle is based on the scientific method that six sigma uses to analyze facts (data) and practical knowledge to improve the processes under consideration. Galbraith states that technology is nothing more than the systematic application of scientific or other knowledge to practical tasks (Galbraith, 1967), and Dosi concludes that it is a collection of elements of practical and theoretical knowledge, the ability to apply it, methods, procedures, experiments and physical devices that

use this knowledge (Dosi, 1982). Six sigma uses these elements. Whereas Burgelman, Maidique and Wheelwright believe that technology represents theoretical and practical knowledge, skills and artifacts that can be applied to the development of products and services, and to their production and delivery. Technology can be embodied in people, materials, cognitive and physical processes, factories, devices and tools (Burgelman et al., 2001).

One could therefore conclude that, in its complexity, six sigma itself is a "technology" based on the DMAIC process.

The conducted literature research has shown the possibility of using the technology acceptance model (TAM), created on the basis of social psychology, combining the assumptions of two theories—TPB and TRA, and while both have been used to explain consumer behavior in the

traditional economy, this fairly new model is mostly used in the e-economy.

Its main advantage is the possibility of selecting external (exogenous) factors, and thus adjusting it in a given case. The original research problem would be the parameterization of the features of the TAM model, i.e., the selection of appropriate external factors that would enable the use of this model to test the acceptance for LSS.

In terms of endogenous factors, this model uses latent variables that explain the substantive process. Thus, the TAM model is a model formulated a priori on the basis of the theory that is the basis for its construction and support for the appropriate analysis methods.

Sternad and Bobek (2013) provide with a TAM model that represents the cumulative body of knowledge from TAM and ERP research over the years has been developed. Specifically, the model divides external (exogenous) factors in three categories:

- Organizational process characteristics, which captures various social processes and mechanisms and support organizations that guide individuals to facilitate the use of an ERP system;
- System and technological characteristics, which includes ERP system functions;
- And personal characteristics, which includes personality characteristics that can influence individuals' perceptions of ERP system acceptance and usage.

Taking into account previously discussed ERP and LSS implementation similirarities, the following conceptual model for LSS acceptance has been proposed as depicted in Diagram 3.

4 Methodology

The research process was carried out as part of the scientific method of incomplete induction (Lisinski, 2016), because in the discussed case, it was not possible to examine the entire population of objects. The scientific procedure of incomplete induction was partially applied here, at the stage of determining the scientific problem and identifying facts and registering phenomena, within which a decision was made to use the TAM model as a standard methodology ensuring the verification of research hypotheses through their statistical verification. This decision was also made due to the fact that no publications in this field concerning lean six sigma applications were found in the available literature.

The subject matter of this work requires the use of the following research methods:

- In-depth source literature studies,
- Diagnostic survey—surveying of:

  – Respondents—lean six sigma practitioners in a pilot study to verify the accuracy of the scale and to perform an initial acceptance assessment for the LSS conception; research objects were selected based on the knowledge of users, size and characteristics of the organization (corporation) that standardize process solutions in the field of LSS,
  – Respondents—lean six sigma practitioners in the main study using the CATI / CAWI method for a sufficiently large sample,

- Analysis of the received responses using structural equation modeling (SEM). The calculations were made in SPSS Amos v.25.
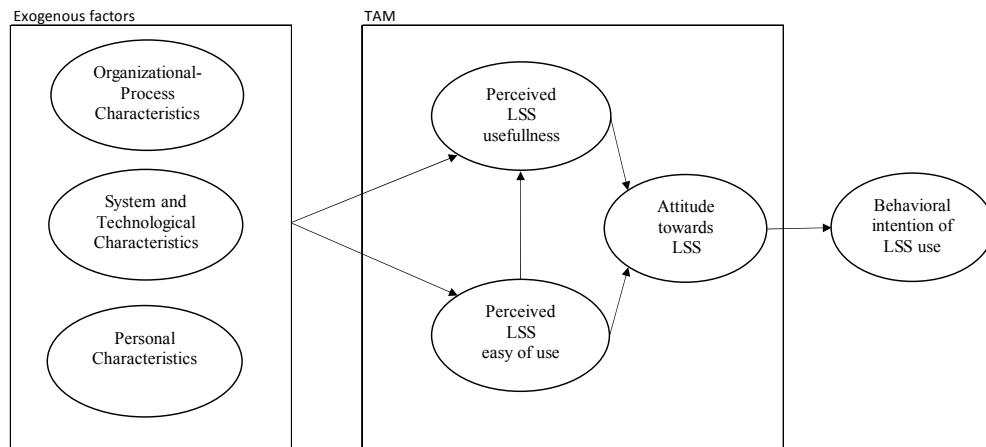

Diagram 3 TAM model adapted to ERP systems. *Source* own work

- The scope of this work covers the presentation and analysis of the results obtained in the pilot study, while the results of the main study will be presented in the next article.

4.1 Diagnosis of External Factors Determining Successful Implementation of Lean Six Sigma

Factors used in the pilot study were selected on the basis of the analysis of scientific studies on the so-called critical success factors, i.e., factors of successful implementation of the LSS management conception. The roots of this approach go back to the total quality management (TQM) theory. Due to the limited editing formula of this publication, only a few of the most important literature sources have been cited.

George considers six sigma culture and critical success factors that determine its creation. Those are (George, 2002a, b).

- Focusing the organization on the customer by carefully translating the so-called voice of the customer to the requirements, with particular emphasis on those that are most important to the customer (critical to quality),
- Ensuring product and process design based on customer requirements using the design for six sigma (DFSS) approach,
- Defining financial measures that translate into the language of business the benefits of improvement projects,
- Involvement of the top management (starting from the CEO of the company) not only into communication, but also in the implementation itself.

Soti et al. (2010) used the technique of interpreting structural modeling (ISM) to determine factors that enable the implementation of LSS and the relationships between them. As a result of modeling, their hierarchy was defined, dividing them into subcategories of:

- Independent variables—the effectiveness of the top management and the availability of funds have been assigned to,
- Connecting variables, which include: availability of expert training, level of qualitative maturity of the organization, adaptability and flexibility of employees in terms of learning, organizational culture and organizational infrastructure,
- Autonomous variables—none in this case,
- Dependent variables—statistical thinking, committed resources for six sigma, technical competence, and proper data collection and retrieval system.

The autonomous factors showed less dependence on other factors and a low driving force for implementation. Dependent factors were weak "drivers," but they depend on other factors.

Italian researchers (Brun 2010) asked whether companies in Italy are implementing six sigma in the same way as it was done at Motorola. The research material consisted of case studies prepared on the basis of workshops that took place at the Polytechnic University in Milan with six sigma experts. The group of "the 12 critical success factors" selected for the comparative study was derived from an original set of factors identified by Antony and Banuelas (2002). The null hypothesis that there is no difference in the adequacy of success factors between six sigma applications under Italian conditions and the traditional approach was not rejected for any of the indicators. The most important factor in the case of the Italian implementations turned out to be the commitment of the management, the link between the six sigma and the business strategy and the cultural change. Only the understanding of six sigma tools and techniques ranked significantly lower than the results of Banuelas' study.

4.2 Pilot Study

As a result of the conducted literature review, nine factors influencing the success of LSS implementation were adopted. These are: strategy, process management, change management, training, management commitment, LSS maintenance practices and its development, project selection, resource availability and followed DMAIC. The last, tenth question concerned employee acceptance for LSS program.

Moreover, in order to make a preliminary assessment (already at the level of the pilot study), to understand how much assumptions of the LSS program are fulfilled, the customer satisfaction index (CSI), often used in marketing research, was used.

Each question was answered with a five-point Likert scale. For each question, the respondent was additionally asked to evaluate the importance of the discussed aspect, also on a five-point qualitative scale.

Research objects were selected based on the knowledge of users, size and characteristics of the organization (corporation) that standardize and standardize process solutions in the scope of the LSS conception. This, in fact, "soft" standardization forced the use of the proprietary method of parameterization of features (detailed literature research on the success factors of lean six sigma implementation, a pilot study confirming the specified factors and the author's experience in implementing this management conception). The parameterization of features is more difficult here than in

IT systems, as these features are related to the subject (organization), which makes them difficult to transfer and standardize.

The survey form was handed over to the participants of the "Lean Trends 2016" conference organized in October 2016 by the Lean Management Polska Association in Lodz. It was emphasized that the questionnaire is addressed only to six sigma or lean six sigma practitioners. Out of the approximately 200 conference participants who are members of this association, 70 completed forms were returned.

5   Data Analysis and Results

As you can see, the vast majority of respondents (80%) had experience in the integrated lean six sigma approach, which confirms the dominant nature of this improvement concept (Figs. 1, 2 and 3) in the surveyed group.

Analysis of reliability (homogeneity) scale defined the Cronbach's alpha coefficient at the level of 0.8968 at a significance level of $\alpha = 0.05$. Thus, it can be concluded that the adopted scale is consistent, i.e., the adopted set of questions describes to a large extent one construct hidden in them. The respondents, with the exception of one person, did not make any comments related to the correct understanding of the questions.

The distribution of answers to the questions posed in the test sample was tested. The largest number of responses concerned the category "I agree" (41%), responses lying on the edge of the negative part of the scale ("I completely disagree") were small (6.9%), and the responses "I completely agree" accounted for slightly over 14% all answers given (Fig. 4).

Legend (vertical axis): 1. Is there strategy which defines clearly business goals agreed on all levels of the organization including scope and goals for LSS in my company?, 2. Is there properly implemented process management through defining key processes, their key metrics and process owners?, 3. Are there established and used project selection criteria?,4. Is there implemented change management through preparing managerial staff, establishing the LSS leader, the deployment champion and proper communication process?, 5. Is fffectiveness of trainings ensured through incorporated hard and soft methods, practicality of training workshops made and one on one sessions with trainers?, 6. Are there ensured resources for LSS through planning of belts to be trained, belt selection critieria and defining project team?, 7. Are particular DMAIC process phases applied adequately to the problem and coached by e. g. assigned Master Black Belt?, 8. Are the sponsor and champions actively engaged into the LSS program by ensuring resources and removing obstacles?, 9. Is sustainment and development od LSS obtained by sharing good practices, belt certification, change of org structures and periodical efficiency and effectiveness periodical reviews?, 10. Is acceptance of employees for LSS ensured through active support of management, preparing them to play new roles and communication on all levels of the organization?

In terms of the weight of the implementation factor studied, the largest number of responses concerned the category of "high importance" (almost half, i.e., 48%), responses lying on the edge of the negative part of the scale ("it does not matter") were marginal (0.7%), and "very significant" responses accounted for as much as 28% of all answers (Fig. 5).

Fig. 1 Respondent characteristics—experience in using improvement methods. *Source* own work
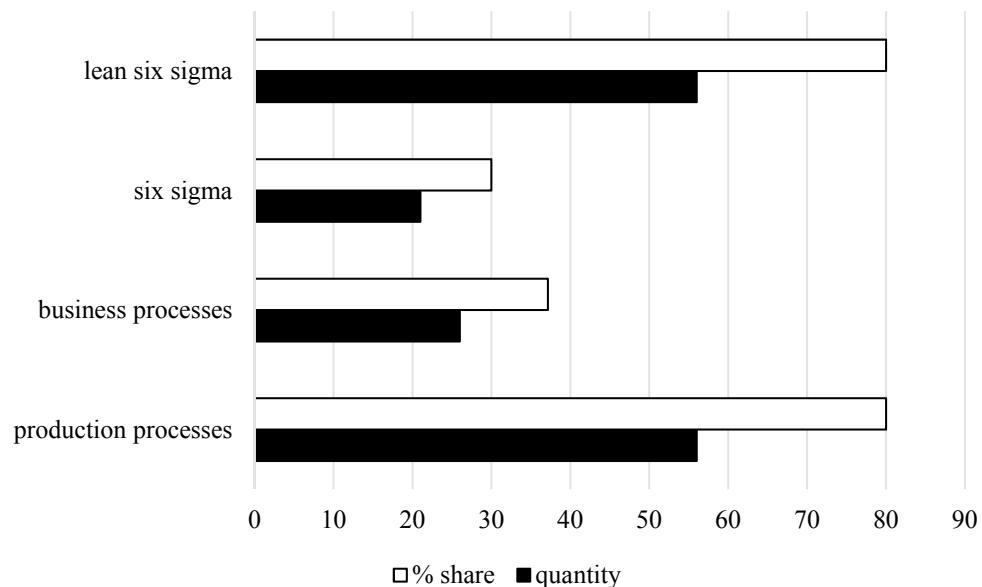
Fig. 2 Respondent characteristics—the played role in improving team. *Source* own work
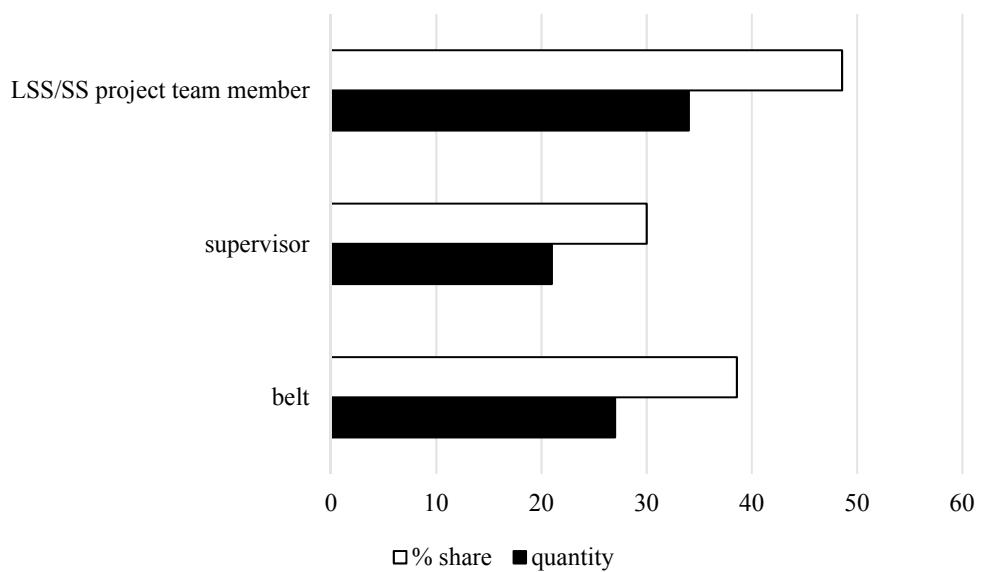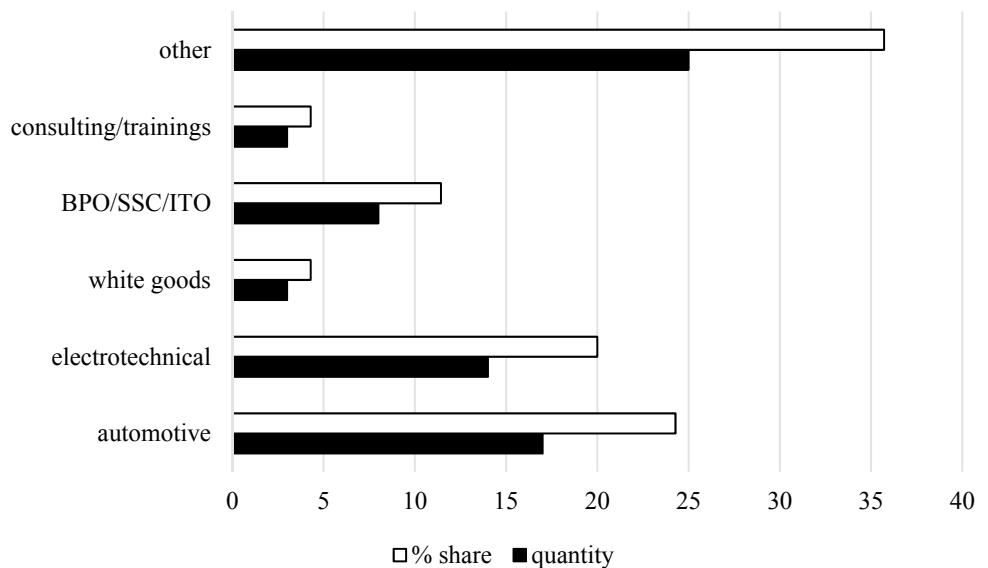
Fig. 3 Respondent characteristics—a branch representative. *Source* own work

In the preliminary analysis customer satisfaction index (CSI) was also calculated. It equals to the value of 136,12 (Table 1). Moreover, a important versus score, positioning map was made (Fig. 6).

6 Discussion and Conclusions

Based on the state of knowledge described in the cited literature on the subject, including the case study, nine factors (strategy, process management, change management, trainings, management involvement, practices sustaining LSS program and its development, project selection, resource

availability, sustained and monitored DMAIC) influencing the LSS implementation were distinguished, which have been confirmed in the pilot study. The external factors adopted in the pilot study were:

- Identified as significant for LSS implementation,
- Found in their organizations,

and the being implemented LSS conception was positively assessed. They will contribute to the TAM model as external inputs.

Due to these results, the first nine questions containing the success factors of the LSS implementation should be

Fig. 4 Distribution of scores in individual questions. *Source* own work
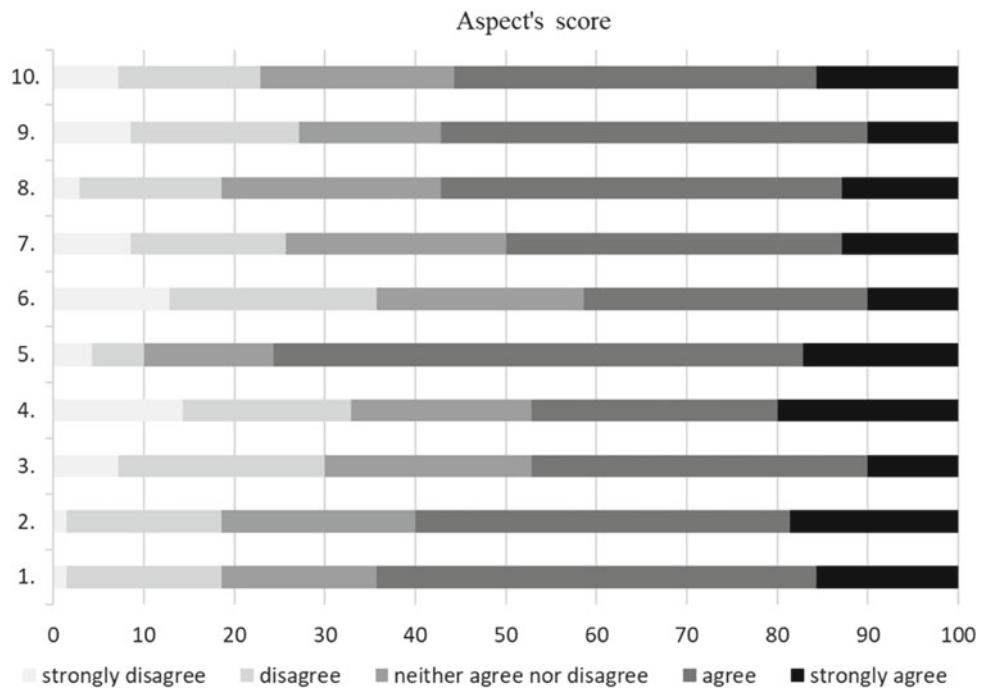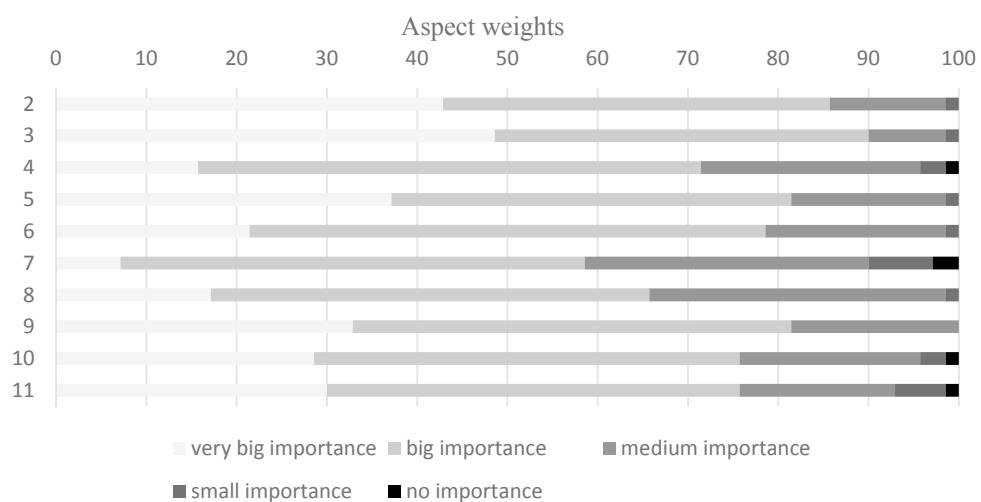
Fig. 5 Distribution of answers for weights (aspect importance). *Source* own work

adopted for the main study, and the question no. 10 regarding acceptance of the LSS management conception should be extended accordingly to investigate the components of acceptance in the TAM model.

In the tested sample, all aspects meet customer satisfaction (which in this case should be understood as the degree of compliance with the requirements of the LSS program), perhaps in order to increase satisfaction, one should work on the aspect contained in question 6, for which the rating of 3.03 is close to the neutral answer of 3. However, it should be noted that all measurement points were placed in the

highest importance—high satisfaction quadrant. They are therefore indicators that need to be sustained in organizations over time.
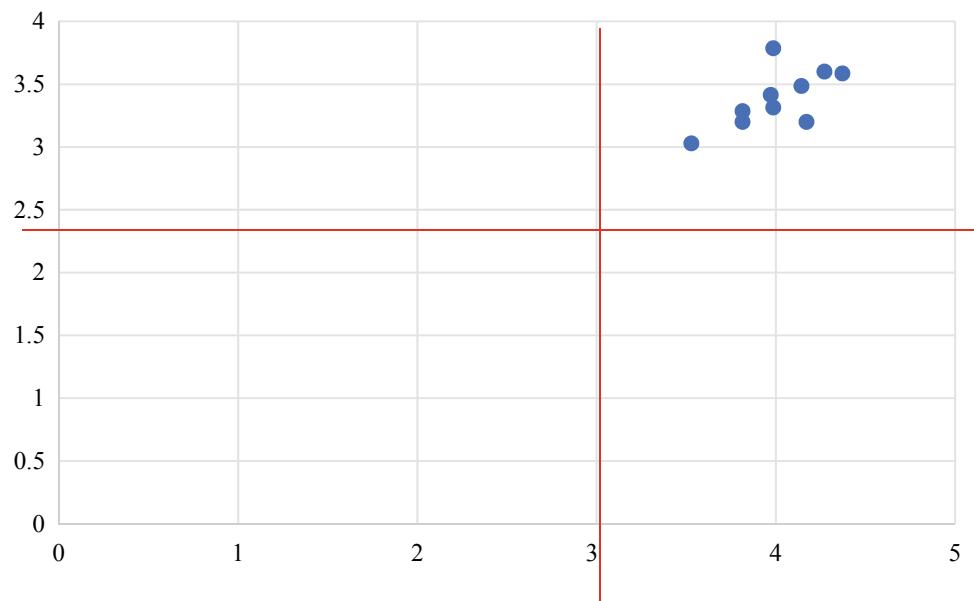
Managers have to understand motivation of LSS participants as their acceptance to the management conception is critical for the success of every implementation. The outcome of the whole study (together with the main one which will be discussed in next paper) can create a diagnose tool for management to monitor the level of the acceptance and possibility to take appropriate corrective actions if necessary.

Table 1 CSI index calculation

Aspect	Weight	Score	Weight *Score
1	4,27	3,60	15,38
2	4,37	3,59	15,67
3	3,81	3,20	12,21
4	4,17	3,20	13,35
5	3,99	3,79	15,09
6	3,53	3,03	10,69
7	3,81	3,29	12,53
8	4,14	3,49	14,44
9	3,99	3,31	13,21
10	3,97	3,41	13,56
			136,12

Source own work

Fig. 6 Positioning map—importance versus Score. *Source* own work

References

Ajzen. (1989). *Attitude Structure and Behavior*. The 3rd Ohio State University Volume on Attitudes and Persuasion, Lawrence Erlbaum Associates, Publishers, p. 248.

Ajzen. (1991). *The theory of planned behavior, Organizational Behavior and Human Decision Process, 50*(2), 179–211.

Antony, J., Banuelas, R. (2002). Key ingredients for the effective implementation of Six Sigma program. *Measuring Business Excellence, 6*(4), 20–27

Banaś, J. (2010). *Użycie modeli na potrzeby użytkowników systemów informatycznych, ujęcie teoretyczne, Organizacja i Zarządzanie* no. 3(11).

Bobek, S., Sternad, S. (2012). End user's knowledge issues in ERP solutions use, Studies and Proceedings of Polish Association for Knowledge Management, no. 58, pp. 129–141. (It should be added at this point that the issue of supporting the lean six sigma concept by ERP class systems has been discussed in a paper presented at a conference scored by Springer—3rd International Conference on Microelectronics and Telecommunication Engineering ICMETE 2019 28 and 29 September New Delhi NCR Campus Ghaziabad India, the tile of the paper was—How much integrated ERP/MES/SCADA/ HMI systems support implementation of lean six sigma management concept? S. Świtek, L. Drelichowski, Z. Polkowski)

Brun, A. (2010). Critical success factors of six sigma implementations in Italian companies. *International Journal of Production Economics, 131*, 158–164.

Burgelman, R.A., Maidique, M.A., Wheelwright, S.C. (2001). (red.), *Technological paradigms and technological trajectories. A suggested interpretation of the determinant and direction of technical change*, McGraw-Hill, New York, p. 2.

Davis, F.D., Bagozzi, R.P., Warshaw, P.R. (1989). *User acceptance of computer technology: a comparison of two theoretical models*. Decision Science, 35(8), pp. 982–1003.

Dosi, G. (1982). Technological paradigms and technological trajectories. *A Suggested Interpretation of the Determinant and Direction of Technical Change, Science Policy Research Unit, 11*, 147–162.

Eckes, G. (xxxx). *Making Six Sigma last.*, pp. 147–184.

Eckes, G. (2001a). *Making Six Sigma last. Managing the balance between cultural and technical change*. Wiley, Inc., pp. 185–208.

Eckes, G. (2001b). *The Six Sigma revolution: how General Electric and others turned process into profit*, Wiley, pp. 41–68.

Galbraith, J. K. (1967). *The new industrial state* (p. 1). Boston: Houghton Mifflin.

Gardner, K. (2014). *Successfully implementing lean six sigma—the lean six sigma deployment roadmap*. Michigan: Pinnacle Press.

George, M. L. (2002a). *Lean six sigma—combining six sigma quality with lean speed*. New York: McGraw-Hill.

George, M.L. (2002b). *Lean Six Sigma: combining Six Sigma quality with Lean speed*, Mc-Graw-Hill, pp. 17–23.

Griffin, R. (2017). *Management, Cengage Learning*, pp. 1–33.

Watson, G.H., Conti, T. (2003). *Six sigma: An evolving stage in maturity of quality. Quality into the 21st century—perspectives on quality and competitiveness for sustained performance*. Kondo, Y., Watson, G.H. (2003). *ASQ Quality Press*, Wisconsin 2003, pp. 223–226.

Lisiński, M. (2016). *Procedury naukowe indukcji zupełnej i niezupełnej w metodologii nauk o zarządzaniu, Zeszyty Naukowe UEK*, no. 6 (954), p. 25.

Lowe, P. (1995). *Management of technology: perception and opportunities*, Chapman & Hall, pp. 3–18.

McLean, R.S., Antony, J., Dahlgaard, J.J. (2017). Failure of continuous improvement initiatives in manufacturing environments: a systematic review of the evidence. *Total Quality Management and Business Excellence, 28*(3–4), 219–237.

Soti, A., Shankar, R., Kaushal, O.P. (2010). Modeling the enablers of Six Sigma using interpreting structural modeling. *Journal of Modelling in Management, 5*(2), 124–141.

Sternad, S., Bobek, S. (2013). Impacts of TAM-based external factors on ERP acceptance. In *HCIST 2013—International Conference on Health and Social Care Information Systems and Technologies. Procedia Technology* 9, Elsevier, pp. 33–42.

Strodtbeck III, G.K., Tatikonda, M.V. (2020). *A magnificent journey to excellence—sixteen years of six sigma at Cummins Inc.*,Productivity Press, New York, pp. 17–22.

Application and Trend with Success Factor Linked to Large Scaled Data: A Case Study

Jyoti Prakash Mishra, Zdzislaw Polkowski, and Sambit Kumar Mishra

Abstract

It is obvious that the large scaled data can be generated as well as processed by implementing the most effective computational techniques. In this regard, applications inked to operation management, transact generation, health care as well as industrial applications require specific trends and patterns within these large socioeconomic datasets. Sometimes, it can be a point of discussion regarding specifying the parameters associated with the voluminous data to prioritize the granular information about the individual cluster. Also in many cases, emphasis can be given to analyze the social networks and social engagement behaviors of individuals by mapping mobility patterns implementing sensors or mechanisms as well as usage of remote sensors to track all the patterns provisioning the coordination with information communication. In some cases also, based on the web analytics along with machine learning, prediction associated with large scaled data invites the opportunities to new mechanisms with conceptual applications in management sector also. While concentrating on granular data, it is essential to entrust the key sources of the voluminous data whether private, public or self quantified. So adoption of the recent mechanisms can lead to generate ambient data which can partially be emitted to be linked with dynamic networks quantifying the actions and behaviors. It is observed that the size and dimension of data while associated and shared in business and general applications are enhanced immeasurably. The textual data may be structured or unstructured. Similarly, the images and social media sites linked to multiplicity platforms can be generated in voluminous structure to be the evident to strategic technology trends. Considering this trend, partially the machine learning techniques or evolutionary as well as heuristic techniques can be applied to prioritize and focus on the majority of data to overcome the specific challenges.

1 Introduction

In context to the current trend, it is a challenge toward analysis of large scaled data and to correlate the patterns accordingly. With the unstructured features, observations have been done on these data focusing the primary issues. In general, there are mechanisms to prioritize these issues either by recognizing the central importance of the same or to define the complementary path to perform experimentation. The large scaled data in such scenario can be the specified tools to analyze and predict the behavioral aspects implementing the sensors to the consideration. Based on the merits of the factual and consistent data, the challenges can be addressed toward implementation of new approaches. Accordingly, it can be grouped into different categories which can be based on data challenges linked to the characteristics of the data considering volume, variety and volatility, mechanisms to process the challenges toward capturing data and management of data considering the privacy, security and ethical aspects.

J. P. Mishra (✉) · S. K. Mishra
Gandhi Institute for Education and Technology, Bhubaneswar, Affiliated to Biju Patnaik University of Technology, Rourkela, Odisha, India
e-mail: jpmishra@gietbbsr.com

S. K. Mishra
e-mail: sambitmishra@gietbbsr.com

Z. Polkowski
Department of Business Intelligence in Management, Wroclaw University of Economics and Business, Wroclaw, Poland
e-mail: zdzislaw.polkowski@ue.wroc.pl

1.1 Intensification of Data Based on Visualization and Variability

While managing the categories of non homogeneous data, it is really difficult to manage the influx rate as well as reconfiguring the structures; as a result, the frequent updates of data are required and can be further supplemented through large complex networks. Similarly while data changes its state based on the type of repository, it is require to implement mining technique as data may offer a different meaning in different state. So the volumes of machine and human-generated data can constitute much greater and their rates of change and variability higher than process-mediated data and somehow it can be related in performing sentiment analysis. Many times, it is required to represent the primary information and knowledge with more accuracy implementing various technologies. In such cases to make all these data approachable, it is required to transform the large and complex datasets into higher normal forms. Of course, it is required to measure the performances in functionalities, scalability as well as response time during visualization of data. During this process, challenges may be faced while analyzing and interpreting the data to obtain end results. As the large scaled data is non-relational or unstructured, transforming and processing such semi-structured data are managed with many constraints. Therefore, it is highly essential to focus on data cleansing, data integration as well as aggregation.

2 Review of Literature

Savitz et al., (2012a) in their work focused on potentiality of business as well as big data which has been linked to strategic technology trends. As per their observation, it is the most suitable nanotechnology and quantum computing. Also the same can be implemented to generate collective intelligence which can be shared mainly through the technological environment.

Rehman et al., (2016) in their work focused on difficulties to deploy the perspective analytics to handle information along with continuous evolution of business process models. They considered the same as the most important and limited examples of good prescriptive analytics in the real world.

Barnaghi et al., (2013) have considered the large scale and the sheer volume of data as a big challenge in its own right. They have prioritized about the heterogeneity, ubiquity and dynamic nature of the different data generation resources and devices in their work which can scale the enormous data itself along with integrating and inferring the physical world data.

Yi et al., (2014) in their work prioritized security as a major issue and along with the associated challenges linked to business as well as big data which earlier could not be accepted globally. Also securing big data has its own distinctive challenges which are not similar to traditional data.

Chen et al., (2014) in their work have focused on research approach based on big data and big data analytics which requires technical and methodical analysis. They have also observed the responses and implemented the survey as tool to obtain the findings.

Kornacker et al., (2015) in their work prioritized on database services in the cloud. Primarily, they have considered Amazon's RDS, Microsoft's Azure SQL Database as well as Google's Cloud SQL for their observations. In addition to that, they have also considered a number of academsic research groups align with proposed cloud DBaaS to support relational database functionality.

Rad et al., (2014) in their work have focused on development of lightweight software container technology considered as open-source projects. Also as these techniques are unique, unanimously the technology linked to determine the performance of container toward data intensive applications can be accepted.

Soror et al., (2010) in their work have focused on scalable database services. As per their observation, the commercial cloud-based relational services have been initiated to validate the market requirements. Somehow, due to lack of scalability beyond single node, the queries can be processed over encrypted data.

Curino et al., (2010) during their study focused on the strength of schematic approach considering the data independence with foreign key information which allows to discover intrinsic correlations hidden in the data. As a consequence, this approach is effective in partitioning databases containing multiple many-to-many relationships.

Gulati et al., (2011) in their work have focused on management of virtual disks linked to data stores which requires automated solutions in placement and load-balancing. They have also analyzed to manage the related issues to characterize the workloads obtaining the decisions base on sampling formulations.

Narasayya et al., (2013) in their work focused on various multitenant systems based on virtualization as well as database platforms. They observed a critical issue in such systems which ensure that each tenant has resources to serve well-formed requests within a certain time period, alternatively a service level object. Compared with other consolidated systems, different approaches can be ensured where these service level objects can meet in the presence of dynamic workload.

Jabłońska et al., (2020) in their work have prioritized on systematic exposure linked to social media along with the comparisons. In fact, their study was focused on investigation of links of use of intensity of Instagram with social comparison models. Also they observed the association of

the results among the analyzed psychological data and social comparison and predicted implementing the artificial neural networks models.

Vasilev et al., (2019) in their work have observed that in some specific cases, the capacity of manufacturing systems cannot be suitable in the enterprises due to lack of sharing of information. In such cases, the authors derived some specific methods for sharing information with downstream partners of supply chains. The main approach in such situation is to send an XML file with free capacity by days from a manufacturing enterprise to its customers. Accordingly, the customers who send orders to the manufacturer are sure that their orders will be accepted and fulfilled.

In general, the large scaled data can be emerged for business with the development and as such can be placed with basic analytics as well as business intelligence associated with new data sources. In fact these can have provision with real-time analytics as well as business intelligence with operational integration. The volume of data generated sometimes grows exponentially and practically is difficult to manage using data warehouse technology (International Data Corporation (IDC), 2014).

Many times, it is seen that the memory linked with solid-state drives permits the system to be uniform delivering the access of speed randomly somehow less than 0.1 ms. Of course there is quite possibility of solution of large scaled data to enhance the access time to data (Dailey, 2019).

Generally, the maximum data linked to big data analytics are unstructured in nature. In such cases, mechanisms can be used to handle and manage implementing the key-value pairs. The ideas linked to global data are used to build strong connections and enable to work as a team as the large scaled data is provisioned with high volume, velocity and variety information to enhance decision-making (Sicular, 2018).

3 Problem Formulation

Mainly, the representation of data is linked to specific structure closely associated with data model toward implementation of the structure. In such scenario, representation of data can be well dictated considering the data generation process as well as communication of data stream. As such representation of large scaled data is provisioned with algorithmic and statistical aspects and of course depending on the schedule of tasks. In many situations, the features of data can be defined considering the domain specific attributes and considering the pipeline during analyzing the data.

In general, specific algorithmic evaluations and statistical analysis can be implemented toward transformation of data with adequate capabilities.

3.1 Algorithm-1

Step 1: Define the size of queries along with databases.

Step 2: Assign the relations to the generation based on query plans.

Step 3: Based on size of query determine the heuristic values.

Step 4: Generate population based on size of queries and query plans.

Step 5: Determine the updated heuristic values projecting the relations in the generation with the query plans and calculate the CPU time.

Step 6: Compare the updated heuristic values with the query size within the database in the specified relation.

If the heuristic values are less than that of the size of queries during processing the databases, then assign this value toward attribute join index and determine the parameterized cost.

Step 7: Calculate the CPU time after achieving the parameterized cost.

Initial time recorded, t_0 (m.sec.) = 95.781250000000000.

Time computed after obtaining achieving parameterized cost, t_1 (m.sec.) = 95.796875000000000.

The differential time within the process of evaluation, t_2 (m.sec.) = 0.015625000000000.
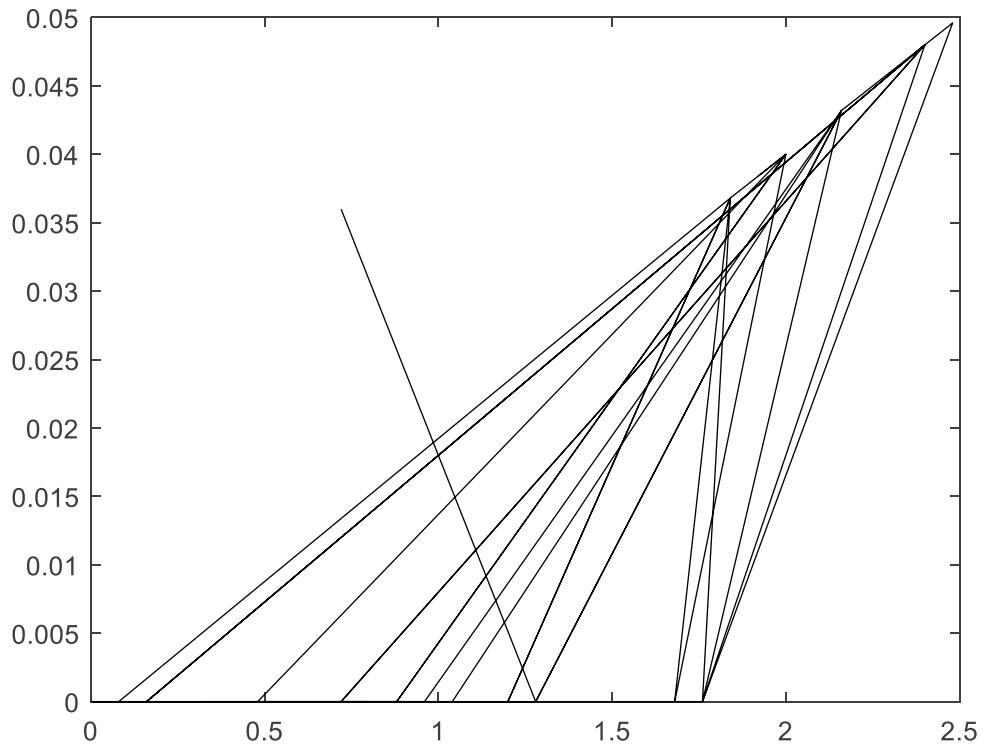
Time recorded after synchronizing heuristic values, t_3 (m.sec.) = 95.796875000000000 (Table 1).

Usually, it is understood that based on parameterization and dynamism, the queries are implemented in specified manner while passing through the databases. As shown Fig. 1, the databases within the cache during execution can also be implemented efficiently while optimizing the query plans. The optimizer in this case rebuilds again the query plans implementing the triggers. The estimation of query plans ultimately selects the execution pattern of plans and optimize with minimum cost values. Sometimes, there is a

Table 1 Parameterized cost with heuristic values in consistent database

Sl. no	Size of databases	Size of queries	Parameterized cost	Heuristic values
1	100	900	0.0144	0.72
2	100	1800	0.0469	2.18
3	100	2700	0.0487	2.35
4	100	3600	0.0500	2.5

Fig. 1 Parameterized cost versus heuristic values

difficult situation to generate specified execution plans for databases, as all the feasible plan variants can be estimated in order to obtain the better execution plans though there is risk in implementing sub optimal execution plans. But still, the problems in implementation in databases can be overcome linking heuristic techniques. The heuristic values in such cases are responsible to monitor the parametric values of each database applying the classification rules. Also, the main intention of heuristic is to obtain the solution within a specified timeframe and try to approximate the solution. Sometimes, it produces results by itself using the optimization criteria to enhance the efficiency.

3.2 Algorithm-2

Step 1: Define the size of database, no. of associated relations and size of query.

Step 2: Determine the population based on size of query plans(termed as chromosomes) and size of query.

Step 3: Assign the crossover probability along with mutation probability and initiate crossover operation.

Step 4: Determine the required plan values within the operation.

Step 5: Regenerate the query plans prioritizing size of chromosomes within the relation.

Step 6: Obtain the plan select values based on query plans.

Step 7: Determine the real cost of query plans processing the plan select values over the queries maintaining the CPU time.
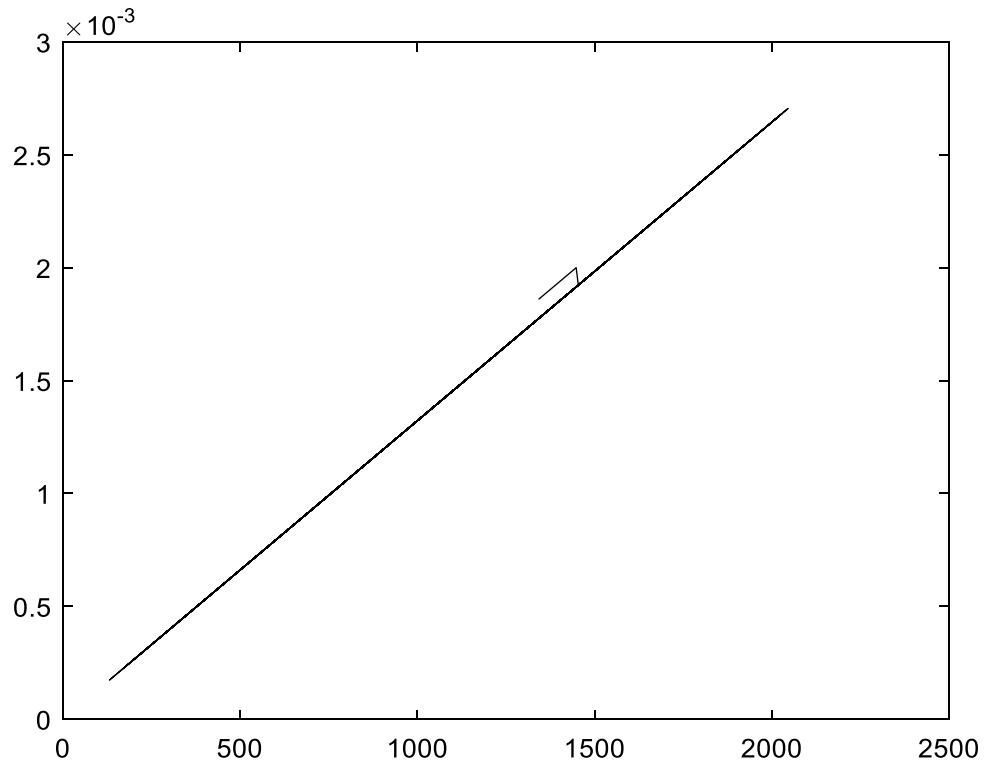
Step 8: Compare the real cost of query plans with the estimated cost of query plans.

Step 9: Determine the functional values of query plans focusing the estimated cost of query plans and size of query plans (Table 2).

Table 2 Query plans with functional values linked to incremental queries

Sl. no	Size of queries	Values of query plans	Functional values
1	900	1357	0.001794380165
2	1800	1601	0.002117024794
3	2700	1801	0.002381487603
4	3600	2029	0.002682975206

Fig. 2 Query plans versus functional values

During execution of queries in the server, initially it is compiled to generate query plans. Usually, each query is associated with query plans prior to its actual execution. In such situation, the cache is responsible to restore the query plans and enhance the performance of databases. As reflected in Fig. 2, the servers generate the query plans based on the functional values and also verify the same with the hash values earlier generated by the query plans and stored in cache. The execution of plan depends on the match of the hash values with the functional values. It is understood that the queries with complex structure need specified mechanisms to confine all the linked applications to manage the resources during allocation. After initiation and instantiation of query response, it is parsed to validate the metadata to ensure that the query is associated with feasible references of the linked databases. In such cases, the optimizing technique associated with the system evaluates the query expansion including the plans to obtain the optimal solution.

4 Discussion and Future Direction

Based on the findings, overall, it is understood that there are certain issues to be resolved implementing the depth case study and analytical approach. The analysis in such case boosts to strengthen the practical implementation linked to analysis of large scaled heterogeneous data. As the large scaled data is in connection with various versatile aspects, it is highly essential to have provision of suitable platform toward analysis of large scaled data.

5 Conclusion

The general as well as specific representations linked to large scaled heterogeneous data have been focused in this application. Based on the occurrence, it is observed that the large

scaled data in all respect can be synthesized to boost for future directions. The techniques as well as methodologies discussed in this paper are of course needful to obtain emerging solutions with strong significance in managing data.

Basically, depending upon the implementation, the conceptualism can be developed to filter the data which can make large scaled usable data in all respect. Prioritizing the growth in process, the accumulation of data can be provisioned with specific application codes with flexibility and independence. So more focus should be given to abstraction mechanisms as well as filtered and scalable data to address multiple levels of abstraction.

References

Barnaghi, P., Sheth, A., & Henson, C. (2013). From data to actionable knowledge: Big data challenges in the web of things. *IEEE Intelligent Systems, 28*(6), 6–11.

Chen, M., Mao, S., & Liu, Y. (2014). Big Data: A survey. *Mobile Networks and Applications, 19*(2), 171–209.

Curino, C., Jones, E., Zhang, Y., Madden, S. (2010). Schism: A workload-driven approach to database replication and partitioning. In *VLDB*.

Dailey, W. (2019). *The Big Data Technology Wave*. Available online: https://www.skillsoft.com/courses/5372828-thebig-data-technology-wave/. Accessed on March 18, 2019.

Gulati, A., Shanmugathan, G., Ahamad, I., Waldspurger, C., Uysal, M. (2011). Pesto: Online storage perfromance management in virtualized datacenters. In *SoCC*, pp. 19:1–19:14.

International Data Corporation (IDC). (2014). *The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things, 2014*. Available online: https://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm. Accessed on May 4, 2018.

Jabłońska, M.R., Zajdel, R. (2020). Artificial neural networks for predicting social comparison effects among female Instagram users. *PLOS ONE*. https://doi.org/10.1371/journal.pone.0229354 February 25, 2020.

Kornacker, M., Behm, A., Bittorf, V., Bobrovytsky, T., et al. (2015). Impala: A modern, open-source SQL engine for Hadoop. In *Biennial Conference on Innovative Data Systems Research*.

Narasayya, V., Das, S., Syamala, M., Chandramouli, B., Chaudhuri, S. (2013). Sqlvm: Performance isolation in multi-tenant relational database-as-a-service (In CIDR).

Rad, P., Lindberg, V., Prevost, J., Zhang, W., et al. (2014). "ZeroVM: Secure distributed processing for big data analytics. In *World Automation Congress*, pp.. 882–887.

Rehman, M. H., Chang, V., Batool, A., & Teh, Y. W. (2016). Big data reduction framework for value creation in sustainable enterprises. *International Journal of Information Management*.

Savitz, E. (2012a). *Gartner: Top 10 strategic technology trends for 2013*. Online Available at https://www.forbes.com/sites/ericsavitz/2012/10/23/gartner-top-10-strategictechnology-rends-for-2013/ (Accessed on 3rd March 2016).

Sicular, S. (2018). *Gartner's Big Data Definition Consists of Three Parts, Not to Be Confused with Three "V"s*. Available online: https://www.forbes.com/sites/gartnergroup/2013/03/27/gartners-big-data-definition-consists-of-threeparts-not-to-be-confused-with-three-vs/#95a45853bf622013. Accessed on May 4, 2018.

Soror, A.A., Minhas, U.F., Aboulnaga, A., Salem, K., Kokosielis, P., Kamath, S. (2008). Automatic virtual machine configuration for database workloads. *ACM Transactions on Database Systems, 35* (1).

Vasilev, J., Cristescu, M. (2019). Approaches for information sharing from manufacturing logistics with downstream supply chain partners. In *Conferences of the department informatics, Publishing house Science and Economics Varna*, Issue 1, pp. 24–29.

Yi, X., Liu, F., Liu, J., & Jin, H. (2014). Building a network highway for big data: Architecture and challenges. *IEEE Network, 28*(4), 5–13.

Empirical Investigation of Resampling Techniques in an Intruder Detection System

Arjun Puri and Manoj Kumar Gupta

Abstract

The intruder detection system plays a fundamental function in recognizing assaults in networks. To design an intelligent intruder detection system invites researchers from the machine learning domain to work in this area. With the availability of KDD99 datasets, some researchers encounter a class imbalance problem in it. This article performs a detailed empirical investigation of various resampling techniques to mitigate the effect of class imbalance. The study is performed on NSL-KDD multi-class datasets using fivefold cross-validation with G-Mean and AUC as evaluation metrics considering the decision tree as a classifier. The study inferred that the SMOTE technique performs well compared with the rest of the art.

1 Introduction

With the coming of innovation and the network of PCs, it likewise expands the danger of assaults. These assaults in networks affect the integrity, confidentiality, and availability of data on the Internet. The widely spread of network increases attacks in various sectors, which either act like eavesdrop or sometimes raise denial of service attacks (Intisar et al., 2019). These attacks may result in the theft of sensitive information on the Internet. There is always a need for an intelligent intruder detection system to secure data from these different attacks. The primary objective of the intruder detection system is to detect intrusion over the Internet. The intruder detection system is needed to be applied at the correspondence level to screen network activities and connections (Zhang et al., 2020). The intruder detection system's design process is divided into two subsections: Signature-based and anomaly-based intruder detection systems (Bedi et al., 2020). Signature-based identify intruders based on the previous attack pattern lead to a problem when a system cannot recognize any new attack. This problem of signature-based intruder detection system needs to address, so anomaly-based system comes into existence. In an anomaly-based intruder detection system, previous as well as new attacks in networks are easily detected.

Anomaly-based intruder detection systems are nowadays improving using different machine learning techniques (Aldweesh et al., 2020). These machine learning techniques are based on probabilities and mainly rely on the distribution of datasets. When there is an imbalance among different classes in datasets, it may result in a class imbalance problem. This problem is often seen in real-time datasets when there is a need to study class with less probability. Traditional classifier's behaviors in imbalanced class datasets are biased toward the majority class.

While studying intruder detection datasets such as KDD'99 and NSL-KDD datasets, the researcher found a class imbalance problem. These datasets contain normal network traffic in the majority than attack instances. To design an effective intruder detection system, researchers try to improve traditional machine learning classification techniques. For improvement, researchers try to use different class imbalance handling techniques to make predictions of traditional classifiers more precise. Many researchers work to handle the class imbalance problem in the intelligent designing of the intrusion detection system. Some

A. Puri (✉) · M. K. Gupta
School of Computer Science and Engineering, Shri Mata Vaishno Devi University, Jammu and Kashmir, Katra, 182320, India
e-mail: Puri.arjun7@gmail.com

M. K. Gupta
e-mail: Manoj.gupta@smvdu.ac.in

researchers try to use resampling techniques, while others rely on an algorithmic modification to deal with an imbalanced class dataset.

This article provides a comprehensive empirical study of different data level class imbalance handling techniques in intruder detection datasets. This thorough investigation may result in further answering the following research questions.

- Does class imbalance affect the recognition of different attacks using traditional decision tree classifiers?
- Which existing resampling technique is suitable for handling class imbalance in intrusion detection datasets?

The remaining sequences of sections of the article are as follows: related work followed by an experimental framework, then results and discussion, and at the end, the conclusion and also contain future work.

2 Related Work

For effective designing an intruder detection system, the class imbalance problem plays a vital role. In (Gonzalez-Cuautle et al., 2020), authors develop a technique to identify intruders in the intruder detection system using SMOTE with a grid-search considering different machine learning algorithms' optimization procedures. This article work authors deal with the tuning of different techniques and try to find the optimal solution for class imbalance in intruder detection system design. Another article (Rodda and Erothi, 2016), where authors consider Naïve Bayes, Bayes-Net, decision tree, and random forest classifier for analysis to observe their imbalanced intruder detection behavior and observe the mentioned techniques, shows poor performance. In (Abdulhammed et al., 2018), authors developed a technique for intruder detection systems using class imbalance handling techniques and show that voting, stacking, random forest, and DNN techniques perform well. In another article (Telikani and Gandomi, 2019), authors develop technique based on cost-sensitive learning called cost-sensitive symmetric autoencoder classifier to deal with class imbalance and classification problem in the intruder detection datasets. They show comparison with symmetric autoencoder (SAE) and non-symmetric deep autoencoder (NDAE) and show that CSSAE technique performs better than other.

For class imbalance handling, various techniques have developed so far. Based on the researcher's, class imbalance handling techniques are categorized into two main subsections: Data level techniques and algorithmic techniques. Data level techniques deal with change in the distribution of datasets among classes where algorithmic techniques

improve existing algorithms and make them robust to handle class imbalance problem in datasets. To overcome class imbalance, extensive work is done on data resampling techniques. In (Chawla et al., 2002), the researchers proposed a synthetic minority oversampling technique to deal with the imbalanced problem. The proposed is suffered from two primary subproblem random instance selections for creating synthetic instances and sometimes suffers from overfitting problems. To remove short comes of SMOTE, various variants of SMOTE are developed to deal with it. Like in (Sáez et al., 2015), authors develop SMOTE with an iterative partitioning filtering technique to deal with the class imbalance and random noise generation by SMOTE instance. In another article (Batista et al., 2004; Puri and Gupta, 2019), the authors try to combine the SMOTE technique with ENN and TomekLink undersampling technique to overcome the SMOTE problem.

However, some authors try to develop techniques under the category of undersampling. In (Seiffert et al., 2010), authors use random undersampling (RUS) technique, which reduces majority instances at random. This random removal of instances may sometimes result in loss of potential information. So, to remove this abnormality in the RUS technique, many researchers develop different techniques like the edited nearest neighbor technique (ENN) (Alejo et al., 2010), cluster center-based undersampling technique (Lemaitre, 2016–17) used for handling class imbalance using the undersampling approach.
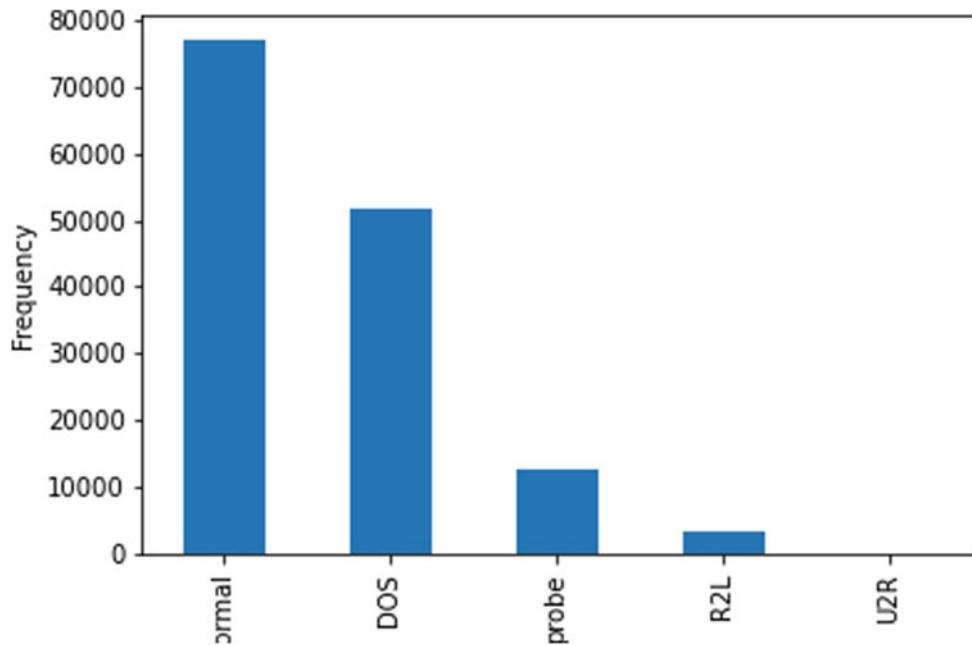
3 Experimental Framework

This section contains detailed descriptions of a dataset, i.e., NSL-KDD datasets, class imbalance handling techniques, classifier used for comparison and evaluation metrics, and experimental design.

3.1 Datasets

NSL-KDD (McHugh, 2000; Tavallaee et al., 2009) is an improved version of KDD'99 datasets. It contains 22 types of attack categories under DOS, Probe, U2R, and R2L where DOS contains Back, Land, Neptune, pod, Smurf, teardrop; Probe category contains Ipsweep, nmap, portsweep, satan; R2L contains ftp_write, guess_password, Imap, Multihop, phf, spy,warezclient,warzmaster; and U2R contains Load_-module, buffer_overflow, rootkit, perl. This dataset contains 41 feature sets where six features are categorical, and the rest are numerical. The detailed category of attacks, along with distribution, is shown in Fig. 1.

Fig. 1 NSL-KDD dataset description

3.2 Class Imbalance Handling Technique and Classifier

For detail comparative analysis of intruder detection system, we consider SMOTE, SMOTE-ENN, SMOTE-TomekLink, SMOTE-IPF as oversampling techniques RUS, ENN, cluster centroid-based undersampling technique as undersampling technique and also consider decision tree (Safavian and Landgrebe, 1991) as a classifier for classification purpose. The detailed description of the category of class imbalance and techniques used is shown in Fig. 2.
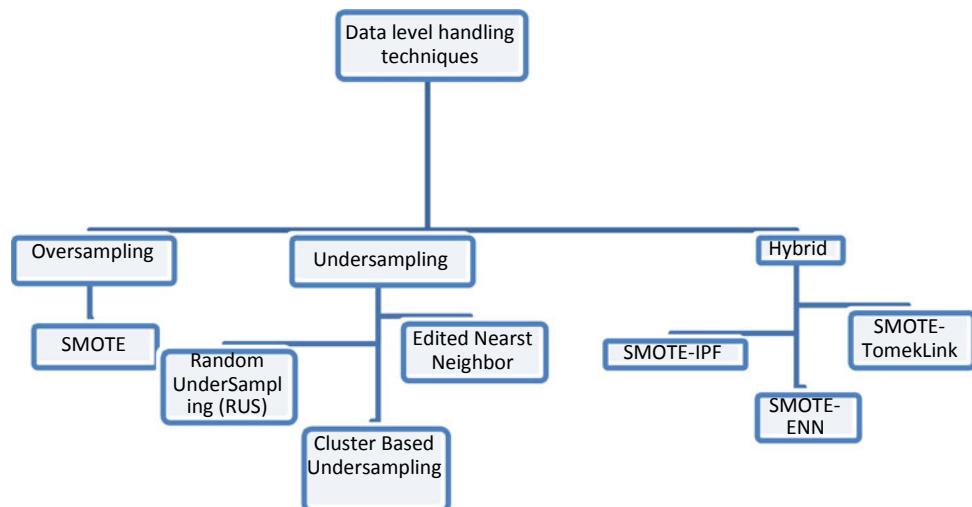
Random Undersampling (RUS) (Seiffert et al., 2009) is used to delete the majority of instances in the datasets randomly. This technique may lose potential information as it

selects an instance to be deleted at random. The whole process may lead to underfitting in the classification of instances.

The cluster-based undersampling technique (Cluster) is another approach where a cluster of majority instances having similar behavior are clustered using clustering technique, and undersampling is done on this majority clustered instances so that it will be considered equivalent to minority instances.

Edited Nearest Neighbor (Wilson, 1972) (ENN) technique also developed to deal with borderline and noisy instances in the datasets. This algorithm may delete instances from majority or minority instances to make a clear decision boundary and make datasets balanced.

Fig. 2 Overview of data level class imbalance handling techniques

SMOTE (Chawla et al., 2002) belongs to the oversampling techniques category. Working with this technique creates artificial minority sample distribution-wise equivalent to majority instances. The algorithm considers minority instances at random. This algorithm results in noisy instances during artificial instance creation and finally results in a disturbance in decision boundary creation.

SMOTE-ENN (Batista et al., 2004) technique advancement over the oversampling technique falls under the hybrid technique, where SMOTE acts as an oversampling technique, and ENN acts as noisy removal in the overall dataset.

SMOTE-TomekLink (Batista et al., 2004; Puri and Gupta, 2019) technique is another variant of the SMOTE technique that falls under hybrid techniques where SMOTE creates noisy instances are removed using the TomekLink undersampling technique.

SMOTE IPF (Sáez et al., 2015) is known as the synthetic majority oversampling technique combined with the iterative partitioning filtering technique where the iterative partitioning filtering technique is used for noisy removal.

3.3 Performance Metrics

For effective measurement of resampling technique in intruder detection datasets, geometric mean (Fernández et al., 2018) and area under the ROC curve (AUC) (Bekkar et al., 2013) as performance metrics because they are sensitive toward the imbalanced class. Geometric mean (G-Mean) is composed of the accuracy of class raise to the root of m, where m is the number of classes. G-Mean is mathematically represented as follows:

$$G - Mean = (Accuracy\ of\ class)^{1/m} \qquad (1)$$

Where as AUC is also considered as the right metric for imbalanced class datasets.

3.4 Experimental Design

This subsection contains a detailed description of the experimental design and describes the overall formulation of an experiment. For the experiment, we consider Python 3.6 as a simulation tool. The whole process is represented in Fig. 3.

The first dataset derived from public sources is divided into training and test parts. We first combine these training and test datasets into one dataset. The processed dataset
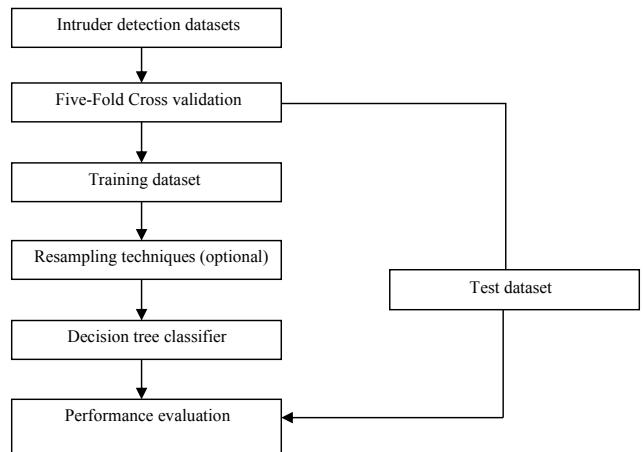
Fig. 3 Experimental flow chart

contains many problems to deal with, like categorical features, which may reduce classifier efficiency and these categorical features need preprocessing and must be converted into the desired form. After that, all features need to have standard represented to scalar normalization to make it independent of scale.

After all preprocessing, we consider fivefold cross-validation for building a model where five times a given dataset is divided into training and testing datasets—considering training datasets as a learning step for machine learning algorithms and testing dataset act as a test for the same algorithm. Sometimes, to improve the decision boundary of given algorithms, we consider different class imbalance handling techniques as resampling techniques in training datasets because if we consider resampling at training, dataset will not cause any biased nature of our experiment.

The overall performance of fivefold cross-validation is collected using the average score of performance metrics.

4 Results and Discussion

This section contains numerical values as the performance of different resampling techniques on NSL-KDD datasets using different data level class imbalance handling techniques with decision tree classifier. Moreover, overall lesson learned for addressing different research questions mentioned in Sect. 1.

Figure 4 shows the results of different resampling techniques to handle class imbalance using G-Mean on the test dataset of the intruder detection system. The experiment is performed using cross-validation and shows the following results.

- The experiment concluded that applying the cluster-based undersampling technique to deal with the datasets' imbalanced problem is not worthy.
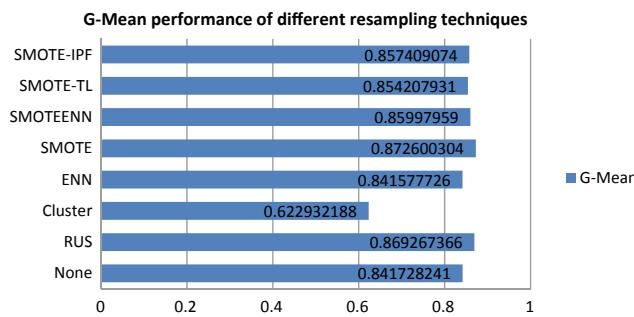
Fig. 4 G-Mean performance of different resampling techniques on test intruder detection datasets

- Further results on comparing ENN with none (without resampling) show similar results; moreover, none ahead of the ENN resampling technique.
- Finally, we also conclude that the SMOTE technique outperforms hybrid techniques like SMOTEENN, SMOTE-TomekLink, and undersampling techniques.
- However, the second-best technique comes from the undersampling technique known as the random undersampling technique.

To further confirm the best resampling technique, we consider AUC as metrics in Fig. 5 and collect the following inferences.

- From the results of this metric, we came up with another side of inferences, where we observe that the hybrid resampling technique like SMOTE ENN and SMOTE-TomekLink and SMOTE techniques show almost similar results.
- Based on observation, we also infer that the cluster-based undersampling technique is the worst choice to deal with the class imbalance in the dataset. Further results confer that none compared with ENN, and RUS shows almost similar results.
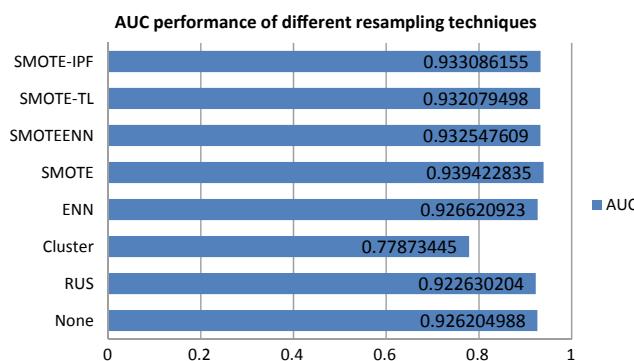
4.1 Lesson Learned

Based on the experiment performed, we answer the above-mentioned research question.

Q1: Does class imbalance affect the recognition of different attacks using traditional decision tree classifier

Ans. The analysis shown in Figs. 4 and 5 shows that class imbalance creates a significant effect on the recognition of different attacks in intruder detection datasets. From the analysis, we concluded based on the non-effectiveness of the traditional classifier while dealing with a class imbalance in the intruder detection dataset.

Q2: Which existing resampling technique is suitable for handling class imbalance in intrusion detection datasets?

Ans. From experiment either by using AUC or G-Mean, we say that SMOTE with a decision tree is an effective solution to deal with class imbalance problem in intrusion detection datasets.

5 Conclusion and Future Work

This article performs a study on multi-class intruder detection system datasets using class imbalance handling techniques with a decision tree as a classifier. From the study, we conclude that intruder detection datasets suffer from imbalanced class distribution, and some resampling techniques show promising results to cope with class imbalance problem. From experimental results, we also conclude that either by using G-Mean or AUC metrics, it is clear that the SMOTE technique outperformance than rest.

This article shows a portion of the study in context with one classifier. Further, this study may be extended with multiple classifiers and also multiple handling techniques for class imbalance.

References

Abdulhammed, R., Faezipour, M., Abuzneid, A., & AbuMallouh, A. (2018). Deep and machine learning approaches for anomaly-based intrusion detection of imbalanced network traffic. *IEEE Sensors Letters, 3*(1), 1–4.

Aldweesh, A., Derhab, A., & Emam, A. Z. (2020). Deep learning approaches for anomaly-based intrusion detection systems: A survey, taxonomy, and open issues. *Knowledge-Based Systems, 189,* 105124.

Alejo, R., Sotoca, J. M., Valdovinos, R. M., & Toribio, P. (2010). *Edited nearest neighbor rule for improving neural networks classifications.* Paper presented at the International Symposium on Neural Networks.

Fig. 5 AUC performance of different resampling techniques on test intruder detection datasets

Batista, G. E., Prati, R. C., & Monard, M. C. (2004). A study of the behavior of several methods for balancing machine learning training data. *ACM Sigkdd Explorations Newsletter, 6*(1), 20–29.

Bedi, P., Gupta, N., & Jindal, V. (2020). Siam-IDS: Handling class imbalance problem in intrusion detection systems using siamese neural network. *Procedia Computer Science, 171,* 780–789.

Bekkar, M., Djemaa, H. K., & Alitouche, T. A. (2013). Evaluation measures for models assessment over imbalanced data sets. *Journal of Information Engineering and Application, 3*(10).

Chawla, N. V., Bowyer, K. W., Hall, L. O., & Kegelmeyer, W. P. (2002). SMOTE: Synthetic minority over-sampling technique. *Journal of Artificial Intelligence Research, 16,* 321–357.

Fernández, A., García, S., Galar, M., Prati, R. C., Krawczyk, B., & Herrera, F. (2018). Performance measures *Learning from Imbalanced Data Sets* (pp. 47–61): Springer.

Lemaitre, G., Nogueira, F., Oliveira, D., Aridas, C. (2016–17). From https://imbalanced-learn.readthedocs.io/en/stable/generated/imblearn.under_sampling.ClusterCentroids.html.

Gonzalez-Cuautle, D., Hernandez-Suarez, A., Sanchez-Perez, G., Toscano-Medina, L. K., Portillo-Portillo, J., Olivares-Mercado, J., & Sandoval-Orozco, A. L. (2020). Synthetic minority oversampling technique for optimizing classification tasks in botnet and intrusion-detection-system datasets. *Applied Sciences, 10*(3), 794.

Intisar, S., Guan, L., & Edirisinghe, E. (2019). *Investigating the Effective Use of Machine Learning Algorithms in Network Intruder Detection Systems.* Paper presented at the Advances in Information and Communication Networks: Proceedings of the 2018 Future of Information and Communication Conference (FICC).

McHugh, J. (2000). Testing intrusion detection systems: A critique of the 1998 and 1999 darpa intrusion detection system evaluations as performed by lincoln laboratory. *ACM Transactions on Information and System Security (TISSEC), 3*(4), 262–294.

Puri, A., & Gupta, M. K. (2019). *Comparative Analysis of Resampling Techniques under Noisy Imbalanced Datasets.* Paper presented at the 2019 International Conference on Issues and Challenges in Intelligent Computing Techniques (ICICT).

Rodda, S., & Erothi, U. S. R. (2016). *Class imbalance problem in the network intrusion detection systems.* Paper presented at the 2016 international conference on electrical, electronics, and optimization techniques (ICEEOT).

Sáez, J. A., Luengo, J., Stefanowski, J., & Herrera, F. (2015). SMOTE–IPF: Addressing the noisy and borderline examples problem in imbalanced classification by a re-sampling method with filtering. *Information Sciences, 291,* 184–203.

Safavian, S. R., & Landgrebe, D. (1991). A survey of decision tree classifier methodology. *IEEE Transactions on Systems, Man, and Cybernetics, 21*(3), 660–674.

Seiffert, C., Khoshgoftaar, T. M., Van Hulse, J., & Napolitano, A. (2009). RUSBoost: A hybrid approach to alleviating class imbalance. *IEEE Transactions on Systems, Man, and Cybernetics-Part a: Systems and Humans, 40*(1), 185–197.

Seiffert, C., Khoshgoftaar, T. M., Van Hulse, J., & Napolitano, A. (2010). RUSBoost: A hybrid approach to alleviating class imbalance. *IEEE Transactions on Systems, Man, and Cybernetics-Part a: Systems and Humans, 40*(1), 185–197.

Tavallaee, M., Bagheri, E., Lu, W., & Ghorbani, A. A. (2009). *A detailed analysis of the KDD CUP 99 data set.* Paper presented at the 2009 IEEE symposium on computational intelligence for security and defense applications.

Telikani, A., & Gandomi, A. H. (2019). Cost-sensitive stacked auto-encoders for intrusion detection in the Internet of Things. *Internet of Things*, 100122.

Wilson, D. L. (1972). Asymptotic properties of nearest neighbor rules using edited data. *IEEE Transactions on Systems, Man, and Cybernetics* (3), 408–421.

Zhang, H., Huang, L., Wu, C. Q., & Li, Z. (2020). An Effective Convolutional Neural Network Based on SMOTE and Gaussian Mixture Model for Intrusion Detection in Imbalanced Dataset. *Computer Networks*, 107315.

An Investigation of Consumers Purchase Decision Towards Private Label Brands in Indian Organised Retail Sector

Ajay Singh

Abstract

The study identifies the key attributes considered by Indian consumers while purchasing private label brand (PLBs). It also studies the impact of identified psychographic and demographic attributes of consumers towards PLB purchase decision. The data was collected from 550 respondents through structured questionnaire from leading retailers of food and grocery as well as clothing and apparel segment in India. Initially, an exploratory factory analysis (EFA) was performed to identify psychographic attributes from consumer survey and different hypothesis framed was tested through multiple regression analysis and Chi square test. The results reveal brand consciousness, price consciousness, quality variability, store loyalty and consumers self-perception emerged as key psychological attributes followed by all socio-demographic factors, i.e. age, occupation, qualification, income and gender have significant impact on consumer PLB purchase decision. Based on the findings, PLB retailers were suggested to design an appropriate strategy to capture the market share of private label brands in Indian organised retail.

1 Introduction

In emerging economies, private label brands are capturing retail market and are a win–win situation for both retailers and customers. Retailers are in position to negotiate with vendors since they do bulk purchasing due to which they can improve profit margins and better control of merchandise mix leading to wide product offerings with appropriate price and good quality. Private label growth is directly linked with growth of organised retail in India. Retailers need more confidence from customers for successful introduction of private label brand. In India, share of private label accounts 7% which is expected to increase further as in European countries and US private label share is high with around 45% and as low as 1% in Chinese market.[1]

Private label products are generally referred as a store brand, brand owned and sold by retailers; it is also known as own label, retailer brand or generics. These products are owned by the retailer rather than manufacturer or producer. Private label brands exist in almost every categories ranging from food and grocery to apparels, clothing, etc. As defined by research scholar (Baltas, 1997), private label products are produced on behalf of retailers or by the retailer and sold with the retailer's own name or trademark within their own outlets. Recently, retailers have aligned private label brands with known consumer pattern, such as everyday value, indulgence and premium, health and wellness, organic and ethical. Likewise, Reliance Retail and Food Bazaar also provides a wide range of PLs to meet different consumer needs. The motive why retailers choose to offer private labels is generating profit margins through by-passing branded suppliers as the control shifts from leading manufacturers to retailers; filling gaps in their range of product which may not be currently handled by premium suppliers; including a product variant with a better size option in

A. Singh (✉)
Department of Business Administration, ABES Engineering College, Ghaziabad, Uttar Pradesh, India
e-mail: ajaysingh.bvu@gmail.com

---

[1]Retail/the-growth-of-private-labels-in-India.https://www.indiaretailing.com.

different categories and using private labels to distinguish their store's product category from competitors; and create a competitive advantage thereby improving both profitability and loyalty for a retailer.

Consumers in the metrocities are going to buy products in hyper market and super markets that made retailers to understand the choice of consumer in different product categories and offer them good value for money in product category which they purchase. Consumers are generally price sensitive, whereas price is not only factor for product utilisation, mainly in food and grocery which 69% market share followed by apparel sector that has 8% market share in organised retail.[2] At the present time, consumers are more cautious in spending. As already explained that different retailers getting involved in private label as they are getting benefit by offering variety of products and increasing their profit, private label brand retailers are producing differentiated products in their stores which was not found before. Hence, if a retailer can provide the local tastes and choices of the consumer by giving top quality private label products, then they can create differentiation from other stores and can become destination stores. Indian retail is rapidly growing and the private label brand is growing from nascent stage to maturity stage as can be easily seen in developed European market. The current study aims at investigating the perception and attitude of consumers towards purchase of private label brands. Also, there is no significant study on consumer perception towards private label products in India. In this light, the key research problem is to explore which factors may have competitive leverage for private label retailers.

2 Literature Review and Hypothesis Development

Consumer behaviour towards private label brands has changed rapidly in last few years (Kumar & Steenkamp, 2007). As private label brands offers increased percentage of product variety in consumer's shopping basket, different scholars and marketers had tried to understand and explore consumers attitude towards private label brands (Ailawadi et al., 2008). Existing academic research on private label brands has tried to understand the consumers of private label brand on different psychographic variables. Different studies focus on price and value consciousness (Burton et al., 1998), quality perceptions (Hoch & Banerjee, 1993), brand loyalty and store loyalty (Garretson et al., 2002) search, risk assessment as well as product involvement (Batra & Sinha, 2000). Although psychographics are definitely important, for different business practices, many consumer product and

service companies majorly or completely focus on socio-demographics attributes. Socio-demographics are crucial for managers since they are one of the most freely accessible and available data and can also be used for segmentation issues with comparatively easy to use with other segmentation variables (Myers, 1967). Unfortunately, despite the significance of socio-demographic attributes in overall managerial decision-making (Baltas, 1997), many academic researches seem to give an ambiguous value to socio-demographic attributes for targeting and segmenting consumers of private label brands. However, researchers have identified the importance of socio-demographic factors (Burton et al., 1998); the idea only gets a brief remark in the overall methodology, analysis and interpretation. This situation of unnoticeable socio-demographic attributes is concerning given that one would anticipate socio-demographic variables, for example, income, size of family and qualification to have some impact on purchase decisions of consumers. Moreover, researchers have observed that the possible moderating influence of socio-demographics is either ignored or examined in an ad hoc nature in the extant research on private label brands (Dick et al., 1997). This research examines the relationships between psychographic and socio-demographic variables for understanding private label brand consumers. The reasons for studying the relationship between the roles played by psychographics and socio-demographics in understanding private label consumers include the following. Firstly, in recent time, with few exceptions (Ailawadi et al., 2008), many researchers have failed to identify the impact of socio-demographic variables. The thought that consumers vary in the efforts they put into shopping is old. There is an agreement among researchers that consumers go for different shopping decisions on the basis of their socio-demographics at different stages of the family life cycle. Such opinions are crucial to marketers because they impact consumers' responses towards marketing strategies. Secondly, past studies have not explored how psychographics and socio-demographics are associated in consumer decision-making processes. Thirdly, majority of research on private label brands were conducted in USA. This is mainly of concern as various other countries have also developed market for private labels. For instance, the UK is considered as the most matured market for private label brands, and the market penetration of private labels is around 42.3%. Consumer studies on culture suggest that country-related factors are considerably influential in understanding the socio-demographic profile of consumers and their purchase decision (Shukla et al., 2013). Hence, findings based only on US consumers may not be right in other region. Taken together, the previous observations provide a strong reason in favour of taking a new way to the moderating influence of socio-demographics on the association between the

---

[2]India Brand Equity Foundation, https://www.ibef.org.

psychographic factor and the attitudes towards private label brands. Such a research work will help develop a better understanding of private label consumers. Particularly, in this study, an extensive review of the literature is done; hypotheses are developed related to association between six different psychographic measures; these are price-related deal proneness, general deal proneness, end-of-aisle display proneness, smart shopper self-perceptions, impulsiveness and brand loyalty along with the role of socio-demographic factors such as gender, age, education, income and family size. The hypotheses framed were successively tested on a sample of Indian consumers, and the direct effects model along with the moderating impact of socio-demographic variables was evaluated. In addressing the above-mentioned issues, this paper makes the following contributions to the literature and retail industry. Firstly, the paper gives more widespread understanding of the mediating effect of socio-demographic variables on the association between consumer psychographics and their attitude towards private label brands. Second, it also highlights the added utility of socio-demographics for profiling private label consumers. The paper is organised as follows. First, we present our conceptual framework and hypotheses to measure the attitude towards private label brands. Next, we present the research methodology employed for the study. Thereafter, we use exploratory factor analysis followed by multiple regression analysis to examine the relationship between the constructs and present the research results. We conclude with a summary of the research findings and the theoretical and managerial implications of this research study.

3 Hypothesis Development

3.1 Price Consciousness and Quality Variability

For carrying out this research, it is crucial to understand about the emergence and concept of private label brands, their importance and customer preferences towards brands and the image of store consumer carry. It has been found (Faria, 1979) price and quality are the two most important factors to buy any product and there exist a direct association between these two attributes. Except from price, quality is other predominant reason in consumer purchase behaviour (Hoch & Banerjee, 1993). A study conducted by Private Label Manufacturers Association (PLMA), USA, in year 1991 identifies various reasons for purchasing private label products by the consumers. Most of consumer wants to purchase private label due to low prices. As identified by Roth (1995), a vital aspect that is associated with human consumption is income pattern of consumers. In a situation when income is limited, the price sensitive customers buy products just to fulfil their most basic and essential needs

rather than satisfying esteemed needs. Another study (Rubel, 1995) also suggested that in case of private label brands, both the price and quality are the key factors for purchasing; however, if the quality offered is similar in case of both private label brands and national brands, then at that instant price becomes the major factor. Past studies have also demonstrated that consumer's price consciousness level increases with less incomes and is higher in case of deal-prone consumers who consider less association between price quality (Blois, 2000). These price conscious consumers usually lack awareness related to perceived risk, less brand loyalty customers look more on promotional offers given by the stores as compared to the quality of product. People with high income are relatively less price sensitive; hence, they purchase more private label products. On the one hand, these private label brands are produced for the situation of economic crisis where consumers are more price sensitive as they want to minimise their expenses by reducing their budget. However, these customers restart buying national brand once the economy recovers. Consumer perceives the product quality from the price offered as they have general understanding that the low price products lack quality since they constitute of poor ingredients and do not meet minimum quality standards (Batra & Sinha, 2000). Studies also found that quality is the major reason that drives consumers to purchase national brands. The quality level of private label products differs from retailer to retailer; however, they are generally inferior to manufacturers' brands (Steenkamp et al., 2003). Another study conducted (Singh & Singhal, 2020) found a positive relationship between the perceived quality and price consumers willing to pay for private label products.

H1a-There exists significant relationship between price consciousness and consumer PLB purchase decision.
H1b-There exists significant relationship between quality variability and consumer PLB purchase decision.

3.2 Brand Loyalty and Brand Image

Brand loyalty is a shopper characteristic which makes consumers value brands more and that just limiting to their switching behaviour. Shoppers who are loyal to a particular brand are less inclined to look for new or less familiar brands such as store brands (Ailawadi et al., 2008). Hence, shoppers who are loyal to the current national brands may show more negative attitudes towards store brands as compared to other shoppers. In the 1980s, a study showed that 84% of the growth in sales occurred because of brand switches. However, further research explained that only 33% of the increase in sales that occurred during the promotional

campaigns is due to the brand switch and that the remaining percentage is because of the growth of the primary demand. It is Kremer and Viot (2012) explained that store brand (SB) has a positive influence on the retailer image. The price image of the store brand is positively associated with the retailer price image. It is Diallo et al. (2013) identified that perception of store image, SB price image, value consciousness, and SB attitude have significant and positive impact on SB buying behaviour. Store familiarity positively affects SB choice, but does not affect SB purchase intention. In a study conducted (Singh & De, 2016) found that brand image is most significant factor considered by PLB consumers.

H1c-There exists significant relationship between brand image and consumer PLB purchase decision.

3.3   Smart Shopper Self-Perception

The self-perception of the smart shopper is an ego-based attribute that relates to the shopper's need to achieve inner compensation by obtaining price savings through the purchase (Garretson et al., 2002). They also suggested that the smart shopper's self-perception can have a favourable impact on the attitude towards store brands as well as the attitude towards manufacture brand promotions. It was also certified that this attribute has a greater effect on the attitude towards manufacturer brand promotions because store brands are time and again sold at lower prices. In contrast, manufacturer brand promotions are not permanent, and therefore, finding promotions of manufacturer brands can provide this type of shopper with a greater sense of achievement than simply purchasing store brands at low and stable prices (Garretson et al., 2002).

H1d-There exists significant relationship between self-perception and consumer PLB purchase decision.

3.4   Store Image

Store image is defined as the complex of a consumer's perceptions towards a store on different (salient) attributes. Store image is reflected in the store's physical atmosphere and in the perceptions of its goods as well as service quality (Semeijn et al., 2004). Consequently, store image strongly influences perception towards store brand (i.e. brand image) (Collins-Dodd and Lindley, 2003) and attitude towards store brand (Semeijn et al., 2004). However, the extrinsic cue (store name) is more appropriate for store brands as

compared to national brands. Therefore, an unfavourable store image will not harm a big brand nor will a positive store image will support a brand with an adverse image. Store aesthetics have no impact on judgements criteria regarding the quality of national brands. Another study (Ballester et al., 2014) found that SI exerts different influences on the four categories of perceived risk, the strength of which varies with value consciousness.

H1e-There exists significant relationship between store image and consumer PLB purchase decision.

On the basis of above psychographic and socio-demographic variable, the Theoretical Framework for Consumer PLB purchase decision was proposed which was tested against different hypothesis framed. The model tries to understand the association of Price Consciousness, Quality Variability, Brand Store Image, Self-Perception on Consumer PLB purchase decision also it tries to understand the impact of socio-demographic variables such as age, occupation, qualification, income and gender on consumer PLB purchase decision (Fig. 1).

4   Research Objectives
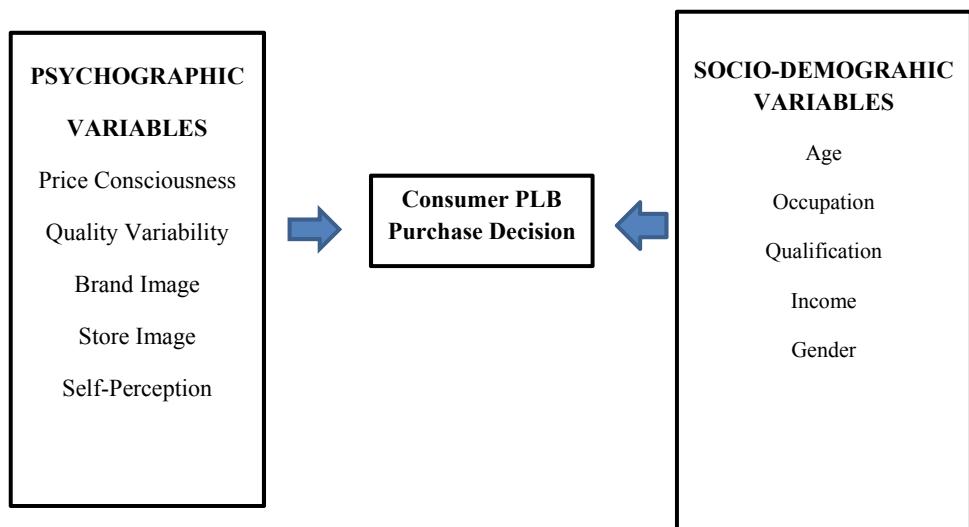
1. To explore the key factors affecting consumer's purchase decision towards private label brands (PLBs) in India.
2. To study the impact of identified psychological and socio-demographic factors on private label brands (PLBs) purchase decision.

5   Research Methodology

Both exploratory and causal research has been used in this study in order to develop the understanding of consumer perspective towards purchase of private label brands' products.

This research is conducted to identify key factors considered by Indian consumer while purchasing private label products from the food and grocery and apparel and clothing segment of Indian retail and further study the impact of these explored factors on PLB purchase decision that will make retailers to understand better insights about the consumer perception in evaluating PLB products. In this study, data was collected by survey method in which structured questionnaire is used on different attributes identified from literature. Questions were asked on Likert scale of 5–1. A total of 18 statement were used along with five demographic

Fig. 1 Theoretical frame work of consumer PLB purchase decision

PSYCHOGRAPHIC VARIABLES

Price Consciousness

Quality Variability

Brand Image

Store Image

Self-Perception

Consumer PLB Purchase Decision

SOCIO-DEMOGRAHIC VARIABLES

Age

Occupation

Qualification

Income

Gender

questions on age, gender, qualification, occupation and income. Sampling technique used was stratified random sampling in which strata was made of top retailers in food and grocery and clothing and apparel segment. The responses were collected from consumers of NCR region (Delhi, Noida, Gurgaon, Ghaziabad) who visits mall frequently.

Demographic questions on age, gender, qualification, occupation and income. Stratified random sampling technique was used in which strata of top retailers in food and grocery and clothing and apparel segment was formed. As shown in the Table 2, Data was collected through structured questionnaire on five demographic factors on age, occupation, qualification, income and gender. A total of 550 questionnaires were floated in different malls of NCR region to gather responses. Data was collected from five food and grocery stores, i.e. Big Bazaar, Easy day, More, Spencer's and Vishal Mega Mart and four Apparel and Clothing Stores such as Shopper Stops, Pantaloons, Westside and Reliance trends. As shown in Table 1, response % is 73.3% in food

and grocery and 76.6% from apparels and clothing was analysed (Table 2).

As shown in above table, responses were collected from five demographic factors on age, occupation, qualification, income and gender. 47.5% of consumers are in 18–25 years followed by 20% in 25–35 years and 9.3% in 35–45 year and 23.3% are in 45 years and above. Occupation of respondents is as follows: 50% are student, 11.8% are service class, 23.6% are business class and 14.5% are self-employed. Majority of consumers approximately 48% are having postgraduate qualification followed by 43.5% graduate consumers. Maximum income (INR/Month) respondents are 33.8% having income above 40 thousand rupees per month followed by 42.2% up to ten thousand rupees per month; approximately, 20% people are having income between twenty to forty thousand rupees per month. In gender category, 61.6% are male and 38.4% are female respondents.

Table 1 Sampling frame

Company Name	Total distribution	Complete response	Response %
FOOD and GROCERY	300	220	73.3
Big Bazaar	100	70	70.0
Easy day	50	38	76.0
MORE	50	42	84.0
Spencers	50	39	78.0
Vishal MegaMart	50	31	62.0
APPARELS and CLOTHINGS	300	230	76.7
Shopper Stop	75	60	80.0
Pantaloons	75	50	66.7
West Side	75	55	73.3
Reliance Trends	75	65	86.7

Source Author calculation

Table 2 Sample characteristics

Socio-demographic variables	Categories	Percent
Age (in years)	18–25	47.5
	25–35	20.0
	35–45	9.3
	45 above	23.3
Occupation	Service	11.8
	Business	23.6
	Student	50.0
	Self-Employed	14.5
Qualification	Undergraduate	1.6
	Graduate	43.5
	Postgraduate	48.0
	Doctorate	6.9
Income (INR/Month)	upto 10 K	42.2
	10-20 k	4.7
	20-40 k	19.3
	Above 40 k	33.8
Gender	Male	61.6
	Female	38.4

Initially, exploratory factor analysis (EFA) was performed on data collected from 550 consumers of food and grocery and apparels in NCR region of India to explore the major factors consumers are considering for private label brand purchase. After performing EFA, it becomes essential to understand the impact and significance level of each identified factor on PLB purchase decision of consumers. In the current research, PLB purchase decision is independent variable and the identified five factors—price consciousness, brand image, quality variability, self-perception and store image—are dependent variable; hence, causal research is required to understand the impact of these explored variables on PLB purchase decision. Causal research as its name implies has the focus on explaining rather than merely describing the phenomenon. The thrust of the study is on explanation of various causes that lead to a particular phenomenon to happen. This type of research is more focused and structured than exploratory research. In current research after performing EFA, multiple regression analysis is performed to understand the impact of identified factors on PLB purchase decision by consumers.

6 Data Analysis

6.1 Factor Analysis

Is a general name denoting a class of procedures primarily used for data reduction and summarisation (Malhotra &

Dash, 2010). Factor analysis also provides means of explaining variation among large variables using newly created small variables. SPSS version 17.0 software is used for conducting exploratory factor analysis.

6.2 Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity

Is conducted before proceeding with factor analysis; there is need to check whether there exists underlying structure between testing variables or not. KMO and Bartlett's test is performed to support the viability of applying factor reduction to data. Both KMO measure of sampling adequacy and Bartlett's test of sphericity identify whether application of factor analysis is appropriate or not (Table 3).

6.3 Feasibility of the Test

KMO test is used to check the feasibility of the factor analysis. For conducting a factor analysis, the Kaiser–Meyer–Olkin measure of sampling adequacy should be greater than 0.7 as in given table, KMO is 0.876 which is greater than 0.5 and approx. Chi square value is 22,656.845 which is high. Therefore, factor analysis can be done on the findings (Table 4).

6.4 Total Variance Explained

Above table gives the total variance explained by each component. We can see the percentage of total variance contributed by the first component is 17.664, the second component is 12.595, third component 9.896, fourth component 9.676 and fifth component 9.558. The eigenvalue for a given factor measures the variance in all the variables accounted for by that factor. The ratio of eigenvalues is the ratio of explanatory importance of the factors with respect to the variables. If a factor has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors. It is also clear from the table that there are in total five distinct components having eigenvalues greater than 1 from the given set of variables. The eigenvalues for

Table 3 KMO and Bartlett's test

Kaiser–Meyer–Olkin measure of sampling adequacy		0.876
Bartlett's test of sphericity	Approx. Chi square	2922.738
	Df	153
	Sig	0.000

Table 4 Total variance explained

Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.743	31.908	31.908	3.180	17.664	17.664
2	1.481	8.230	40.138	2.267	12.595	30.258
3	1.280	7.109	47.247	1.781	9.896	40.154
4	1.114	6.186	53.433	1.742	9.676	49.831
5	1.072	5.955	59.389	1.720	9.558	59.389
6	0.808	4.486	63.875			
7	0.759	4.216	68.091			
8	0.717	3.982	72.073			
9	0.662	3.679	75.752			
10	0.609	3.381	79.133			
11	0.596	3.311	82.444			
12	0.576	3.201	85.645			
13	0.563	3.126	88.771			
14	0.466	2.589	91.360			
15	0.459	2.552	93.912			
16	0.415	2.303	96.215			
17	0.363	2.015	98.230			
18	0.319	1.770	100.000			

factors 1, 2, 3, 4 and 5 are 5.743, 1.481, 1.280, 1.114, 1.072, respectively.

6.5 Rotated Component Matrix

In this study, orthogonal rotation is used in data reduction compared to oblique rotation which is used to find significantly larger number of constructs. Factor rotation is done to redistribute the earlier factor variance to later ones in order to get more meaningful and interpretable factor structure (Table 5).

For exploratory purposes, lower level has been used such as 0.4 for the central factor and 0.25 for other factors. Loading is basically the correlation coefficient for the variable and factor. Factor loading shows the variance explained by the variable on that particular factor (Nunnally, 1970). In any event, factor loadings must be interpreted in the light of theory, not by arbitrary cutoff levels. In Table 4, the item loading is in the range 0.546–0.726 which indicates the each item is extracted well to be clubbed in respective factors. Six items are clubbed into first component with item loading ranging from 0.558 to 0.762. Four items are clubbed into second component with item loading 0.546–0.713. Two items were clubbed into third component with item loading 0.687–0.702, three items were clubbed into fourth component with factor loading from 0.574 to 0.689 and three items were clubbed into fifth component with item loading 0.614–0.673.

Six items related to price were clubbed into first factor named price consciousness; four items related to brand were clubbed into second factor named brand consciousness. Two items related to quality were clubbed into third factor named quality variability, three items related to consumer perception were clubbed into fourth factor named consumer self-perception and three items related to store were clubbed into fifth factor named store image.

6.6 Multiple Regression Analysis

In the present study, the dependent variable identified is PLB purchase decision and its relationship with various independent variables explored in the research is brand image, price consciousness quality variability, consumer self-perception and store image. The multiple regression analysis is done so as to access the impact of different independent variables brand image, price consciousness, quality variability, consumer self-perception and store image on the dependent variable PLB purchase decision (Table 6).

Dependent Variable: Consumer PLB Purchase Decision

This table gives the model summary for the set of independent and dependent variables. R^2 for the model is 0.805 which means that 80.5% of variation in dependent variable

Table 5 Rotated component matrix

	Component				
	1	2	3	4	5
Q1	**0.726**	0.249	0.032	0.093	−0.039
Q2	**0.707**	0.248	0.105	−0.041	0.188
Q4	**0.684**	0.157	0.085	0.240	0.138
Q3	**0.626**	0.214	0.058	0.283	0.128
Q5	**0.622**	0.016	0.069	0.235	0.259
Q18	**0.558**	0.177	0.436	−0.167	0.086
Q13	0.137	**0.713**	0.225	0.224	−0.086
Q11	0.201	**0.702**	0.055	0.113	0.182
Q12	0.344	**0.691**	0.198	0.034	0.106
Q10	0.171	**0.546**	−0.237	0.146	0.419
Q14	0.198	0.023	**0.702**	0.309	0.052
Q15	0.061	0.225	**0.687**	0.165	0.149
Q8	0.201	0.278	0.080	**0.689**	0.039
Q9	0.042	0.235	0.183	**0.655**	0.187
Q6	0.447	−0.189	0.230	**0.574**	0.119
Q17	0.119	0.020	0.468	−0.055	**0.673**
Q16	0.132	0.089	0.306	0.157	**0.664**
Q7	0.264	0.197	−0.209	0.205	**0.614**

Table 6 Model summary

Model	R	R^2	Adjusted R^2	Std. error of the estimate	Durbin-Watson
1	0.805[a]	0.647	0.644	0.610	2.042

[a]Predictors: (Constant), Brand Image, Price Consciousness, Quality Variability, Self-Perception, Store Image

(PLB purchase decision) is explained by the five independent variables brand image, price consciousness, store image, quality variability, self-perception. The Durbin Watson statistic for the model is 2.042. The desired value should be in the range 1.5–2.5. Hence, assumption that the residuals are uncorrelated is valid. The next table gives the regression coefficients, greater the coefficient larger is the impact of the independent variable on PLB purchase decision and the variable is significant if p value is less than 0.05 (Table 7).

The final equation that has been considered is:

$$
\begin{aligned}
\text{PLB Purchase Decision} = {} & 3.302 + 0.706 * (\text{Brand Image}) \\
& + 0.352 * (\text{Price Consciousness}) \\
& + 0.203 * (\text{Quality Variability}) \\
& + 0.109 * (\text{Store Image}) \\
& + 0.035 * (\text{Self - Perception})
\end{aligned}
$$

From the above table, it is found that contribution of brand image is maximum for PLB purchase decision followed price consciousness, quality variability, store image and self-perception. All independent variables are significant except self-perception.

6.7 Chi Square Test

Since literature has also identified the effect of socio-demographic profile of consumer on consumer PLB purchase decision; hence, five hypotheses were developed and Chi square test was conducted to identify the influence of different demographic variables such as age, gender, occupation, income and qualification on consumer PLB purchase decision (Table 8).

H2a-There is no significant relationship between age and consumer PLB purchase decision.
H2b-There is no significant relationship between gender and consumer PLB purchase decision.
H2c-There is no significant relationship between occupation and consumer PLB purchase decision.
H2d-There is no significant relationship between income and consumer PLB purchase decision.
H2e-There is no significant relationship between qualification and consumer PLB purchase decision.

On the basis of above table, it is seen that the Chi square values of age are 23.948 with degree of freedom 12, and p

Table 7 Hypothesis testing by multiple regression analysis

Hypothesis	Model		Unstandardised coefficients		Standardised coefficients	T	Sig	
			B	Std. error	Beta			Outcome
	1	(Constant)	3.302	0.026		126.933	0.000	
H1a		Price Consciousness	0.352	0.026	0.344	13.519	0.000	Accepted
H1b		Brand Image	0.706	0.026	0.691	27.121	0.000	Accepted
H1c		Quality Variability	0.203	0.026	0.198	7.786	0.000	Accepted
H1d		Self-Perception	0.035	0.026	0.034	1.336	0.182	Rejected
H1e		Store Image	0.109	0.026	0.106	4.170	0.000	Accepted

[a]Dependent Variable: Consumer PLB Purchase Decision

Table 8 Hypothesis testing of consumer socio-demographics by Chi square test

Hypothesis	Socio-demograhics	Chi Square value	df	P value	Outcome
H2a	Age	23.948	12	0.021	Accepted
H2b	Gender	14.318	4	0.006	Accepted
H2c	Occupation	40.7	12	0.000	Accepted
H2d	Income	22.199	12	0.035	Accepted
H2e	Qualification	27.651	12	0.006	Accepted

value is 0.021 ($p < 0.05$); hence, age is having significant relationship with consumer PLB purchase decision followed by gender having Chi square values 14.318 with degree of freedom 4, and p value is 0.006 ($p < 0.05$); hence, gender is having significant relationship with consumer PLB purchase decision. Similarly, occupation is having Chi square values 40.71 with degree of freedom 12, and p value is 0.000 ($p < 0.05$) which is significant, also Income is having Chi square values 22.199 with degree of freedom 12, and p value is 0.006 ($p < 0.05$) which is significant and finally qualification is having Chi square values 27.651 with degree of freedom 12, and p value is 0.006 ($p < 0.05$) which is also significant. Hence, all the five socio-demographic factors have significant impact on consumer PLB purchase decision,

7 Conclusion and Recommendations

This study identifies the key attributes that are considered by Indian consumer while making purchase decision for private label brand among top retail chains of food and grocery and clothing apparel sector. Several price and non-price-related attributes were identified through literature review for different national and private label brands. Nine of them namely price consciousness, quality variability, self-perception, value consciousness, brand image, brand

loyalty, store loyalty, store image and impulsiveness were identified crucial from consumer perspective for PLB purchasing. These nine factors comprising of 18 items were surveyed from the top retail stores of food and grocery and clothing and apparels in NCR region. EFA results revealed 18 items into five specific factors, namely price consciousness, brand image, quality variability, self-perception and store image. Causal analysis identified the most significant and discriminating factor as brand image for PLB purchasing followed by price consciousness, quality variability and store image. Self-perception found to be insignificant as it varies from individual to individual. Also in case of socio-demographic factors, all factors, i.e. age, gender, occupation, qualification, income are found significant in Indian context as compared to other countries where income was key concern for PLB purchase decision.

Hence, findings of the study suggest that retailers should focus on brand building by persuading and informing customers about private label product through promotional offers, discounts, voucher, etc. and set price relatively lower to established brand so that consumers start purchasing the private label products and become habitual of the same; thereafter, improving better quality big retailers can attract more customer and increase profitability; also, retailers should work on the demographic of Indian consumers and provide suitable products option for all customer segment.

8 Limitation of Study

The major limitation of the study is that it was conducted only in the NCR region of India which may not be true representation of the retail population as majority of economically weaker consumers lives in different part of the country. Also the research was limited to only two product categories, i.e. food and grocery and clothing and apparel; other retail categories need to be explored before generalizing the private label buying concept. The study was conducted in limited time frame due to which variation in sample characteristics may occur if more time and effort is given.

9 Managerial Implications of the Study

Private label products are in the retail stores from last few decades but still there is a need to understand the consumer psychology by the retailers to increase the market share in India as the country has huge market potential. This study is important for those retailers who are planning to increase their store brands /private label brands acceptance in the market. This study explores retailers' consumers' attitudes, preferences and behaviour towards private label products which will help retailers to devise new strategy for PLB consumers in India. As future of organised retail in India is having tremendous growth potential, unlike developed nations which is having matures organised retail market India is in the nascent stage and in next few years it will compete with developed nations in organised retail market. Hence Private label brand strategy adopted by the big retailers will be the future where retailers will come up with innovative and differentiated private label products which will give intense competition with national brand.

References

Ailawadi, K., Pauwels, K., & Steenkamp, J. B. (2008). Private-label use and store loyalty. *Journal of Marketing, 72,* 19–30.

Ballester, E. D., Esparallardo, M. H., & Orenjuela, A. R. (2014). Store image influences in consumers' perceptions of store brands: The moderating role of value consciousness. *European Journal of Marketing, 48*(9/10), 1850–1869.

Baltas, G. (1997). Determinants of store brand choice: A behavioral analysis. *The Journal of Product and Brand Management, 6*(5), 315–324.

Batra, R., & Sinha, I. (2000). Consumer-level factors moderating the success of private label brands. *Journal of Retailing, 76*(2), 175–191.

Blois, K. J. (2000). *The oxford textbook of marketing.* Oxford University Press.

Burton, S., Lichtenstein, D. R., Netemeyer, R. G., & Garretson. J. A. (1998). A scale for measuring attitude toward private label products and examination of its psychological and behavioral correlates. *Journal of the Academy of Marketing Science,* 293–306.

Collins, D., & Colleen, L. T. (2003). Store brands and retail differentiation: the Influence of store Image and store brand attitude on store own brandperceptions. *Journal of Retailing and Consumer Services, 10,* 345–352.

Diallo, M. F., Chandon, J. L., Cliquet, G., & Philippe, J. (2013). Factors influencing consumer behavior towards store brands: Evidence from the French market. *International Journal of Retail and Distribution Management, 41*(6), 422–441.

Dick, A., Jain, A., & Richardson, P. (1997). How consumers evaluate store brands. *Journal of Pricing Strategy and Practice, 5*(1), 18–24.

Faria, A. J.(1979). Generics: The new marketing revolution. *Akron Business and Economics Review* 33–38.

Garretson, J. A., Fisher, D., & Burton, S. (2002). Antecedents of private label attitude and national brand promotion attitude: Similarities and differences. *Journal of Retailing, 9,* 78–91.

Hoch, S. J., & Banerjee, S. (1993). When do private labels succeed. *Sloan Management Review, 34*(4), 57–67.

Kremer, F., & Viot, C. (2012). How store brands build retailer brand image. *International Journal of Retail and Distribution Management, 40*(7), 528–543.

Kumar N., & Steenkamp. J. (2007). *Private label strategy: How to meet the store brand challenge* (1st ed.). Boston: Harvard Business School Press.

Malhotra, N. K., & Dash, S. (2010). *Marketing research: An applied Orientation* (6th ed.). Pearson Education.

Myers, J. G. (1967). Determination of private brand attitudes. *Journal of Marketing Research, 8,* 409–418.

Nunnally. J. C. (1970). *Introduction to psychological measurement.* New York: McGraw-Hill Book Company.

Roth, M. S. (1995). The effects of culture and socio-economics on the performance of global brand image strategies. *Journal of Marketing Research, 32*(2), 163–175.

Rubel, C. (1995). Price, quality important for private label goods. *Marketing News, 29*(1), 24.

Semeijn, J., Van, A. C. R., & Ambrosini, A. B. (2004). Consumer evaluations of store brands: Effects of store image and product attributes. *Journal of Retailing and Consumer Services, 11*(4), 247–258.

Shukla, P., Banerjee, M., & Adidam, P. T. (2013). The moderating influence of socio-demographic factors on the relationship between consumer psychographics and the attitude towards privatelabel brands. *Journal of Consumer Behaviour, 2*(6), 423–435.

Singh, A., & De, D. A. (2016). A study of factors for private label brands' success in food, grocery and apparels. *International Journal of Management Practice, 9*(1), 93–107.

Singh, A., & Singhal, R. K. (2020). Emerging third generation private label brands: retailers' and consumers' perspectives towards leading Indian retail chains. *International Journal of Business and Emerging Markets, 12*(2), 179–203.

Steenkamp, J., Batra, R., & Alden, D. L. (2003). How perceived brand globalness creates brand value. *Journal of International Business Studies, 34*(1), 53–65.

Prediction of COVID'19 Outbreak by Using ML-Based Time-Series Forecasting Approach

Devesh Kumar Shrivastava, Akhilesh Kumar Sharma, and Sachit Bhardwaj

Abstract

The COVID-19 now became a pandemic and rising rapidly and spreading in all parts of the world like fire. India reported its first COVID-19 case on January 30, when a student arrived in Kerala from Wuhan. Thousands of people are acquiring this deadly virus daily and with many people dying from it. The major concern of all the countries is to protect its citizens and try to eradicate this disease as fast as possible. This paper aims to perform exploratory analysis using the concepts of data science on the confirmed cases, total deaths, and total recovered cases of this virus. The research work predicts the spread of the outbreak for the next five days by using time-series forecasting algorithms. This paper deals with learning about how the corona virus is spreading and using that trend to predict for the upcoming days. It would be able to predict to a suitable accuracy which can help the government learn about the statistics of this disease and prepare further for protection against this. The results are discussed at last with prediction and error estimates.

1 Introduction

In machine learning, patterns are observed using statistics and the learning of model is performed by continuous iterations until an estimation of data prediction is observed. This study most commonly synthesizing useful concepts from the historical data. Machine learning is a method of training machines, i.e., computers to make a prediction based on some training data and experience. Application of machine learning is limitless, i.e., from health care industry to statistical-based conditions of a country. Machine learning is not just limited to a particular field, but it can be used to improve the existing knowledge of a field by learning from the previous data and predictions. In briefly, machine learning is an application of artificial intelligence that automates analytical model building by using an algorithm that iteratively learns from data without being explicitly programmed (Sharma et al., 2018). We can predict the further outcome or predicted outcome by analyzing through time-series order. Patterns like seasonality, trends, irregularity and cyclicity are used as features to predict the upcoming variable of interest. There are various application of time-series forecasting like earthquake prediction, stock market prediction, etc. The performance of the time-series forecasting models can be compared by evaluation error rate. The most in use error rate is root mean squared error.

2 Literature Review

Stephanie et al. (2020) in her research work analyzed the impact of COVID-19 with respect to geographical differences over features like population density, distribution of age, diagnostic capacity, etc. Leeb et al. (2020) in his research work analyzed the impact of COVID-19 targeting the specific age group, i.e., school-going children.

Lim et al. (2020) in his research work analysis the impact of COVID-19 targeting the specific section, i.e., interns

---

D. K. Shrivastava · A. K. Sharma (✉) · S. Bhardwaj
Department of Information Technology, Manipal University Jaipur, Jaipur, Rajasthan, India
e-mail: akhileshshm@gmail.com

D. K. Shrivastava
e-mail: devesh988@yahoo.com

S. Bhardwaj
e-mail: sachitbhardwaj@yahoo.in

287

working in University Hospital. Hayashi et al. (2020) in her research work analyzed the changed seasonal effect of influenza virus and SARS-Cov-2 due COVID-19 rules and regulations.

Wilson et al. (2020) in their research work performed clustering approach over COVID-19 impact on University Campus. Hawas (2020) in his research work performed time-series prediction for daily infection (COVID-19) rates in Brazil using RNN.

Alonso et al. (2020) in their research work discussed the various challenges for post-COVID-19 era and proposed some strategies for them. Lee and Lin (2020) in their research work analyzed the COVID-19 precaution relationships with other common infections and studied the impact of their outburst due to COVID-19. Cardil and de-Miguel (2020) proposed a scenario in his research work where COVID-19 rules and regulations could directly intervene and cause more damage by natural disasters. Filimonau et al. (2020) observed the section in their research work and manifested their commitment toward the job.

3 Methodology

Metric is a measurement of errors between the grouped observations that express the same phenomenon (Sharma, 2015). The most common metric used is root mean squared error (RMSE) which is also used in this paper.

Root mean squared error (RMSE) is calculated as the square root of average of squared differences between actual and predicted observations as shown in Eq. 1. RMSE can be used to penalize large errors as the error is squared before taking average.

$$\text{RMSE} = \sqrt{\sum_{i=1}^{n} \frac{(\hat{y}_i - y_i)^2}{n}} \qquad (1)$$

where $\hat{y}_1, \hat{y}_2, \ldots, \hat{y}_n$ are predicted values, $y_1, y_2, \ldots, y_n$ are observed values and n is the number of observations.

Three time-series csv file datasets were fetched from Kaggle dating from January 22 to March 15. The three datasets are—confirmed, deaths, recovered. There are a of total 451 rows and 58 columns for each of these three datasets with features as province/state, country, latitude, longitude, dates from January 22, 2020 to March 15, 2020. The analysis has been done on all the features excluding the latitude and the longitude of the given locations.

The three csv file datasets were loaded to the Jupiter notebook using Pandas library and were converted into data frames that helped in representing the data through its in-memory 2d table. All the columns were extracted from the datasets using the.key () function. From this, further all the date columns were extracted using the loc () function. The analysis performed on the datasets and then appended into lists was total confirmed cases, total deaths, total recovered. Using these values from the lists, we calculated the mortality rate (total deaths/total confirmed), recovery rate (total recovered/total confirmed). All the dates and cases were converted into Nd array using NumpyPy. The dates stored into datasets were type casted into date-time format from integers and for better visualization. Using the loc () function on the Nd arrays, latest confirmed cases, latest death cases, latest recovered cases were displayed, i.e., from March 5, 2020 to March 15, 2020. The total number of confirmed cases per country was calculated. The unique values of provinces/states were stored, and it was observed that there were a lot of not a number (NAN) values assigned to these provinces/states which were removed using the pop () function. Top ten countries which had the greatest number of cases were calculated. As China was the first country to get affected by this deadly disease, it had the highest number of cases. To analyze this situation, a comparison was made between China and rest of the world on the basis of total number of confirmed cases. The dataset is pre-processed. As the model deals with dependent and independent variables, the dataset is split into training set and test set using the train test split 70% of the dataset is trained first and 30% of the dataset is kept for testing.

Polynomial Regression A polynomial function is used with the concept of curve fitting to forecast the variable of interest as shown in Eq. 2

$$f(x) = c_0 + c_1 x + c_2 x^2 \cdots c_n x^n \qquad (2)$$

where n is the degree of the polynomial and c is a set of coefficients.

Support Vector Machine Regression Poly, sigmoid and Rbf (Gaussian) functions have been set inside the kernel which would further perform parallel processing of the data and produce the optimal function for the most appropriate prediction (Sharma & Shrivastav, 2020).The equation of hyperplane is shown in Eqs. 3 and 4, The Lagrangian form is minimized for w and b, where w is width of the margin and b is the constant.

$$g(x) = w^T x + b \qquad (3)$$

$$J(w, b, \alpha) = \frac{1}{2} w^T w - \sum_{i=1}^{N} \alpha_i d_i (w^T x_i + b) + \sum_{i=1}^{N} \alpha_i \qquad (4)$$

Holt's Linear Model Method proposed by Holt involves two smoothing relations, i.e., trend (b_t) and level (ℓ_t) with a forecast equation ($\hat{y}_{t+ht}$) as shown in Eqs. 5–7.

$$\hat{y}_{t+ht} = \ell_t + hb_t \tag{5}$$

$$\ell_t = \alpha y_t + (1-\alpha)(\ell_{t-1} + b_{t-1}) \tag{6}$$

$$b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)b_{t-1} \tag{7}$$

where $0 \le \alpha \le 1$ (level smoothing parameter) and $0 \le \beta^* \le 1$ (trend smoothing parameter).

Holt's Winter Model Method proposed by Holt involves three smoothing relations, i.e., trend (b_t), level (ℓ_t) and season (s_t) with a forecast equation ($\hat{y}_{t+ht}$) as shown in Eqs. 8–11.

$$\hat{y}_{t+ht} = \ell_t + hb_t + s_{t+h-m(k+1)} \tag{8}$$

$$\ell_t = \alpha(y_t - s_{t-m}) + (1-\alpha)(\ell_{t-1} + b_{t-1}) \tag{9}$$

$$b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)b_{t-1} \tag{10}$$

$$s_t = \gamma(y_t - e_{t-1} - v_{t-1}) + (1-\gamma)s_{t-m} \tag{11}$$

where k is the integer part of $(h-1)/m$, $0 \le \alpha \le 1$ (level smoothing parameter) $0 \le \beta^* \le 1$ (trend smoothing parameter) and $0 \le \gamma^* \le 1$ (seasonal smoothing parameter).

AutoRegressive Model(AR Model) In (autoregressive model (AR model) with the successor of past values of variables, variable of interest can be forecasted using linear combinations. An order of p AR model is shown in Eq. 12.

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t \tag{12}$$

where ε_t is white noise.

Moving Average Model (MA Model) In (moving average model (MA model) with the help of past forecast errors, variable of interest can be fore- casting in a regression alike model by using Eq. 13.

$$y_t = c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \tag{13}$$

where ε_t is white noise.

Autoregressive Integrated Moving Average Model (ARIMA Model) (Autoregressive integrated moving average model (ARIMA model) is the combination of moving average and autoregression model as shown in Eq. 14. It follows the same stationary and invertibility environment as autoregressive and moving average models.

$$y_t' = c + \phi_1 y_{t-1}' + \cdots + \phi_p y_{t-p}' + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t \tag{14}$$

where y_t' is the differenced series.

Facebook's Prophet Model Facebook's Prophet Model predicts over nonlinear variables like trend, seasonality, holidays, idiosyncratic changes which is shown in the Eq. 15.

$$y(t) = g(t) + s(t) + h(t) + e(t) \tag{15}$$

where $g(t)$ is trend models non-periodic changes, $s(t)$ is seasonality which presents periodic changes, $h(t)$ is ties in effects of holidays and $e(t)$ covers idiosyncratic changes not harbored by the model.

The methodology section includes the stepwise algorithmic description where the research article presents the systematic research conducted and analyzed the trend on the COVID-19 dataset. The various algorithms applied and studied, and the conclusion has been presented at last. The mentioned methodology depicts the technical analysis related to the disease trends and the directions of the pandemic with respect to the duration/timing. The stipulated time is increasing, and the resultant spread also increases with the much-affected persons seems to be deadly among individuals Fig. 1 shown methodology.

4 Result

4.1 Polynomial Regression

As shown in Fig. 2, we have predicted the trend of confirmed cases using polynomial regression for the next five days, i.e., September 24, 2020 to September 29, 2020.
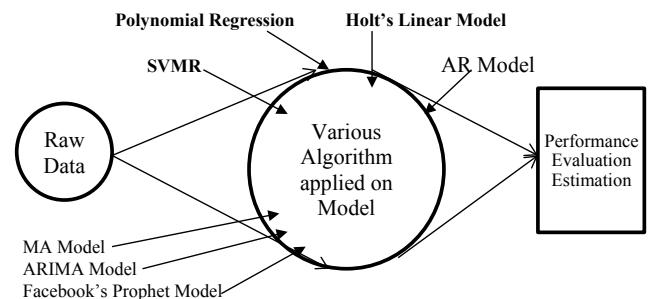

Fig. 1 Methodology
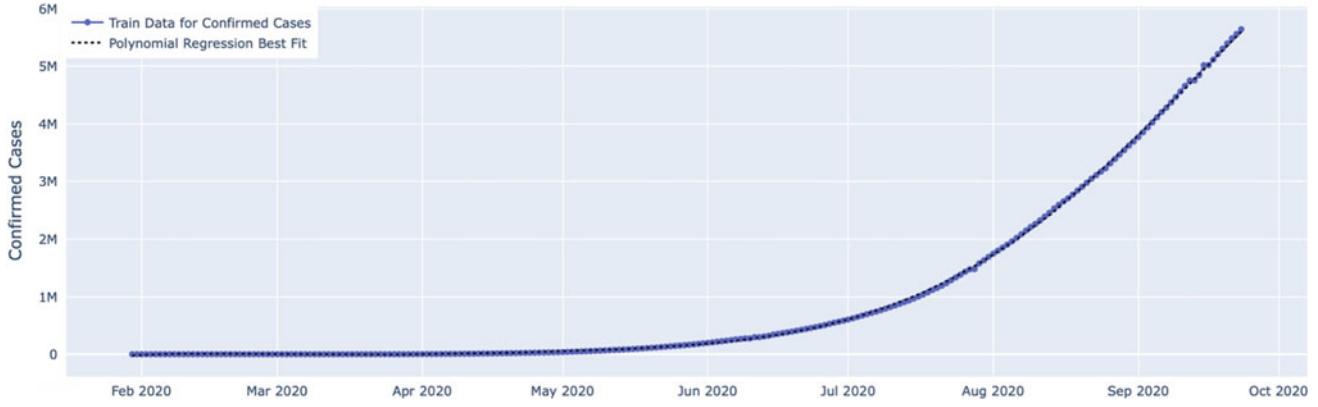
Fig. 2 Polynomial regression

4.2 Support Vector Machine Regressor

As shown in Fig. 3, we have predicted the trend of confirmed cases using support vector machine regressor for the next five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 1,005,399.938. Predicted confirmed cases are 7,387,905, 7,606,222, 7,830,090, 8,059,624, 8,294,945. This model performed worst.

4.3 Holt's Linear Model

As shown in Fig. 4, we have predicted the trend of confirmed cases using Holt's linear model for the next five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 113,382.878. Predicted confirmed cases are 5,909,289, 6,006,013, 6,102,737, 6,199,461, 6,296,186.

4.4 Holt's Winter Model

As shown in Fig. 5, we have predicted the trend of confirmed cases using Holt's winter model for the next five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 224,526.107. Predicted confirmed cases are 6,142,376, 6,284,535, 6,412,858, 6,583,385, 6,740,125.

4.5 AR Model

As shown in Fig. 6, we have predicted the trend of confirmed cases using autoregressive model (AR model) for the next five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 134,715.533. Predicted confirmed cases are 5,954,376, 6,057,034, 6,160,121, 6,263,644, 6,367,599.
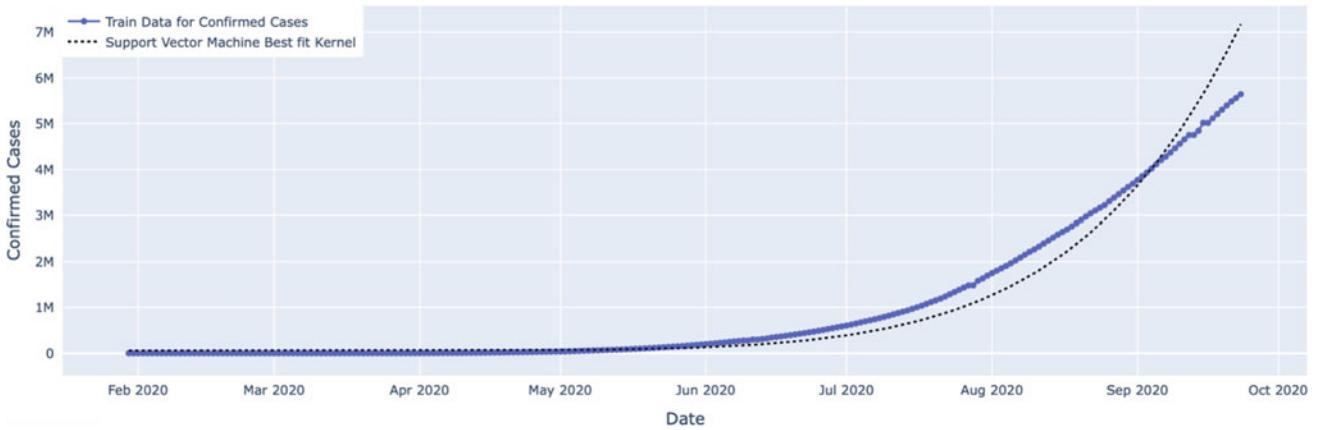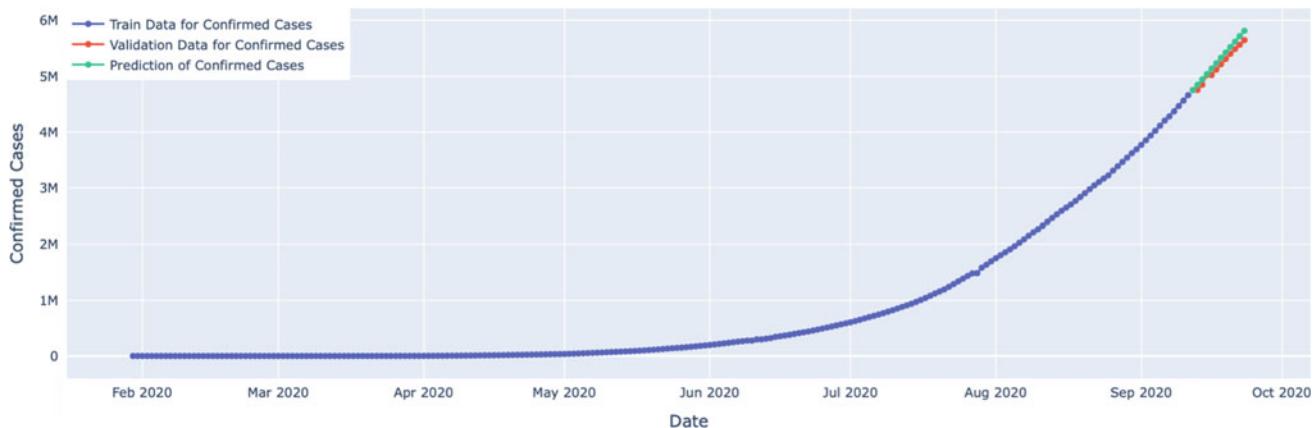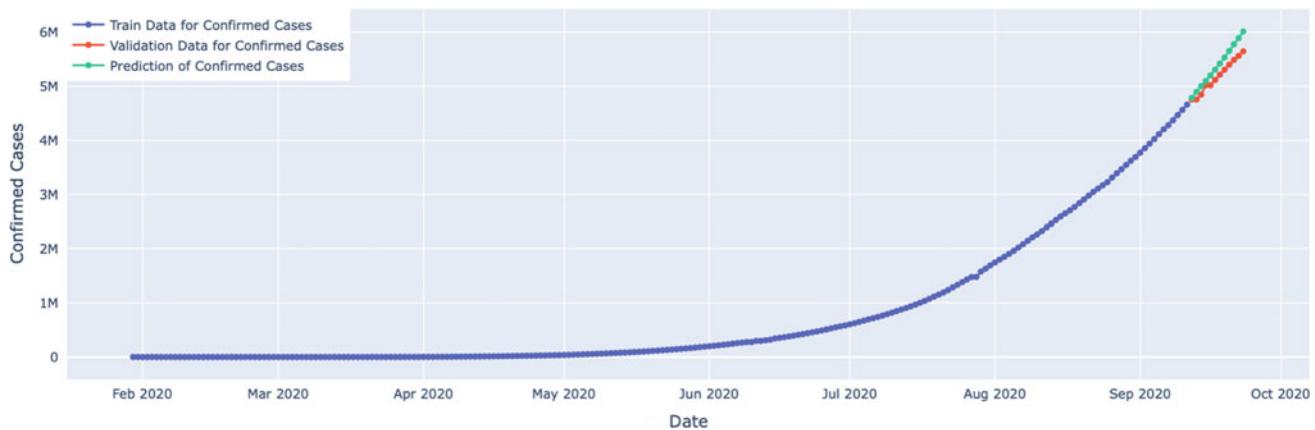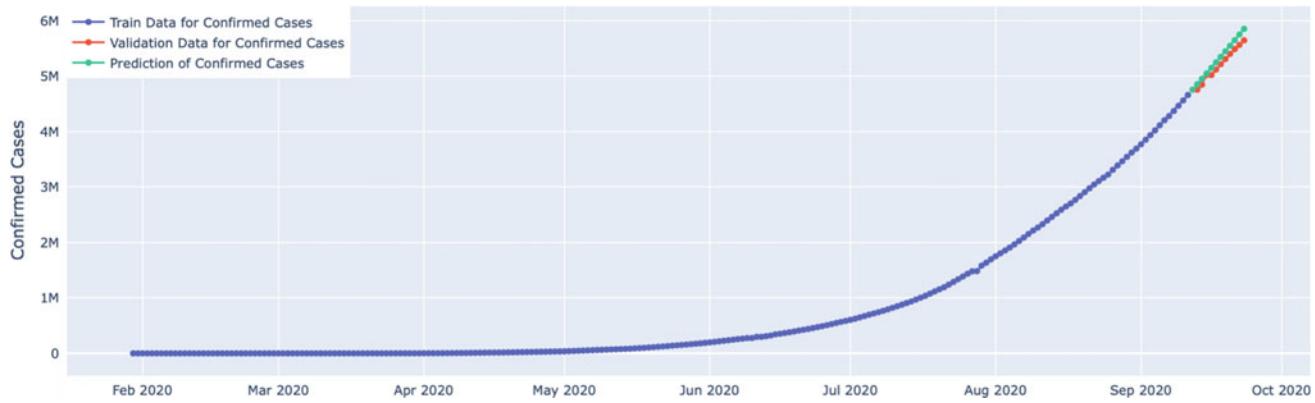

Fig. 3 Support vector machine regressor

Fig. 4 Holt's linear model


Fig. 5 Holt's winter model

Fig. 6 AR model

4.6 MA Model

As shown in Fig. 7, we have predicted the trend of confirmed cases us polynomial regression for the next five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 37,850.063. Predicted confirmed cases are 5,682,521, 5,760,792, 5,839,125, 5,914,426, 5,989,599. This model performed as second best for MA model.
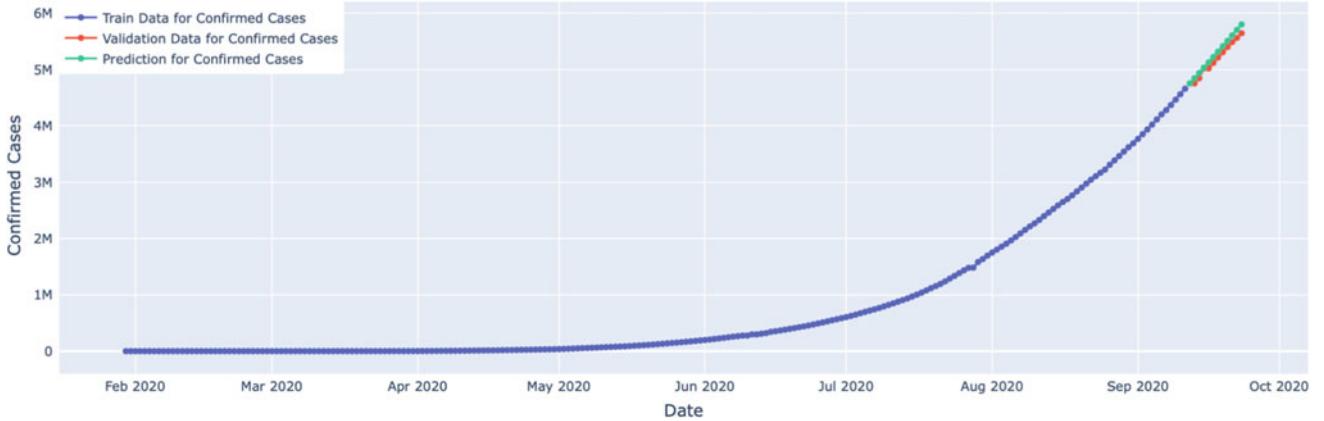
Fig. 7 MA model

4.7 ARIMA Model

As shown in Fig. 8, we have predicted the trend of confirmed cases using (autoregressive integrated moving average model (ARIMA model) for the next five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 112,111.823. Predicted confirmed cases are 5,912,914, 6,012,312, 6,112,132, 6,212,373, 6,313,037.

4.8 Facebook's Prophet Model

As shown in Fig. 9, we have predicted the trend of confirmed cases using Facebook's Prophet model for the next

five days, i.e., September 24, 2020 to September 29, 2020. The root mean squared error (RMSE) was observed to be 36,248.027. Predicted confirmed cases are 5,598,438, 5,674,748, 5,751,535, 5,825,041, 5,899,729, whereas the upper bounds for the respective days are 5,666,743, 5,745,622, 5,824,853, 5,897,610, 5,968,758. This model performed bet.

4.9 Average of All Models

The average of all the prediction model's prediction for confirmed cases in the period between September 24–28 are observed as 6,017,199, 6,127,316, 6,236,641, 6,350,228, 6,462,896 (Figs. 10 and 11).
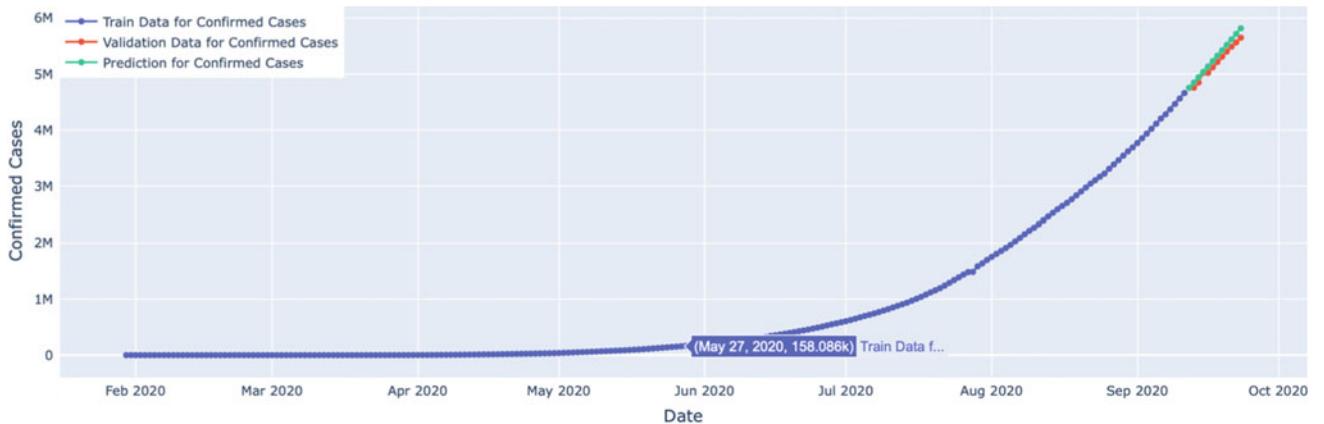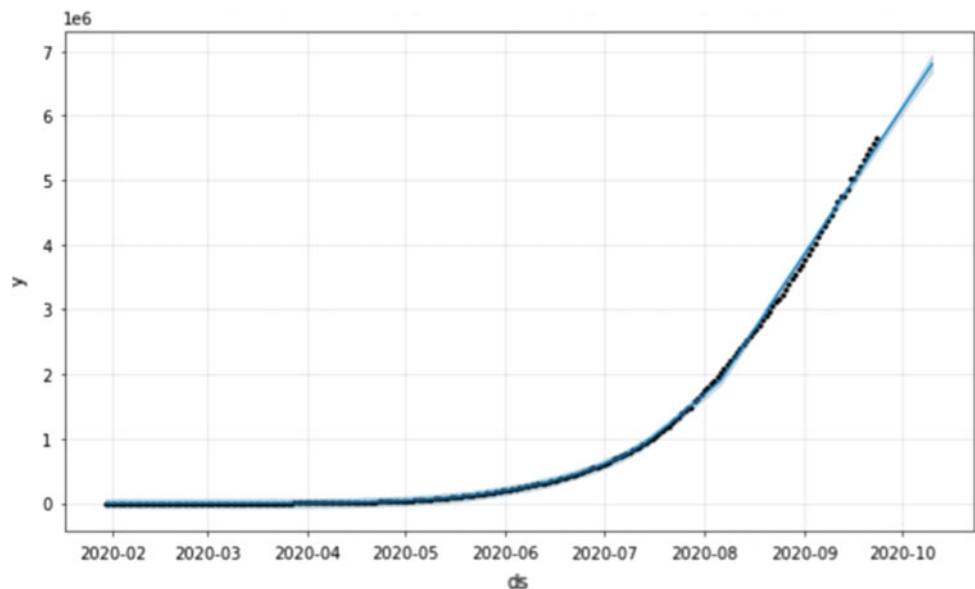

Fig. 8 ARIMA model

Fig. 9 Facebook's Prophet model

5 Conclusion and Future Work

From the analysis and the prediction, it is evident that corona virus is growing at a very rapid pace. It raises a serious concern in the world as its affects are catastrophic. It is a deadly virus which has taken up many lives and continues to do the sam. It is need of the hour to know about its effects on the whole world. This project helps the government in analyzing the situation and predicting its future outcomes so that preventive measures can be taken to contain and prevent this widely spreading disease.

The following work can be considered as future work:

1. Applying geospatial analysis, i.e., manipulating the data with the help of longitude and latitude of a place which would help in containing a place in which the outbreak has taken place at large scale so that it is localized to that certain area and not allowing it to spread any further.
2. Using a graphical user interface which would help in analyzing the situation in a more user-friendly way.

Model Name	Root Mean Squared Error
7 Facebook's Prophet Model	36248.027538
0 Polynomial Regression	37850.063460
5 Moving Average Model (MA)	105576.927210
6 ARIMA Model	112111.823352
2 Holt's Linear Model	113382.878426
4 Auto Regressive Model (AR)	134715.533347
3 Holt's Winter Model	224526.107572
1 Support Vector Machine Regresssor	1005399.938112

Fig. 10 Root mean squared error of all models

Date	Polynomial Regression Prediction	SVM Prediction	Holt's Linear Model Prediction	Holt's Winter Model Prediction	AR Model Prediction	MA Model Prediction	ARIMA Model Prediction	Prophet's Prediction	Prophet's Upper Bound	Average of Predictions Models
2020-09-24	5682521	7387905	5909289	6142376	5954376	5900231	5912914	5598438	5666743	6017199
2020-09-25	5760792	7606222	6006013	6284535	6057034	5998567	6012312	5674748	5745622	6127316
2020-09-26	5838125	7830090	6102737	6412858	6160121	6097322	6112132	5751535	5824853	6236641
2020-09-27	5914426	8059624	6199461	6583385	6263644	6196495	6212373	5825041	5897610	6350228
2020-09-28	5989599	8294945	6296186	6740125	6367599	6296088	6313037	5899729	5968758	6462896

Fig. 11 Prediction of all models

References

Alonso, A. K., Bressan, S., O'Shea, A., Sakellarios, M., IaosKoresis, N., Solis, A., Santoni, M., & Leonardo. (2020). COVID-19, aftermath, impacts, and hospitality firms: An international perspective. *International Journal of Hospitality Management, 91*, 102654. https://doi.org/10.1016/j.ijhm.2020.102654

Cardil, A., & de-Miguel, S. (2020). COVID-19 jeopardizes the response to coming natural disasters. *Safety Science, 130*, 104861. https://doi.org/10.1016/j.ssci.2020.104861.

Filimonau, V., Derqui, B., & Matute, J. (2020). The COVID-19 pandemic and organizational commitment of senior hotel managers. *International Journal of Hospitality Management, 91*, 102659. https://doi.org/10.1016/j.ijhm.2020.102659. Epub 2020 Aug 31. PMID: 32904709; PMCID: PMC7458044.

Hawas, M. (2020). Generated time-series prediction data of COVID-19's daily infections in Brazil by using recurrent neural networks. *Data Brief, 32*. 106175. https://doi.org/10.1016/j.dib.2020.106175. Epub 2020 Aug 19. PMID: 32839733; PMCID: PMC7437445.

Hayashi, T., Yaegashi, N., Konishi, I. (2020). *COVID-19 era, preventive effect of no going out against co-infection of the seasonal influenza virus and SARS-CoV-2*. Cold Spring Harbor Laboratory Press. 09.27.20202739.

Lee, H. H., & Lin, S. H. (2020). Effects of COVID-19 prevention measures on other common infections, Taiwan. *Emerging Infectious Diseases, 26*(10), 2509–2511. https://doi.org/10.3201/eid2610.203193. Epub 2020 Jul 30. PMID: 32730735; PMCID: PMC7510692.

Leeb, R. T., Price, S., Sliwa, S., Kimball, A., Szucs, L., Caruso, E., Godfred-Cato, S., & Lozier, M. (2020). COVID-19 trends among school-aged children United States, March 1–September 19, 2020.

Lim, W., Teoh, L. Y., Seevalingam, K. K., & Kuppusamy, S. (2020). *COVID-19 pandemic in University Hospital: Is there an effect on the medical interns?* Cold Spring Harbor Laboratory Press. 10.01.20205112.

Sharma, A. K., & Shrivastav, D. (2020). Statistical approach to detect Alzheimer's disease and autism spectrum-related neurological disorder using machine learning. In *Proceedings of SmartCom 2020. Smart Innovation, Systems and Technologies* (Vol. 182). Berlin: Springer.

Sharma, A. K., et al. (2015). Categorization of ICMR Using feature extraction strategy and MIR with ensemble learning. *Procedia Computer Science, 57*(201), 686–694.

Sharma, A. K., Chaurasia, S., & Srivastava, D. K. (2018). Supervised rainfall learning model using machine learning algorithms. In *Intelligent systems and computing book series* (Vol. 723, pp. 275–283).

Stephanie, B., Virginia, B., Nancy, C., Aaron, C., Ryan, G., Aron, H., Michelle, H., Tamara, P., Matthew, R., Katherine, R., Benjamin, S., Tami, S., Preethi, S., Emily, U., Michael, V., Hilary, W., & John, W. (2020). Geographic differences in COVID-19 cases, deaths, and incidence United States, February 12–April 7, 2020.

Wilson, E., Donovan, C. V., Campbell, M., Chai, T., Pittman, K., Sena, A. C., Pettifor, A., Weber, D. J., Mallick, A., Cope, A., Porterfield, D. S., Pettigrew, E., & Moore, Z. (2020). Multiple COVID-19 clusters on a University Campus—North Carolina, August 2020.

A Review on COVID-19 Diagnosis Using Imaging and Artificial Intelligence

Sourabh Singh Verma, Santosh K. Vishwakarma,
and Akhilesh Kumar Sharma

Abstract

The coronavirus epidemic is still on a surge and has harsh impacts on various factors across the globe including the economy and health. Though the recovery rate is also increasing, daily reporting cases are also increasing substantially. The best way till now is to take precautions and following the government guidelines. Till today, many different countries are line up to produce effective vaccination, but still, no such vaccine has completed its trial, and further, it will take a long time for the production and distribution among common citizens. We currently have a test process known as reverse transcription-polymerase chain reaction (RT-PCR) that is not reliable during the early stage of the disease. Also, a fast diagnosis is required as RT-PCR is time taking operation. Hence, imaging can be useful for the diagnosis as it can be quick and more reliable even in the early stage of the COVID-19 disease. Artificial techniques can be applied to radiological images such as CT scans and X-rays. In this article, we review the various research and responses in diagnosing the said disease using AI techniques on radiological images. Our findings suggest that using AI techniques like Convolution Neural Networks plays an important role in the diagnosing the COVID-19 by providing quick results and accuracy.

Keywords

COVID-19 • Diagnose • Survey • Review • Corona • Machine learning

S. S. Verma · S. K. Vishwakarma (✉) · A. K. Sharma
SCIT Manipal University Jaipur, Jaipur, Rajasthan, India
e-mail: santoshscholar@gmail.com

S. S. Verma
e-mail: ssverma80@gmail.com

A. K. Sharma
e-mail: akhileshshm@gmail.com

1 Introduction

The coronavirus outbreak emerges initially in December 2019 (Wu et al., 2020; Huang et al., 2020), still, it is surging in various countries. To date around the globe, there are 1,090,734 infected case reported out of which 28,845,540 has recovered and 976,038 deaths are reported.[1] It was declared as a pandemic by the World Health Organization in March 2020 (World Health Organization, 2019). As per numbers, the mortality rate is quite low 3.07%, and the recovery rate is 73.6%. However, the mortality rate is quite high for the critical patient (Rothan & Byrareddy, 2020), or the patient who is already suffering from some issues.

There are varying levels of symptoms related to the COVID-19, and typically, it includes distress in respiration apart from its symptoms may also include normal flu symptoms like headache, fever, cough, fatigue, muscular stress, etc. Unlike SARS, it not only has a bad impact on the respiratory system but also affects other vital organs such as kidney and liver (McIntosh, 2019). The current potential test procedure reverse transcription-polymerase chain reaction (RT-PCR) required to be done repeatedly to confirm the status of the patient, and also, it is not accurate in asymptotic or initial stage. The accuracy and efficiency issues of RT-PCR lead to innovate a new way to effectively and quickly diagnose. From experience, radiology images are used for the diagnosis of various diseases. These images can be used as a supplement or follow-up process of PCR. Particularly, radiological chest images such as X-rays and compound tomography (CT) can be used in the early stages of the disease (Zu et al., 2019).

The main objective of this research article is to survey various quality articles published in the field of COVID-19 diagnosis with the help of artificial intelligence techniques especially machine learning. Their extensive experiments are compared considering evaluated parameters and metrics.

---

[1] https://www.worldometers.info/coronavirus/ last accessed 2020/10/08.

This article will help researchers to compare various published researches add will also get comprehensive information about Covid-19 to add it's a dataset available across the research community. The remaining content of this paper includes Sect. 2, it will introduce important features of machine learning algorithms, and it will also highlight the different matrices that are used to measure results. Section 3 will include various comparisons done in this survey to analyze potential models to diagnose COVID-19.

2 Basic Taxonomy for Machine Learning Diagnosis COVID-19

In most of the recent research on COVID-19 diagnosis, it has been observed that most researchers are using available convolution neural networks models CNN or proposing their own CNN models. As it shows promising results with high accuracy of detection of the disease. Unlike ANN models that have only fully connected nodes, CNN has multiple layers with different functions such as feature extraction using the convolution matrix as shown in Fig. 1. It also uses an activation function to introduce non linearity such as sigmoid and ReLu. It also uses Max pool layers to minimize the spatial dimensions of the input. CNN also uses dropouts for thining the network during the training phase, and to prevent overfitting, thus it will improve the effectiveness of the whole model. An overall CNN model is shown in Fig. 1 with multiple layers and including Max pool and fully connected layer.

Convolution layer in CNN is used to apply a convolution filter/kernel to the image to produce the required resulting feature where each convolution filter represents some feature of interest, as shown in Fig. 2. Not like fully connected layers, the convolution layer helps to reduce the number of input pixels. Various filters are used to extract different features from images. For an input image I and filter F, the convolution step is shown in Eq. (1) as follows:

$$(I * F)(i,j) = \sum_a \sum_b F(a,b)I((i-a)(j-b)) \quad (1)$$

where a, b are index in filter matrix and i, j are index in the image.

In Fig. 2, we have moved the kernel by one step, and this is known as a stride. The stride may be large if you do not want to override the pixels of the input image. After going through the convolution process, the dimensionality can be further reduced by using pooling. The most used pooling is known as Max pooling which considers the maximum value in the pool window and ignores others. Mostly, authors reviewed in this article have used Max pooling to reduce the dimension. The whole process in CNN includes training of the model and testing of the model, and for this, the whole input is divided into two sets of test data and train data randomly.

3 Review on Proposed Models and Evaluation Comparisons

3.1 Evaluation Metrics and Confusion Metrics

To understand the various survey conducted, it is important to know the evaluation parameters and metrics used to verify
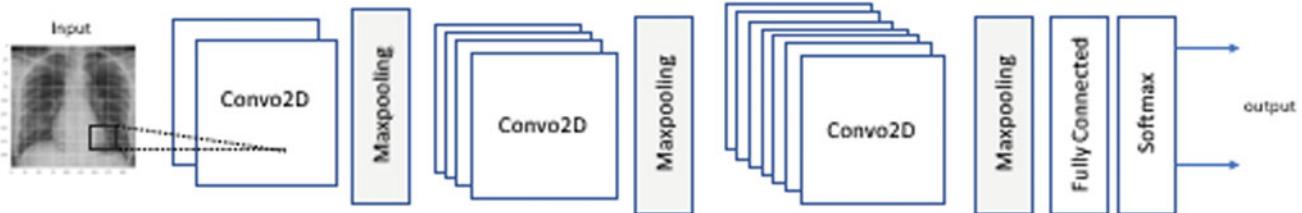

Fig. 1 Convolution neural network


Fig. 2 Convolution process for feature extraction using kernel
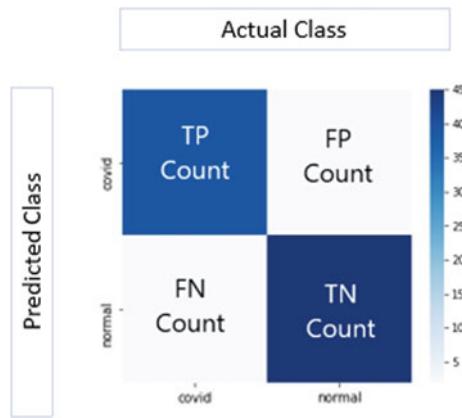
Fig. 3 Convolution metrics

a. Datasets and image distribution
b. Experimental setup and review on performance metrics of proposed machine learning models.

Based on the above facts, these models were reviewed and compared.

3.2 Datasets

There are various free datasets are available which consist of X-ray images of COVID-19, pneumonia, SARS and normal persons. As per the present scenario, availability of COVID-19 X-ray images is much less than what is available for the other disease and normal ones. The dataset and images used by the proposed articles are represented in Table 2 as follows.

The augmentation can be used to increase the number of COVID images, as only 66 images (Ucar & Korkmaz, 2020) are available in the given dataset, and a large number of normal and pneumonia images are available. This may be efficient to predict the cases which are COVID negative, but as the task is to diagnose COVID cases using X-ray, it was required that number of positive images must be increased, so various types of image augmentation are applied to outcome 1229 COVID images.

the results of any proposed CNN models. All the evaluation parameters are derived from the confusion metrics. The confusion matrix has four quadrants that can be seen in Fig. 3.

All the research papers we reviewed have discussed and used the confusion metrics for processing the research. The confusion matrix consists of four quadrants, and these are True Positive TP, False Positive FP, False Negative FN and True Negative TN. TP is the number of positive cases correctly identified in the model, and FP is the number of positive cases wrongly identified as negative cases. FN is the count of negative cases wrongly identified as positive cases, and TN is the count of total negative cases correctly identified as negative. To be an ideal classification, it is required that FN and FP should be zero.

Based on four quadrants of confusion matrix, Table 1 shows different metrics that can be evaluated.

For a detailed review, we will compare and review a limited set of quality published articles such as (Rahimzadeh & Attar, 2020; Mohammed, 2020; Ucar & Korkmaz, 2020; Mahmud et al., 2020).

These all articles have proposed some new models or modified the existing models to improve the results, i.e., efficiency and effectiveness of the updated model for giving better results. To review these articles, we have considered the following important facts:

3.3 Result Discussion and Review on Performance Metrics of Compared Machine Learning Models

Before starting with the result comparison, let us get a brief on the methodology used in these models. Model (Rahimzadeh & Attar, 2020) manages to use an unbalanced dataset to train efficiently. They also propose a model, that is a concatenation of Xception and ResNetV20 model. The overall accuracy obtained for all the cases is 91.4% (Mohammed, 2020) uses the DarkNet model (Redmon et al., 2017) as the basis for classification, and it is using seventeen layers of convolution layers followed by flattening. It uses

Table 1 Performance metrics

Metrics	Equations	Desire value	
		Most	Least
Accuracy (ACC)	$(N_{TP} + N_{TN})/(N_{TP} + N_{TN} + N_{FN} + N_{FP})$	1	0
Sensitivity	$N_{TP}/(N_{TP} + N_{FN})$	1	0
Specivity	$N_{TN}/(N_{TN} + N_{FP})$	1	0
Precision	$N_{TP}/(N_{TP} + N_{FP})$	1	0
False positive rate	$N_{FP}/(N_{TN} + N_{FP})$	0	1
F-Score	$(2 \times \text{Precision} \times \text{sensitivity}/(\text{precision} + \text{sensitivity})$	1	0

Table 2 Dataset and image distribution

Article	Dataset	Input images		Distibution (others)	Augmentation
		Covid-19	Others		
Rahimzadeha and Attar (2020)	Chestxray dataset (https://github.com/ieee8023/covid-chestxray-dataset and (https://www.kaggle.com/c/rsna-pneumonia-detection-challenge	149	484	250 normal 234 pneumonia	Yes
Mohammed (2020)	Xu (2020), Wang et al. (2017)	127	1000	500 normal 500 pneumonia	No
Ucara and Korkmaz (2020)	Chest X-ray dataset (Cohen, 2020) and Kaggle chest X-ray pneumonia dataset (Kermany et al., 2018)	66	5245	1349 normal 2896 pneumonia	Yes {after augmentation 1229 each case of Covid19, pneumonia and Normal}
Mahmud et al. (2020)	X-Ray images collected in Guangzhou Medical Center, China	305	915	305 normal 305 bacterial pneumonia 305 viral pneumonia	No

Table 3 Comparison chart for performance metrics

| Article	Model	Experimental setup	Compared with	Performance metrics in %				
				Accuracy	Sensitivity	Specificity	Precision	F1-Score
Rahimzadeh and Attar (2020)	Xception and ResNet50V2 concatenation	GPU: Tesla P100 RAM:25 GB At Google collaborator (using Keras)	Xception, ResNet50V2	99.50	80.53	99.56	35.27	48.9
Mohammed (2020)	DarkCovidNet	Not specified	Ioannis (2020), Wang and Wong (2020), Sethy and Behra (2020), Hemdan et al. (2020), Narin et al. (2020), Song et al. (2020), Wang et al. (2020), Zheng et al. (2020), Xu et al. (2020)	98.08	95.13	95.3	98.03	96.51
Ferhat Ucara et al. (Ucar and Korkmaz 2020)	COVIDiagnosis-Net	GPU: Quadro M4000 RAM:32 GB using Matlab	Li and Zhu (2020), Wang and Wong (2020), Afshar et al. (2020), Farooq and Hafeez (2020), Chowdhury et al. (2020)	98.3	98.3	99.1	98.3	98.3
Mahmud et al. (2020)	CovXNet	GPU: NVIDIA RTX 2080 Ti with 4608 CUDA cores RAM: 24 GB	Residual, Inception, VGG16	97.4	97.8	94.7	96.3	97.1
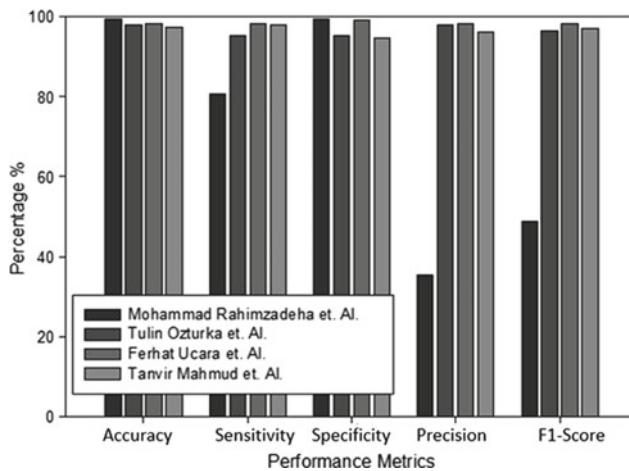
Fig. 4 Visualization depicting comparison of performance metrics

LeakyRelU operations for nonlinearity, in classification, it was successful to mark accuracy of 98% for binary classification that is much higher comparing with multiclass classification. Squeezenet with Baysen optimization is used (Ucar & Korkmaz, 2020) to design a model for COVID-19 cases. Different convolution stride sizes and paddings are used for model configuration, and to increase the number of infected images, it uses image augmentation with different parameters such as sheer, flip, brightness, and noise. It is classifying the images into three categories COVID, pneumonia and normal, overall accuracy is 98.26%, while overall specificity is 99.13%. In CovXNet (Mahmud et al., 2020), the metalerner is introduced to process on different shapes of input images, and it uses Relu as an activation function. In binary classification, its accuracy is up to 97.4%.

To elaborate the comparison, in Table 3, we have shown different performance metrics, models, and data on which these articles are analyzed. The accuracy for COVID-19 image detection ranges from 97.44 to 99.50, the sensitivity ranges from 80.53 to 98.3, precision ranges from 35.27 to 98.3, the minimum value of specificity is 94.7, while the maximum is 99.56 and range 48.9–98.3 in terms of F1-score. The plot in Fig. 4 visualizes comparisons using the given proposed models with different performance metrics. The result in the plot is itself illustrative for instance, and it shows (Wu et al., 2020) is having highest accuracy. In this visualization, all metrics are shown in percentage

4 Conclusion

From literature and previous experiments, it is found that the deep learning method is a rapid and accurate way to classify the images into binary or multiclass images. During the COVID period, various researchers contributed their work using deep learning models to examine the radiological images. Researchers and contributors are still adding CT and X-ray images in the open datasets. In this paper, we surveyed on proposed models for COVID-19 diagnosing using radiological images. For comparisons, we have considered various metrics such as accuracy, sensitivity, specificity, and F1 score. It is found that deep learning models are very promising for COVID-19 detection, and the accuracy of these models ranges from 97.4 to 99.50%. For the urgent need, in the future, computer vision will be contributing farther to investigate such viral infections.

References

Afshar, P., Heidarian, S., Naderkhani, F., Oikonomou, A., Plataniotis, K. N., Mohammadi, A., et al. (2020). Covid-Caps: A capsule network-based framework for Identification of Covid19 cases from X-Ray images. https://arxiv.org/abs/2004.02696.

Chowdhury, M. E. H., Rahman, T., Khandakar, A., Mazhar, R., Kadir, M. A., Mahbub, Z. B., et al. (2020). Can AI help in screening Viral and COVID-19 pneumonia? https://arxiv.org/abs/2003.13145.

Cohen, J. P., Morrison, P., Dao, L. (2020). *COVID-19 image data collection*. https://arxiv.org/abs/2003.11597.

Farooq, M., & Hafeez, A. (2020). COVID-ResNet: A deep learning framework for screening of COVID19 from radiographs. http://arxiv.org/abs/2003.14395.

Hemdan, E. E. D., Shouman, M. A., & Karar, M. E. (2020). COVIDX-Net: A framework of deep learning classifiers to diagnose COVID-19 in X-Ray images. https://arxiv.org/abs/2003.11055.

Huang, C., Wang, Y., et al. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet, 395*(10223), 497–506.

Ioannis D. A., & Bessiana, T. (2020). COVID-19: automatic detection from X-Ray images utilizing transfer learning with convolutional neural networks. https://arxiv.org/abs/2003.11617.

Kermany, D., Zhang, K., & Goldbaum, M. (2018). Labeled optical coherence tomography (OCT) and chest X-Ray images for Classification. Mendeley Data, V2. http://dx.doi.org/10.17632/rscbjbr9sj.2.

Li, X., & Zhu, D. (2020). COVID-Xpert: An AI powered population screening of COVID-19 cases using chest radiography images. https://arxiv.org/abs/2004.03042.

Mahmud, T., Rahman, M. A., & Fattah, S. A. (2020). CovXNet: A multi-dilation convolutional neural network for automatic COVID-19 and other pneumonia detection from chest X-ray images with transferable multi-receptive feature optimization. *Computers in Biology and Medicine, 122*, 103869.

McIntosh, K. (2020). *Coronavirus disease 2019 (COVID-19): Epidemiology, virology, clinical features, diagnosis, and prevention*. 2020-04-10.

Mohammed, K. (2020). Automated detection of COVID-19 coronavirus cases using deep neural networks with X-ray images. *Al-Azhar University Journal of Virus Researches and Studies*.

Narin, A., Kaya, C., & Pamuk, Z. (2020). Automatic detection of coronavirus disease (COVID- 19) using X-Ray images and deep convolutional neural networks. https://arxiv.org/abs/2003.10849.

Rahimzadeh, M., & Attar, A. (2020). A modified deep convolutional neural network for detecting COVID-19 and pneumonia from chest X-ray images based on the concatenation of Xception and ResNet50V2. *Informatics in Medicine Unlocked, 19*, 100360.

Redmon, J., & Farhadi, A. (2017). Yolo9000: Better, faster, stronger. https://arxiv.org/abs/1612.08242.

Rothan, H. A., & Byrareddy, S. N. (2020). The epidemiology and pathogenesis of coronavirus disease(COVID-19) outbreak. *Journal of Autoimmune* 102433.

Sethy, P. K., & Behera, S. K. (2020) Detection of coronavirus disease (COVID-19) based on deep features. *Preprints* 2020, 2020030300 (https://doi.org/10.20944/preprints202003.0300.v1).

Song, Y., Zheng, S., Li, L., Zhang, X., Zhang, X., Huang, Z., & Chong, Y. (2020). Deep learning enables accurate diagnosis of novel coronavirus (COVID-19) with CT images, medRxiv.

Ucar, F., & Korkmaz, D. (2020). COVIDiagnosis-Net: Deep Bayes-SqueezeNet based diagnosis of the coronavirus disease 2019 (COVID-19) from X-ray images. *Medical Hypotheses, 140,* 109761.

Wang, X., Peng, Y., Lu, L., Lu, Z., Bagheri, M., Summers, R. M. (2017). Chestx-ray8: Hospital-scale chest x-ray database and benchmarks on weakly-supervised classification and localization of common thorax diseases. In *Conference 2017, Conference on Computer Vision and Pattern Recognition* (pp. 2097–2106). Honolulu: IEEE.

Wang, S., Kang, B., Ma, J., Zeng, Z., Xiao, M., Guo, J., & Xu, B. (2020). A deep learning algorithm using CT images to screen for Corona Virus Disease (COVID-19), medRxiv.

Wang, L., & Wong, A. (2020). *COVID-Net: A tailored deep convolutional neural network design for detection of COVID-19 cases from chest radiography images*. https://arxiv.org/abs/2003.09871.

World Health Organization. (2019). Novel Coronavirus(2019-nCoV) Situation Report-30. https://www.who.int/docs/defaultsource/coronaviruse/situationreports/20200219-sitrep-30-covid-19.pdf?sfvrsn=6e50645_2.

Wu, F., Zhao, S., Yu, B., et al. (2020). A new coronavirus associated with human respiratory disease in China. *Nature, 579*(7798), 265–269.

Xu, X., Jiang, X., Ma, C., Du, P., Li, X., Lv, S., et al. (2020). *Deep learning system to screen coronavirus disease 2019 pneumonia, engineering*, In Press. arXiv preprint arXiv:200209334.

Xu, X., Jiang, X., Ma, C., Du, P., Li, X., Lv, S., et al. (2020). Deep learning system to screen coronavirus disease 2019 pneumonia. arXiv preprint arXiv:200209334.

Zheng, C., Deng, X., Fu, Q., Zhou, Q., Feng, J., Ma, H., & Wang, X. (2020). Deep learning-based detection for COVID-19 from chest CT using weak label, medRxiv.

Zu, Z. Y., Jiang, M. D., Xu, P. P., Chen, W., Ni, Q. Q., Lu, G. M., & Zhang, L. J. (2020). Coronavirus disease 2019 (COVID-19): A perspective from China. *Radiology*. https://doi.org/10.1148/radiol.2020200490.

Mobile Robot Path Planning Approaches: Recent Developments

Raashid Manzoor and Neerendra Kumar

Abstract

Robotics is the current growing technology with various applications in many fields practiced so far. The bit-by-bit strategies are assembled to know the growth of way arranging systems in different environmental situations and to spot the research gap. It reviews the most important contributions to the mobile robot path planning field from classical approach to heuristic approaches. The classical approaches include cell decomposition method, road map method, artificial potential field method; heuristic approaches such as genetic algorithm (GA), neural network (NN), ant colony optimization (ACO), and particle swarm optimization (PSO) are studied. Because of the numerous computational problems, heuristic methods outperformed the classical methods and gained great reputation. The navigation of static and dynamic surroundings is also examined and it has been remarked that the heuristic approaches have executed efficiently in all aspects when differentiated with classical methods. The paper ended up with tabular knowledge, and graphs analyzed the regularity of separate navigational policies which can be utilized for particular implementation during robot navigation.

Keywords

Classical approach • Heuristic approach • Path planning

1 Introduction

Robots soon will quickly be involved in day-to-day lives of humans as research is now moving toward mobile robots that can help us in our daily lives. Robots are machines which mimic human productivities in which sensor are used for sensing, actuators for decision making, and effectors for output.

1.1 Robot Navigation

Navigation is one of the most important process of robotics. Navigation is the process of precisely determining one's location and moreover, it is a desperate need and necessity for all mobile robots to plan and follow the path. Two main categories by which robotic navigation has been solved are deterministic algorithms and non-deterministic algorithms, and nowadays evolutionary algorithms which are hybridizing of both deterministic and non-deterministic algorithms are being used to solve the problems. In robot route, way arranging is one of the significant undertakings and hence, pulled in numerous researchers in the ongoing time in Hidalgo-Paniagua et al. (2016). Worldwide way organizer and nearby way organizer are the two primary pieces of the route arrangement of independent robot. The route cycle can be subisolated into two sections, worldwide route and nearby route. Worldwide route strategy is utilized to discover internationally ideal way based on the environment. Anyway without satisfactory cloister data, the worldwide route technique is not appropriate consequently nearby route strategy can likewise be applied when the environment is obscure or priory obscure. In robot navigation, obstacle avoidance is one of the significant assignments (Kumar & Vámossy, 2018c). Hindrances in the robot's way can be sorted as static and dynamic. Static are those which do not change their position and direction. Dynamic changes their position or direction after the beginning of route measure,

R. Manzoor
Department of Computer Science and Information Technology, Central University of Jammu, Samba, 181143, India
e-mail: raashidbhat123@gmail.com

N. Kumar (✉)
School of Applied Informatics and Applied Mathematics, Óbuda University, Budapest, Hungary
e-mail: neerendra.kumar@phd.uni-obuda.hu

different necessities of impediment shirking can be fulfilled for the changing separation among robot and the hindrances (Mousazadeh et al., 2018). The scope to analyze in uncertain environment is important in people. Like, if we human need to cross a road, if there is no movement of objects or things moving from the road, we cross the road safely. But if there is movement of objects, our focal point is on the objects coming toward us, then we stand by and mark the actual time to move to the other point. Then we choose whether to cross the road or not. In order to copy human, so the robot has potential to navigate in dynamic environment without colliding with the objects. For mobile robot to move in dynamic environment, where there are number of objects and human is challenging task due to the difficult structure of given environment. To overcome the situation of path planning, various algorithms based on deterministic, non-deterministic, and neural network are developed (Pandey, 2017) now robot can maintain and can take their own decision without human manipulation.

Navigation components

The components that a navigation robot needs are shown in Fig. 1.

- Sensors to obtain impressions of the current locations.
- Cognition to perceive sensed data. A control system to execute the required behavior.
- A control system to execute the required behavior.

2 Literature Review

The author of the paper mainly focused on the following problems in robot navigation:

I. Optimal path planning
II. Collision prevention.
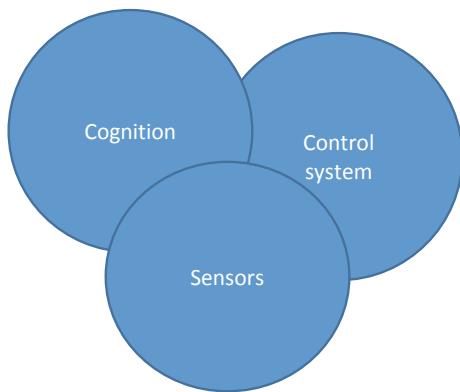
Fig. 1 Navigation components

For mobile robots good path planning of versatile robots can spare a ton of time, yet in addition lessen capital speculation of portable robot (Zhang et al., 2018). Right now, the path planning issue is one of the most investigated points in independent advanced mechanics. That is the reason finding a protected way in troublesome climate is a significant necessity for the accomplishment of any automated undertaking (Hassani et al., 2018). In Hassani et al. (2018), in addition to this also find shortest path from start to goal position. Mobile robots, having to navigate in a dynamic environment, are too demanding a job as the position of obstacles is not known before the navigation process begins. Many of the researchers have put up with collision-free robot navigation, after path planning was proposed to avoid obstacles (Khan & Ahmmed, 2016). The authors have used range sensors as the sensing element for localization. The issue of way arranging in obscure climate does not have any data of its current circumstance yet approaches past aggregated from route measure (Saha & Dasgupta, 2017). To address the navigation process, the authors in Saha and Dasgupta (2017) proposed a novel, machine learned-based algorithm called semi-Markov decision process. The robot's distance range sensors can acquire the path of various objects in the robot's navigation path. Application of this variety of obstacles is to keep the robot from catching (Mousazadeh et al., 2018). In static obstacles of random shapes, the collision-bound robot navigation in a static environment, the persistent-bug algorithm to stop global and local loop trapping are considered as testing of the algorithm. A Simulink model for robot navigation in an unknown environment with obstacle avoidance is presented in (Kumar & Vámossy, 2018c). In Kumar and Vámossy (2018c), a robot position, laser scanning, and scanning period algorithm are executed to recognize the recurrence of obstacles during the navigation phase. Different scientists are attracted to fuzzy logic for obstacle avoidance in robot navigation process. An etiquette-based fuzzy logic architecture for mobile robot navigation in dynamic environment is presented in Bao et al. (2009). Moreover, the authors in Bao et al. (2009) have designed and implemented four basic behaviors for mobile robot navigation in complex environment which include tracking behavior, obstacle avoidance, deadlock disarming behavior, and goal seeking. Optimal solution and large operational qualities of the organization would be characterized dependent on the potential and the idea of neurons interconnections. An epic organically inspired neural organization approach exists for impact-free constant robot way arranging in a powerful climate. This model can be useful to car like robots and multirobot systems. The state space of the neural organization is the arrangement of the robot, and the enthusiastically changing environment is spoken to by the dynamic movement scene of the neural organization. The objective was universally

pulled in towards the robot, whereas obstacles push the robot away to avoid collisions. In Kozakiewicz and Ejiri (2002), a neural network approach to path planning was developed for 2D robot. The robot moves from initial to final location if its neighboring point closer to goal location is vacant. A far less expensive four wheel mobile robot platform has the potential to travel as a line follower robot in a two-dimensional setting with obstacle avoidance (Oltean, 2019). The robot successfully recovers from the collisions and the deterrent evasion can be dealt with by utilizing the bumper functions of the turtlebot (Kumar et al., 2016). In Kumar et al. (2016), the main disadvantage of the work is that the work does not lead to collision-free navigation. Consequently, the methods based on sensors which lead to obstacle avoidance without collision during navigation can be taken for future work. Fuzzy interference system with rotation angle for robot inputs and space between the robot obstacle is built in Singh and Thongam (2018). Anyway the fuzzy surmising framework created in Singh and Thongam (2018) is not applicable in dynamic environment but only to static environments. A model in Simulink is developed with unadulterated interest and fuzzy rationale regulators in Kumar and Vámossy (2018b). In Singh and Thongam (2018), the pure pursuit controller seeks a straight path from the start to the next target position and the controller used avoids robot navigation obstacles. The proposed work in Kumar et al. (2017) is based on pure pursuit algorithm, and the probabilistic guides in robot path and the guide of the robot's path is created as inhabitancy lattice. In this map, the probabilistic guides are acquired. An efficient path from begin to end, robot course is procured from probabilistic aides. Test work is performed on turtlebot robot in gazebo test system. MATLAB is utilized as programming language. The bondage of the work is that it is appropriate to the condition with static impediments. For future work, there is opportunity to build this work for the dynamic condition with dynamic or moving items. In Gupta and Nesaraj (2016), the work is focused on to find the shortest distance from start to goal without any collision. Also, obstacles of various dimensions are considered. So the main algorithm is partitioned into three subframes.

Subframe of path length: If no object is present in the given environment, this subframe calculates the diagonal length between source and goal point.

Subframe of path authorization: If there is some object present in the path, then path length will not be same. Then obstacle avoidance function is to be used.

Subframe for levelness: This subframe is used to find the levelness of given environment and calculates the levelness curve angle twist points that are recovered through Biezer curve method. In Patle et al. (2018), robot navigation in uncertain environment is explained, where dynamic objects are also present. The proposed paper is based on firefly algorithm. Fuzzy controllers explore minimum time instants. By using these controllers' dynamic objects gets recognized without any difficulty. This algorithm is powerful over all other algorithms. It reduces seeking time and robot easily navigates in the environment. Distance can be computed through Euclidian distance. In Kumar and Vamossy (2018a), the author proposed that laser scan is executed for localization and mapping. Various computations have been showed to achieve the laser scanning. The foremost computation was proposed to collect and reserve the laser examined features obtained from the robot scan. The next computation is to perform matching and map building. By making use of good output matches, a neural network is developed.

3 Path Planning Approaches in Robot Navigation

Path planning is the necessary component in navigation of mobile robots. It is one of the most researched topics in mobile robotics. Path planning is the action to plan a route in a given environment by reducing the total cost associated with the path. Path planning of mobile robot can be restricted based on the environment and type of algorithm used. It can be concluded in both static as well as dynamic environments. Path planning is mainly based on two divisions as follows:

I. Local path planning
II. Global path planning.
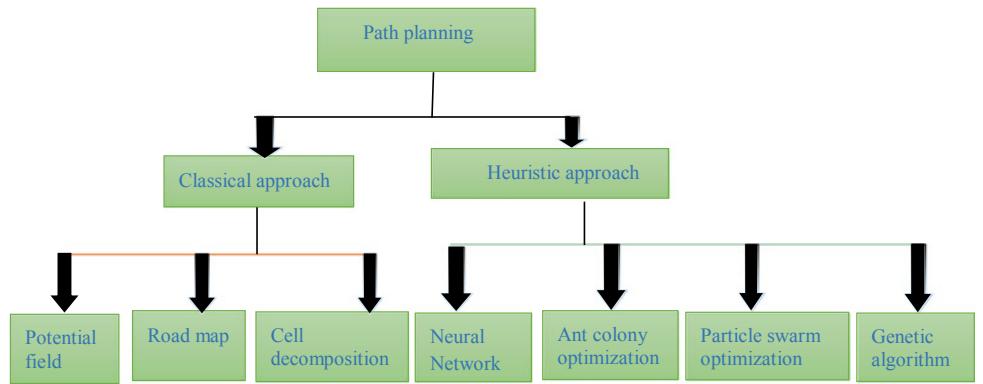
Numerous methods employed for navigation of mobile robot are broadly classified into two divisions that are classical approaches and heuristic approaches (Kosser & Kumar, 2019) (Fig. 2).

3.1 Classical Approaches

In this approach, either an answer would be found or it would be demonstrated that such an answer does not exist. The primary impediment of such techniques is their computation intensiveness and inability to cope with unpredictability. Such disadvantages make them exquisite in real world. Methods, such as cell decomposition, potential field, and roadmap, are categorized as classical methods:

Cell decomposition: It is mostly used in literature survey in path planning approaches. In this, the thought is to decrease the hunt space by utilizing portrayal dependent on cells.

Fig. 2 Classification of path planning algorithms

The idea behind this approach is to decay the free space into set of simple regions called cells. The aim of this is to reach the end point safely. the basic path planning algorithm based on cell decomposition are in Zafar and Mohanta (2018). Following are the steps used for cell decomposition as motion planner for robot:

i. Split the search space to connected regions called cells.
ii. Construct a chart through neighboring cells. In such a chart, vertices signify cells and edges associate cells and have a typical limit. Give a path from the obtained cell sequence.

The limitations of this approach are:

i. No passage way among narrowly spaced obstacles.
ii. Oscillations in narrow passages.
iii. Oscillations in the existence of obstacles.

Road map: It is also called as high way method. It is an approach to get starting with one point then onto the next and the association among the free spaces is spoken to by a bunch of one dimensional bends. Here, hubs assume a vital function in getting the ideal way for the robot. It is mostly used to locate the briefest way from the robot's underlying situation to objective position. Visibility and Varoni diagram are two mainstream strategies for creating guides. Visibility diagram is the chart whose vertices comprise of the beginning, target, and the vertices of polygonal impediment of the deficiency of visibility chart is that the subsequent littlest ways contact hindrances at the vertices or even at edges and afterward are undependable. Varoni charts are equipped for tending to this disadvantage.

In the Varoni diagram, roads stay as far away as possible from obstacles; therefore, it has the tight path and little longer than visibility graph.

Potential field method: In this method, repulsive and attractive forces are assigned for the obstacles. Attractive

field is generated which moves inward to goal. In each time stamp, a different potential field is generated across the free space.

The attractive force is given by

$$U_{att} = 0.5 * K_{att} \; \rho \; (\text{goal})^2 \qquad (1)$$

The repulsive force is given by

$$U_{rep} = 0.5 * K_{rep} * (1/\rho(q) - 1/\rho_0)^2 \qquad (2)$$

where K_{att} and K_{rep} are positive constants. ρ_0 is the potential function.

Resulting force is given by

$$U(q) = U_{att}(q) + U_{rep}(q) \qquad (3)$$

where U_{att} is the attractive potential and U_{rep} is the force of repulsion. Barriers are avoided while moving toward target. It is based on the method where map is predefined.

3.2 Heuristic Approaches

The main algorithms in heuristic approach are genetic algorithm (GA), ant colony optimization (ACO), and practice swarm optimization (PSO).

Genetic algorithm: It is the global search and optimization method. This calculation mirrors the cycle of regular choice where the fittest people are chosen for propagation so as to deliver posterity of people to come. This technique was proposed in 1975 by professor J. Hull and from Michigan University. In each algorithm (Zhu et al., 2015), path improvement is applied. The smoothness function is calculated through path length and smoothness function. This shows exceptional results as compared to other algorithms (Zhu et al., 2015). The population is the sequence of strings known as chromosomes. First specific multiplication is applied to the current populace so that string makes various duplicates relative to their own wellness which is a halfway

populace. Second, GA selects "guardians" from the ongoing populace with a predisposition that better chromosome is probably going to be chosen. Third, GA recreates kids (new strings) from chose guardians utilizing hybrid or change administrators. Hybrid is fundamentally comprising in an arbitrary trade of pieces between two strings of the transitional populace. This algorithm rectifies the problem of premature convergence and the length of the path obtained is shorter and the convergence speed is near to genetic algorithm.

Ant Colony Optimization: Ant colony optimization (ACO) is a populace based all-inclusive scanning technique for the arrangement of complex combinatorial issues, which is motivated by behavior of real ant colonies which was developed by Marco Dori-go in the 1990s. This technique is acceptable where source and goal are predefined. This style is based on multigoal path planning problems in the presence of obstacles. This technique is based on following algorithm:

  i. Create ants.
 ii. Iterate for each ant until entire task is completed.
iii. Place pheromone on visited sites.
 iv. Daemon actions.
  v. Vanishing pheromone.

These techniques are used for path planning (Zhu et al., 2015; Bartecki et al., 2018) and obstacle avoidance.

Particle swarm optimization: Particle swarm optimization was presented by Eberhar and Kennedy (1995) which was roused by the scrounging conduct of winged creatures. It is nature-based metaheuristic calculations which influence the social conduct of animals, for example, fish schools and fowl rushes. The calculation mimics the scavenging conduct of flying fowls and accomplishing their objectives through a joint collaboration between winged animals. Every molecule of multitude advancement look in a gathering led by particles which was introduced haphazardly. The particles move its stance and speed as indicated by the measurements of the gathering. Particle update its speed and position as indicated by the equation introduced in Wang et al. (2017). The robot path planning with obstacle avoidance using particle swarm optimization was proposed in Bartecki et al. (2018), and this algorithm solves the problem of incomplete convergence.

Neural networks: Neural organization or neural network (NN) is the investigation of understanding the interior usefulness of the cerebrum. It has been for the most part reused in looking through enhancement, learning, and example acknowledgment issues because of its capacity to give straightforward and ideal arrangement. By and large operational qualities of the organization would be characterized dependent on the potential and the idea of neurons interconnections. A tale organically persuaded neural organization access that exists for crash free continuous robot way arranging in a powerful climate.This model can be helpful to vehicle like robots and multirobot frameworks. The state space of the neural organization is the arrangement of the robot, and the overwhelmingly changing climate is spoken to by the dynamic action scene of the neural organization. The objective was universally pulled in toward the robot, while hindrances drive the robot away to dodge crashes. In Kozakiewicz and Ejiri (2002), an NN way to path planning was progressed for two-dimensional robot. An automation learning policy gives in Qiao et al., (2009). The nature of their exertion is that, as indicated by the intricacy of the environmental factors, the NN changes addition and cancellation of new concealed layers during the preparation with no communication to achieve the route work. Li et al. (2015) introduced the utilization of NN to quick concurrent limitation and planning procedure (Fast SLAM) to dispose of the mistake collection created by a wrong odometry model and off base linearization of the SLAM nonlinear capacity. The utility of the NN with quick SLAM develops the versatile robot to explore without crash with the snag in the obscure climate or dynamic climate. Following a steady assessment of the exploration papers referenced in the writing survey, the navigational arrangement is sorted as traditional methodologies and heuristic methodologies. A couple of years back, the majority of the effort in the control of advanced mechanics was raced to utilize old style moves toward as it were. Old style systems have numerous deficiencies like computational issues, failure in dealing with numerous vulnerability, detecting issue for constant route, and substantially more. Henceforth in the suspicion of the old style approach, each time there remains question if the arrangement got will be precise. Albeit heuristic methodologies are reused for route in an obscure climate. They are anything but difficult to actualize, canny and more proficient for robots; thus they are utilized continuously route issues. Furthermore, given the best result over old style draws near, Table 1 gives a definite investigation of these methodologies utilized for route of robots till now (Fig. 3).

Table 1 shows complete analysis of different algorithms of path planning approaches (Patle et al., 2019). The utilization of the two methodologies, old style and heuristic methodologies, has been considered over a three-dimensional workspace for way arranging of airborne and submerged vehicles. In Table 1, the use of an individual calculation for three-dimensional way arranging is depicted and, from the information, clearly heuristic methodologies have been applied all the more broadly for investigating the three-dimensional climate within the sight of most

Table 1 Comparative analysis of classical and heuristic algorithms

Navigation	Aerial navigation	Underwater navigation
Cell decomposition	Yes	No
Road map	Yes	No
Potential field	Yes	No
Genetic algorithm	Yes	Yes
Ant colony optimization	Yes	Yes
Neural network	Yes	Yes

Fig. 3 Applications of classical and heuristic approaches

noteworthy vulnerability in correlation with traditional methodologies. The traditional methodology is not plentiful savvy for self-governing way arranging in three-dimensional climate, henceforth to improve their quality and execution they have been hybridized with GA, ACO, and so on. Practically all heuristic and traditional methodologies are utilized to handle the way arranging issue in an elevated climate too.

Different algorithms considered in literature review until now are winded up in Table 2 on the basis of different framework. These algorithms are mainly centered on path planning and their navigation environment. Like form of environment that is static, dynamic, inside, and outside. Moreover, identity of obstacle is also described whether it is static, dynamic, or both static and dynamic.

4 Challenges

After review of literature, various challenges occur during navigation. Path planning, which is great subject that how robot marked which path is suitable to come to the final point? There is no collision of robot in the navigation environment. In a given environment, the different number of static and dynamic objects may be present in the navigation environment. Keep away from such obstacle and to

resolve that which path is acceptable for robot is a challenging task.

Localization is one more matter in robot navigation that is how to consider itself in the given environment. A map of domain is specified to the robot for navigation. This approach is suitable, if there is only one robot in static environment. But if there is dynamic environment and for multirobot system then this is much more challenging task.

Mapping is one of the most challenges in robot navigation that how robot report where it is presently and what it has to reflect to navigate in the navigation environment. And how robot decided in which location it has to move is suitable in the particular environment.

5 Conclusion

The paper reviews some of the classical and heuristic methods for robot path planning. Between classical algorithm and heuristic algorithm, classical approach has more limitation than heuristic approach in terms of path cost and time execution. The execution of classical methods can be enhanced by mixing with heuristic methods. Further research task can be expanded to switch the obstacle shape and location to verify convergence of heuristic approaches. The hybrid algorithms which integrate the classical and

Table 2 A comparative analysis of various algorithms

Algorithm	Year	Static system	Dynamic system	Simulation	Real system	Authors	Navigation
Fuzzy logic and pure pursuit	2016	Yes	Yes	Yes	Yes	Kumar and Vamossy (2018c)	Unknown
Standard deviation-based algorithm	2018	Yes	Yes	Yes	Yes	Singh and Thongam (2018)	Unknown
Path plan with subfunction	2016	No	Yes	Yes	Yes	Kumar et al. (2017)	Unknown
Firefly algorithm	2018	Yes	Yes	Yes	Yes	Gupta and Nesaraj (2016)	Unknown
Laser scan algorithm	2018	Yes	No	Yes	Yes	Patle et al. (2018)	Unknown
Path planning using bumper event	2016	Yes	Yes	Yes	N0	Oltean (2019)	Unknown
Goal-oriented algorithm	2016	Yes	Yes	Yes	Yes	Saha and Dasgupta (2017)	Known

heuristic methods can be used to find the collision-free optimal path. The execution of classical methods is being refined by hybridizing with heuristic approaches. The main problem focused is on robot navigation and path planning. We conclude that path planning with complete obstacle avoidance is still major challenge in robot navigation. Most of the work which has been done on single robot. In future, we have to implement multirobotic system.

References

Bao, Q. Y., Li, S. M., Shang, W. Y., & An, M. J. (2009). A fuzzy behavior-based architecture for mobile robot navigation in unknown environments. In *2009 International Conference on Artificial Intelligence Computational Intelligence AICI 2009* (Vol. 2, pp. 257–261). https://doi.org/10.1109/AICI.2009.125.

Bartecki, K., Król, D., & Skowroński, J. (2018). Wyznaczanie kluczowych wskaźników wydajności procesu produkcyjnego - część I: Badania teoretyczne. *Primary Automation on Robotics, 22*(3), 5–13. https://doi.org/10.14313/PAR.

Eberhart, R., & Kennedy, J. (1995). New optimizer using particle swarm theory. In *Proceedings of International Symposium on Micro Machine and Human Science* (pp. 39–43). https://doi.org/10.1109/mhs.1995.494215.

Gupta, N., & Nesaraj, O. (2016). Robot navigation in dynamic environment (pp. 0–4).

Hassani, I., Maalej, I., & Rekik, C. (2018). Robot path planning with avoiding obstacles in known environment using free segments and turning points algorithm. *Mathematical Problems in Engineering*. https://doi.org/10.1155/2018/2163278.

Hidalgo-Paniagua, A., Vega-Rodríguez, M. A., & Ferruz, J. (2016). Applying the MOVNS (multi-objective variable neighborhood search) algorithm to solve the path planning problem in mobile robotics. *Expert Systems with Applications, 58,* 20–35. https://doi.org/10.1016/j.eswa.2016.03.035.

Khan, S., & Ahmmed, M. K. (2016). Where am I? Autonomous navigation system of a mobile robot in an unknown environment. In: *2016 5th International Conference on Informatics, Electronics Vision, ICIEV 2016* (pp. 56–61). https://doi.org/10.1109/ICIEV.2016.7760188.

Kosser, F., & Kumar, N. (2019). Robot navigation and path planning techniques challenges: A review. *11*(2), 115–125

Kozakiewicz, C., & Ejiri, M. (2002). Neural network approach to path planning for two dimensional robot motion (91), 818–823. https://doi.org/10.1109/iros.1991.174585.

Kumar, N., & Vamossy, Z. (2018a). Laser scan matching in robot navigation. In *2018 IEEE 12th International Symposium on Applied Computational Intelligence and Informatics (SACI)* (pp. 241–246). https://doi.org/10.1109/SACI.2018.8440969.

Kumar, N., & Vámossy, Z. (2018b). Robot navigation with obstacle avoidance in unknown environment. *International Journal of Engineering and Technology, 7*(4), 2410–2417. https://doi.org/10.14419/ijet.v7i4.14767.

Kumar, N., & Vámossy, Z. (2018c). Obstacle recognition and avoidance during robot navigation in unknown environment. *International Journal of Engineering and Technology, 7*(3), 1400–1404. https://doi.org/10.14419/ijet.v7i3.13926.

Kumar, N., Vamossy, Z., & Szabo-Resch, Z. M. (2016). Robot obstacle avoidance using bumper event. In *SACI 2016—11th IEEE International Symposium on Applied Computational Intelligence and Informatics, Proceedings* (pp. 485–490). https://doi.org/10.1109/SACI.2016.7507426.

Kumar, N., Vamossy, Z., & Szabo-Resch, Z. M. (2017). Robot path pursuit using probabilistic roadmap. In *CINTI 2016—17th IEEE International Symposium of Computational and Intelligence Informatics Proceedings* (pp. 139–144). https://doi.org/10.1109/CINTI.2016.7846393.

Li, Q. L., Song, Y., & Hou, Z. G. (2015). Neural network based FastSLAM for autonomous robots in unknown environments. *Neurocomputing, 165,* 99–110. https://doi.org/10.1016/j.neucom.2014.06.095.

Mousazadeh, H., et al. (2018). Developing a navigation, guidance and obstacle avoidance algorithm for an unmanned surface vehicle (USV) by algorithms fusion. *Ocean Engineering, 159*(April), 56–65. https://doi.org/10.1016/j.oceaneng.2018.04.018.

Oltean, S. E. (2019). Mobile robot platform with Arduino Uno and Raspberry Pi for autonomous navigation. *Procedia Manufacture, 32,* 572–577. https://doi.org/10.1016/j.promfg.2019.02.254.

Pandey, A. (2017). Mobile robot navigation and obstacle avoidance techniques: A review. *International Robotics and Automation Journal, 2*(3), 96–105. https://doi.org/10.15406/iratj.2017.02.00023.

Patle, B. K., Pandey, A., Jagadeesh, A., & Parhi, D. R. (2018). Path planning in uncertain environment by using firefly algorithm. *Defence Technology, 14*(6), 691–701. https://doi.org/10.1016/j.dt.2018.06.004.

Patle, B. K., Babu, G., Pandey, L. A., Parhi, D. R. K., & Jagadeesh, A. (2019). A review: On path planning strategies for navigation of mobile robot. *Defence Technology, 15*(4), 582–606. https://doi.org/10.1016/j.dt.2019.04.011.

Qiao, J., Fan, R., Han, H., & Ruan, X. (2009). Q-Learning based on dynamical structure neural network for robot navigation in unknown environment. In *Lecture Notes on Computer Science (including Subseries Lecture Notes on Artificial Intelligence of Lecture Notes Bioinformatics)* (Vol. 5553, no. PART 3, pp. 188–196). LNCS. https://doi.org/10.1007/978-3-642-01513-7_21.

Saha, O., & Dasgupta, P. (2017). Real-time robot path planning around complex obstacle patterns through learning and transferring options. In *2017 IEEE International Conference on Autonomous of Robot Systems Competition. ICARSC 2017*, (pp. 278–283). https://doi.org/10.1109/ICARSC.2017.7964088.

Singh, N. H., & Thongam, K. (2018). Mobile robot navigation using fuzzy logic in static environments. *Procedia Computer and Science, 125,* 11–17. https://doi.org/10.1016/j.procs.2017.12.004.

Wang, Y., Cai, F., & Wang, Y. (2017). Application of particle swarm optimization in path planning of mobile robot. In *AIP Conference on Proceedings* (Vol. 1864). https://doi.org/10.1063/1.4992840.

Zafar, M. N., & Mohanta, J. C. (2018). Methodology for path planning and optimization of mobile robots: A review. *Procedia Computer Sci., 133,* 141–152. https://doi.org/10.1016/j.procs.2018.07.018.

Zhang, H. Y., Lin, W. M., & Chen, A. X. (2018). Path planning for the mobile robot: A review. *Symmetry (Basel), 10*(10). https://doi.org/10.3390/sym10100450.

Zhu, Z., Wang, F., He, S., & Sun, Y. (2015). Global path planning of mobile robots using a memetic algorithm. *International Journal of Systems Science, 46*(11), 1982–1993. https://doi.org/10.1080/00207721.2013.843735.

Requirements Prioritization Using Logarithmic Fuzzy Trapezoidal Approach (LFTA)

Yash Veer Singh, Bijendra Kumar, and Satish Chand

Abstract

Requirement prioritization (RP) is considered as an important phase of SDLC in the process of requirements engineering. Requirement prioritization techniques are very useful for making good decisions to determine the relative priority weights of the requirements as per their importance. The existing techniques are very complex and time consuming in fuzzy environment. FAHP is a very appropriate approach for RP. The FAHP has found its significant applications in today's scenario and majority of the applications in requirement prioritization are derived by using EA and FPA and nonlinear techniques for fuzzy AHP priority derivation. However, FPA-based nonlinear approach is effective one but exhibits several issues of uncertainty and complexity. The performance of such prioritization approaches does not provide the appropriate priority as per the customer expectations, create multiple and conflict priority vectors, may result in different conclusions which are not acceptable to fuzzy pairwise comparison matrix. This research paper helps to overcome the issue of existing approach, proposes an effective and appropriate priority technique for fuzzy AHP called logarithmic fuzzy trapezoidal approach (LFTA) to conclude the priorities vector of requirements engineering. The proposed technique is used to resolve the typical gaps and meets the customer expectations of judgment making in real-life applications This technique is tested on real-life project 'selection rank 1 of college' based on different criteria's.

Keywords

Requirements prioritization • FAHP • LFTA • FPA • Extent analysis

1 Introduction

RP is a key phase of software development life cycle (SDLC) in requirement engineering (RE) process. This phase consists of an identification of every requirement like validation of requirements, requirement elicitation and gathering, analysis, their documentation, and management. RE includes 'RP' that is used to ranking the requirements as per their weights of importance (Sadiq & Jain, 2014; Sipahi & Timor, 2010; Soh, 2010; Sun, 2010). We take an example of a project when it has insufficient resources; hard execution plan, too many high customer hopes, and then customer requirements must be arranged as per their priority beforehand.

Therefore, RP is much significant for choosing the accurate set of requirements and makes many judgments during the final product release. For this reason, several researchers are engaged in the process of developing the correct set of priorities for decision in RP. As per previous research studies like FAHP and FPA, existing techniques dealing with uncertainty and ambiguity, fuzziness in RP, when multiple stakeholders have different opinions of alternatives. Nowadays, we make various selections, like selection of rank 1 college, skilled faculty, buying a DVD-player, new smart phone, food, etc. Regularly, we are not in any case aware of making one. Normally, we do not have more than a one or two decisions to consider, an example, which is the rank 1 college, skilled faculty, best brand based on quality. Indeed, even with a few judgments,

Y. V. Singh (✉)
ABES Engineering College, Information Technology, Ghaziabad, 201009, UP, India
e-mail: yashveersingh85@gmail.com

B. Kumar
NSUT/Computer Engineering, New Delhi, 110078, India
e-mail: bizender@gmail.com

S. Chand
JNU/School of Computer and System Science, New Delhi, 110003, India
e-mail: schand20@gmail.com

selections can be so tough to take. Similarly, it is having tens, thousand, and hundreds or even a huge number of choices, judgments become much more typical task in RE. This paper explains the mathematical form to solve the requirement prioritization, difficulty of decision making. The importance of software requirements can be varied according to the problem of selecting decision or decision making. In previous existing methods test on software providers, seller/buyer does not have well organized and method of selection. In this paper, evaluate a case study of college selection using two techniques of RP, which is used to determine the importance of candidate requirements and pairwise comparison technique. Therefore, a pairwise comparison method for RP is used. In this research work, A LFTA is demonstrated to overcome the limitations of FAHP and FPA.

2   Related Work

There are so many conflicts arises when the priority of requirements in the equation of linguistic variables (Sun, 2010). The linguistic variables are those variables that cannot be represented by numerical values. FAHP has found enormous applications in the present time, subsequently fuzzy decisions are easier to evaluate the weights of requirements as compared to crisp decisions (Sadiq & Jain, 2014). It decided the FAHP can find more and better applications in immediate future. The use of FAHP to RP needs scientific methods for deriving the weights produced from pairwise comparison (PWC) matrices with EA and FPA (Veerabathiran & Srinath, 2012) is depend on nonlinear technique (Wang & Chin, 2011). The application of FAHP for evaluating the priorities in the form of weights in the EIS (estimate index system) can be momentarily explained as follows. After that first a hierarchical configuration is designed (Soh, 2010), and then a group of judges is designed and requested for evaluation for the criteria's, attributes, or characteristics. The comparison of arrangement of one criterion over another can be done with the common agreement of all the team/group members, which are in the form of a linguistic valuation (Ho et al., 2010). In this proposed novel approach, linguistic valuation (crisp input sets) decided by a group of judges is transformed to LFTA which is shown in Fig. 3. Then these logarithmic fuzzy trapezoidal numbers (Kahraman & Kaya, 2010; Sipahi and Timor, 2010) are used to figure out the evaluation matrices of judges fully based on the PWC technique.

The matrices of PWC are used to calculate the priorities of multiple criterias and features by using the fuzzy AHP technique. Existing techniques for FAHP weight origin can be categorized into two types of classes, one class is to originate a group of fuzzy priorities, next one is to emerge a

group of crisp priority weights derived through a fuzzy PWC matrix. The technologies derived through fuzzy weights emerging from fuzzy PWC state normally consist of the geometric mean approach (Jaskowski et al., 2010; Sun, 2010) and least-squares approaches) (LSM) (Dubois,2011), linear goal programming (LGP) technique, and Lambda–Max techniques (Calabrese et al., 2013). The methods for originating crisp weights derived through PWC matrices comprise the FPP and EA. Since fuzzy weights are not able to compute easily crisp ones, several research ideas describe that enormous usual of FAHP application applies a simple EA method for FAHP weight derivation. EA approach (Celik et al., 2009) represented to be unacceptable and the outcomes generated by EA do not designate the priority weight of judgment criteria. So, it has directed to a significantly large number of mismanagings in the existing research work (Abu-Taha, 2011; Büyüközkan & Berkol, 2011; Bueyuekoezkan & Ruan, 2007; Cebeci & Ruan, 2007; Chan & Kumar, 2007; Chan et al., 2008; Celik et al., 2009; Haghighi et al., 2010; Heo et al., 2010; Kahraman et al., 2006; Kaya & Kahraman, 2010; Kelemenis & Askounis, 2010; Shaw et al., 2012; Sevkli, 2010; Ye, 2010; Yücel & Güneri, 2011). Speciously, its use as a weight priority derivation method should be avoided (Sadiq & Jain, 2015). FPA nonlinear priority method proposed has also found numerous applications in current years. Unfortunately, the methods go out to matter to a number of important weaknesses. Such as, it may produce many identical or uniform dispute priority weights for pairwise comparison matrix, managing with dissimilar outcomes. Such types of non-uniqueness outcomes harm its applications as a priority technique for FAHP. In addition, proposed examination system was found to be more, complete and accurate through the assessment technique, that compared to conventional FAHP and AHP using EA technique. Although (Nagpal et al., 2015; Wang et al., 2016; Zhü, 2014) FAHP has been realistic in many cases, who use FAHP would comprehend the problems connected with this method (Khan et al., 2015). Author employs FAHP on marketing data to decompose the problem into a two-dimensional type (Serhani et al., 2020). Author explains such type of questions (i) selection methods which are generally applied; (ii) problem conservational and selection criteria for supplier management which are well-liked; (iii) selection shortcomings. Decision making using AHP on precipitation data (Govindan et al., 2015; Khazaeni et al., 2012; Vaishnavi et al., 2017) on green product development with multi-criteria group decision-making (MCDM) technique. To present an exact priority method for FAHP, the proposed technique (LFTA) for FAHP weight/priority derivation, which communicates priorities weights for fuzzy pairwise comparison matrix by using originates crisp priorities weights and logarithmic nonlinear programming.

3 Requirements Prioritization Techniques

(a) FAHP: Fuzzy Analytical Hierarchical Process

A trapezoidal fuzzy number (TFN) consists of variety of global states. This investigation represents the fuzzy weights which are contained in MCDM demonstrated through linguistic variables expressed in the trapezoidal fuzzy numbers.

A trapezoidal fuzzy number is expressed as $\tilde{F}s = (a, b, c, d)$ and also represented through the following function:

$$\mu_{Fs}(x) = \begin{cases} \frac{x-a}{b-a} & a \leq x \leq b \\ 1 & b \leq x \leq c \\ \frac{d-x}{d-c} & c \leq x \leq d \end{cases} \qquad (1)$$

Here, 'b' and 'c' are known intervals in mode $\tilde{F}s$ while 'a' and 'd' are the decision parameters which demonstrates the lower value and upper value in the form of bound (lower and upper) on $\tilde{F}s$. Figure 1 shows the range for the evaluations.

(b) Fuzzy Preference Approach (FPA)/Extent Analysis (EA) Nonlinear Priority Technique

It can be represented by the following equation:

Subject to
$$\begin{cases} -E_i + a_{ij}E_j + \beta(b_{ij} - a_{ij})E_j \leq 0, \ i = 1,\ldots,n-1; \ j = i+1,\ldots,n, \\ E_i - c_{ij}E_j + \beta(C_{ij} - b_{ij})E_j \leq 0, \ i = 1,\ldots,n-1; \ j = i+1,\ldots,n \\ \sum_{i=1}^{n} E_i = 1, \\ E_i \geq 0, \ i-1,\ldots,n. \end{cases}$$
$$(2)$$

To understand better, we mentioned an approach represented in above Eq. (2) to the AHP fuzzy priority examination named as FPP or FPA-based nonlinear priority method. After evaluation this approach, we finalized these following research summary:
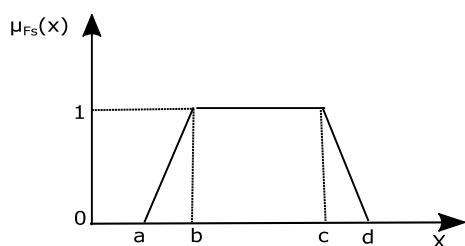

**Fig. 1** Membership degree function for fuzzy trapezoidal
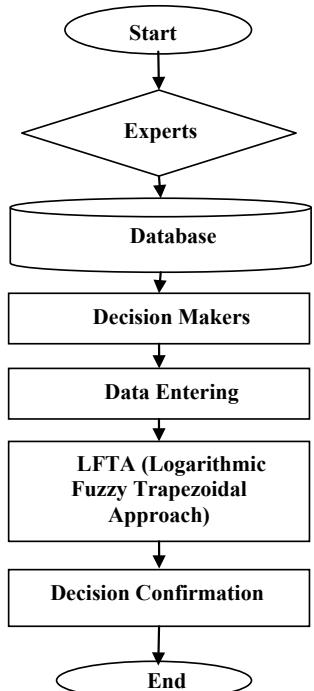
1. Membership degree function having negative value denotes no judgment or no sense.
2. Equation number (2) denotes multiple optimal solutions in case of inconsistency among fuzzy judgments.
3. In fuzzy PWC matrix, the value of priority weight vectors for lower and upper triangular elements is same.

4 Proposed LFTA Method

The proposed method solves the limitations of EA in RP with LFTA. The proposed method contains the following steps which is shown in Fig. 2

(i) **Expert Model (Information Gathering)**: This model can be selected by the judges and students to gather all the accurate data regarding the institute like the placement of the student's, infrastructure technical and cultural activity, faculty profile, and research at the superior salary package.

(ii) **Database Model (Storing information in Database)**: The second phase of the LFTA model is used for storage of data, assimilation, and explanations of all information of college, computed by decision makers and students for taking optimal decisions.

(iii) **Decision Makers Model (Taking Optimal Decisions)**: During the admission time, the students choose the rank 1 college that fulfills their academic and placement criteria's for their study and job

Fig. 2 Proposed LFTA model

placements. In this proposed approach, they must be always demanded to select the choice of gear. This research work carried out to solve and exploit their suggestions to concise the LFPP technique.

(iv) Data Inflowing Model (LFTA)

Decision makers play very important role to analyze and pass all the information.

Proposed LFTA Model:

This model solves the above limitations of EA in RP with LFTA shown in Fig. 3. This model provides the following outcomes to overcome the existing limitations.

[1] This model provides always positive value among 0 and 1 for the membership function (β) to eliminate inconsistency in the mid of the fuzzy judgments.

[2] This model provides always unique solutions which is always optimal for fuzzy decisions in the form of weight vectors to maintain consistency.

[3] In this model, the outcomes of upper and lower triangular elements of the PWC matrix are same in the form of priority weights vectors.

$$\overline{\overline{E\underbrace{*^1}_{J}}} = (0.4540, 0.1820, 0.1820, 0.1820), \beta^* = -1.98 \tag{3}$$
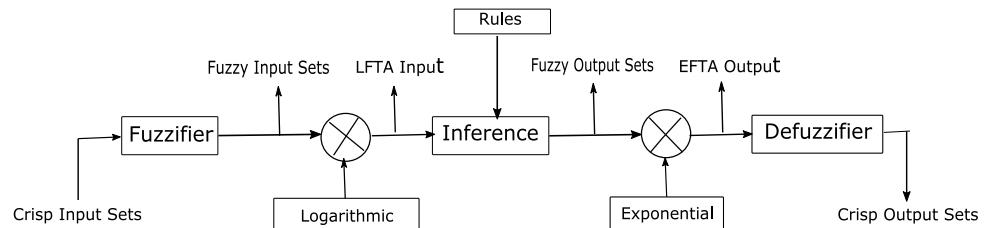
$$\overline{\overline{E\underbrace{*^2}_{J}}} = (0.24, 0.25, 0.25, 0.26), \beta^* = -1.98 \tag{4}$$

$$\overline{\overline{E\underbrace{*^3}_{J}}} = (0.2863, 0.2379, 0.2379, 0.2379), \beta^* = -1.98 \tag{5}$$

These dissimilar priority weights vectors certainly create fuzzy AHP (FAHP) decision-making, complex, and more complex. In the further section, we will design a LFTA-based methodology to overcome above mentioned drawbacks.

Let judges give fuzzy judgments instead of exact judgments for fuzzy PWC matrix, so it is concluded that the criterion i is among a_{ij} and d_{ij} as significant as typical j through b_{ij} and c_{ij} most likely. A trapezoidal fuzzy PWC matrix can be demonstrated:

$$J =$$
$$\begin{bmatrix} (1,1,1,1) & (a_{12},b_{12},c_{12},d_{12}) & (a_{13},b_{13},c_{13},d_{13}) & (a_{14},b_{14},c_{14},d_{14}) \\ (a_{21},b_{21},c_{21},d_{21}) & (1,1,1,1) & (a_{23},b_{23},c_{23},d_{23}) & (a_{24},b_{24},c_{24},d_{24}) \\ \cdots & \cdots & \cdots & \cdots \\ (a_{n1},b_{n1},c_{n1},d_{n1}) & (a_{n2},b_{n2},c_{n2},d_{n2}) & (a_{n3},b_{n3},c_{n3},d_{n3}) & (1,1,1,1) \end{bmatrix}$$
$$\tag{6}$$

We use here the PWC matrix in the Eq. (3), and then we apply logarithmic on the following Eq. (7). This LFTA judgment $\tilde{a}_{ij}$ is looked as close to TFN and the membership degree can consequently be represented as:

$$\ln = (\ln a_{ij}, \ln b_{ij}, \ln c_{ij}, \ln d_{ij}), \quad i,j = 1,\ldots,n. \tag{7}$$

$$\mu_{ij}\left(\ln\left(\frac{E_i}{E_j}\right)\right) = \begin{cases} \dfrac{\ln\left(E_i/E_j\right) - \ln(a_{ij})}{\ln(b_{ij}) - \ln(a_{ij})}, & \ln\left(\dfrac{E_i}{E_j}\right) \le b_{ij}, \\ \ln(1) = 0, & b_{ij} \le \ln\left(\dfrac{E_i}{E_j}\right) \le c_{ij}, \\ \dfrac{\ln(d_{ij}) - \ln\left(E_i/E_j\right)}{\ln(d_{ij}) - \ln(c_{ij})}, & \ln\left(\dfrac{E_i}{E_j}\right) \ge c_{ij}, \end{cases} \tag{8}$$

Here, $\mu_{ij}(\ln (E_i/E_j))$ is represented the membership degree for the $\ln (E_i/E_j)$ that estimated accurately the LFTA decision $\ln\tilde{a}_{ij} = (\ln a_{ij}, \ln b_{ij}, \ln c_{ij}, \ln d_{ij})$. To obtain a crisp weight vector for maximize and minimize, the membership degree presented below in the Eq. (14).

$$\beta = \min\left\{\mu_{ij}\left(\ln\left(\frac{E_i}{E_j}\right)\right) \Big| \quad i = 1,\ldots,n-1; \quad j = i+1,\ldots,n\right\} \tag{9}$$

In conclusion, the outcome approach can be generated of maximizing the membership degree β

$$\text{Subject to} \begin{cases} \mu_{ij}\ln\left(\frac{E_i}{E_j}\right) \ge \beta, \ i = 1,\ldots,n-1; \ j = i+1,\ldots,n, \\ E_i \ge 0, \ i = 1,\ldots,n. \end{cases} \tag{10}$$

To maximize the membership degree $(1-\beta)$ \hfill (11)

Fig. 3 Block diagram of proposed approach 'LFTA'

Subject to

$$\begin{cases} -\ln E_i + E_j + \beta \ln(b_{ij}/a_{ij}) \geq \ln(a_{ij}), i = 1, \ldots, n-1; j = i+1, \ldots, n \\ \ln E_i - E_j + \beta \ln(d_{ij}/c_{ij}) \geq -\ln(d_{ij}), i = 1, \ldots, n-1; j = i+1, \ldots, n \\ E_i \geq 0, i = 1, \ldots, n. \end{cases}$$

(12)

Generally, here is no certification of Eq. (12) that will generate positive value at each instant for the membership degree (β). Here is the main cause at the back generating a value which is negative for membership function β. The meaning of this meaningless value is that it assigns no fuzzy weights that can achieve the fuzzy judgments inside the support intervals. Finally, there is not all little of equalities $\ln E_i - \ln E_j - \beta \ln(b_{ij}/a_{ij}) \geq \ln a_{ij}$ or $-\ln E_i + \ln w_j - \beta \ln(d_{ij}/c_{ij}) \geq -\ln d_{ij}$, it may be holding at same time.

To keep away from 'β' for permitting a value which is negative, a new technique introduced to generate positive value examination of new the variables γ_{ij} and σ_{ij} for the values $i = 1, \ldots, n-1$ and $j = i+1, \ldots, n$ so that they carry jointly the subsequent inequalities.

$$\ln E_i - \ln E_j - \ln(b_{ij}/a_{ij}) + \gamma_{ij} \geq \ln a_{ij}, i = 1, \ldots, n-1; j = i+1, \ldots, n,$$

(13)

$$-\ln E_i + \ln E_j - \ln\left(\frac{d_{ij}}{c_{ij}}\right) + \sigma_{ij} \geq -\ln d_{ij}, i = 1, \ldots, n-1; j = i+1, \ldots, n$$

(14)

This is the mainly desirable aspects so these values of the 'evaluated variables' have improved and less important. So suggested the 'LFTA' technique which is given below nonlinear priority approach for FAHP priority observation:

$$k = (1-\beta)^2 + M \cdot \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left(\gamma_{ij}^2 + \sigma_{ij}^2\right)$$

(15)

Subject to

$$\begin{cases} z_i - z_j - \beta \ln\left(\frac{b_{ij}}{a_{ij}}\right) + \gamma_{ij} \geq \ln a_{ij}, i = 1, \ldots, n-1; j = i+1, \ldots, n, \\ -z_i + z_j - \beta \ln\left(\frac{d_{ij}}{c_{ij}}\right) + \sigma_{ij} \geq -\ln d_{ij}, i = 1, \ldots, n-1; j = i+1, \ldots, n \\ \beta, z_i \geq 0, i = 1, \ldots, n, \\ \gamma_{ij}, \sigma_{ij} \geq 0, i = 1, \ldots, n-1; j = i+1, \ldots, n, \end{cases}$$

(16)

Formerly the above linear equation; then we identify the two approaches that may generate different most favorable results that are dismissed. Let $z_i^*(i = 1, \ldots, n)$ exist the best optimal value of Eq. (16). These weight priorities of the fuzzy PWC matrix $J = \tilde{a}_{ij_{n*n}}$ which can be achieved:

$$E_i^* = \frac{\exp(Z_i^*)}{\sum_{i=1}^{n} \exp(Z_j^*)}, i = 1, \ldots, n,$$

(17)

Here, exp () is representing an exponential function, named as $\exp(z_i^*) = e^{z_i^*}$ for $i = 1, \ldots, n$. We state in this approach that exploits Eq. (16) for the FAHP weight priority evaluation as LFTA approach and resulting weight priorities as LFTA priorities. Finally the regard of LFTA approach, we have the following two statements.

(a) **First Statement**: The fuzzy weights concluding by proposed method using LFTA are that the results of lower elements of the triangular PWC matrix are accurately same as the results from upper elements of the triangular PWC matrix.

(b) **Second Statement**: This method 'LFTA' generates unique optimal solutions in the form of reliable and consistent fuzzy weight priority vector for every fuzzy PWC matrix.

(c) **Decision authentication Approach**: Lastly, the information of fuzzy approach generated by LFTA is presented to the judges. Then judges resolve a critical selection through optimal decisions.
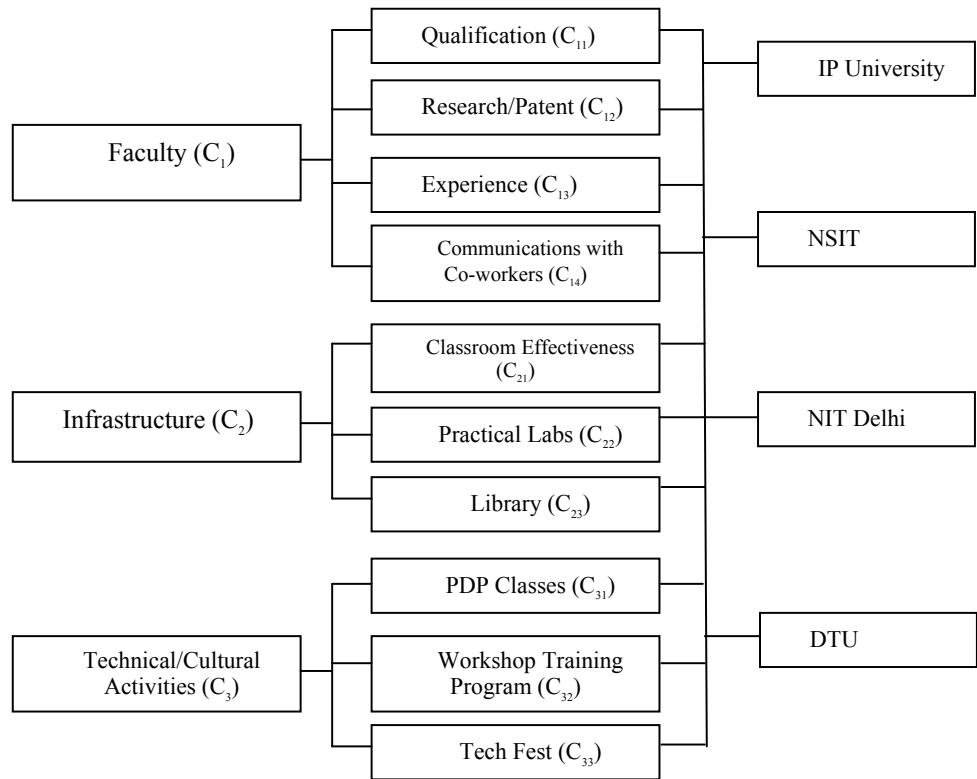
5 Result Estimation

In the result estimation part, we explained the results of our proposed method naming as LFTA through one real-life example. Here, we tested three mathematical examples. First two mathematical examples are acquired from the existing reference paper to authenticate the proposed approach and third example took to prove the proposed approach that is more precise, persuade to obtain most excellent judgment vector through the proposed LFTA methodology to reveal its prospective applications and the advantages in fuzzy decision making over EA's weight priority on the real-time examples.

Example: We take a real-life problem for the 'selection of rank 1 college issue' in front of the students like in the Celik et al. (2009) of 'ship registry selection' that has hierarchical formation in the selection of rank 1 college as shown in Fig. 4.

In this diagram, C_1, C_2, and C_3 are the selection parameters. While each selection parameter has multiple

Fig. 4 Hierarchical formations for the 'college selection problem'

sub-decision parameters. Students select best college among NIT Delhi, NSIT, IP University, and DTU based on their required selection criteria's. Celik et al. (2009) presented a problem named as 'selection of ship registry' through EA technique which has found to be intolerable and unreliable and may generated the wrong outcomes. EA priority approach allocates a zero fuzzy weight priority to every of the judgment criteria C_2 and C_3. If priorities weights were found zero for C_2 and C_3, then these two decision criteria's must never considered. Finally, allocating a zero fuzzy

weight priority to any of the sub-decision parameter inside the tree formations in Fig. 4 made no sense. So, the EA must be declined. So, we reexamine on the problem of 'rank 1 college selection' through this method 'LFTA' to produce precise results. Tables 1, 2, 3, 4, 5, 6 and 7 reveal fuzzy PWC matrices obtained for 'rank 1 college's choices problem'.

The hierarchical formation for 'rank 1 college selection' using 'faculty' parameter by using EA:

Table 1 Fuzzy PWC matrix for selection criteria regarding its priorities weights and judgment goal

Criteria	C_1	C_2	C_3	LFTA	EA priorities (Celik et al., 2009)
C_1	(1,1,1,1)	(3/2,2,3,7/2)	(3/2,2,3,7/2)	0.4407	1
C_2	(2/7,1/3,1/2,2/3)	(1,1,1,1)	(2/3,1,2,5/2)	0.3121	0
C_3	(2/7,1/3,1/2,2/3)	(2/5,1/2,1,3/2)	(1,1,1,1)	0.2472	0
$\beta = 0.4$					

Table 2 Fuzzy PWC matrix for the four sub-criteria of 'faculty (C_1)' and its normalized LFTA priorities weights

Criteria	C_{11}	C_{12}	C_{13}	C_{14}	LFTA	EA priorities (Celik et al., 2009)
C_{11}	(1,1,1,1)	(5/2,2,1,1/2)	(1,1/2,1/3,1/4)	(2/3,1/2,1/3,1/5)	0.1854	0.1413
C_{12}	(2,1,1/2,2/5)	(1,1,1,1)	(2/5,1/2,1/3,1/5)	(2/3,1,2,5/2)	0.2818	0.1797
C_{13}	(1,2,3,4)	(2/5,1/2,1,3/2)	(1,1,1,1)	(2/5,1/2,1,2)	0.2143	0.2610
C_{14}	(5,3,2,3/2)	(4,5,2,4)	(1/2,1,1/2,5/2)	(1,1,1,1)	0.3485	0.4179
$\beta = 0.11$						

The hierarchical formation for 'rank 1 college selection' using 'infrastructure' parameter by using EA:

Table 3 Fuzzy PWC matrix for the sub-criteria 'Infrastructure (C_2)' and its normalized LFTA priorities weights

Criteria	C_{21}	C_{22}	C_{23}	LFTA	EA priorities (Celik et al., 2009)
C_{21}	(1,1,1,1)	(2/5,1/2,2/3,1)	(1,1,1,1)	0.3195	0
C_{22}	(1,3/2,2,5/2)	(1,1,1,1)	(5/2,3,7/2,9/2)	0.4176	1
C_{23}	(1,1,1,1)	(2/9,2/7,1/3,2/5)	(1,1,1,1)	0.2627	0
$\beta = 0.561$					

The hierarchical formation for 'rank 1 college selection' using 'technical and cultural activity' parameter by using EA:

Table 4 Fuzzy PWC of selection sub-criteria 'technical/cultural activity (C_3)' and its normalized LFTA priorities weights

Criteria	C_{31}	C_{32}	C_{33}	LFTA	EA priorities (Celik et al., 2009)
C_{31}	(1,1,1,1)	(2/3,1/2,2/3,1)	(2/5,1/2,1,3/2)	0.3674	0.1461
C_{32}	(1,3/2,2,3/2)	(1,1,1,1)	(5/2,1/2,1/3,1/5)	0.3322	0.1461
C_{33}	(2/3,1,2,5)	(5,3,2,2/5)	(1,1,1,1)	0.3004	0.7078
$\beta = 0.508$					

Table 5 Fuzzy PWC matrix of the colleges concerning the sub-criteria of C_1 and their normalized priorities weights

	IP University	NSIT	NIT Delhi	DTU	LFTA	EA priorities (Celik et al., 2009)
A: College's comparisons concerning the sub-criterion C_{11}						
IPU	(1,1,1,1)	(2/7,1/5,1/3,2/5)	(2/9,1/4,2/7,1/3)	(2/3,1,3/2,2)	0.3234	0
NSIT	(5/2,3,5/2,7/2)	(1,1,1,1)	(3/2,2,5/2,3)	(3/2,2,5/2,3)	0.2800	0.5239
NIT	(3,7/2,4,9/2)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	(3/2,2,3,7/2)	0.2101	0.4761
DTU	(2,2/3,1,3/2)	(1/3,2/5,1/2,2/3)	(7/2,1/3,1/2,2/3)	(1,1,1,1)	0.1865	0
$\beta = 0.25$						
B: College's comparisons concerning the sub-criterion C_{12}						
IPU	(1,1,1,1)	(2/5,1/2,1,3/2)	(2/7,1/3,2/5,1/2)	(5/2,2,1,1/2)	0.1853	0
NSIT	(2/3,1,1/2,5/2)	(1,1,1,1)	(2/5,1/2,3/5,2\3)	(3/2,2,5/2,3)	0.2305	0.3482
NIT	(2,5/2,3,7/2)	(3/2,5/3,2,5/2)	(1,1,1,1)	(3/2,2,5/2,3)	0.1702	0.6518
DTU	(2,1,1/2,2/5)	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	0.4128	0
$\beta = 0.24$						
C: College's comparisons concerning the sub-criterion C_{13}						
IPU	(1,1,1,1)	(2/3,1,1/2,5/2)	(2/3,1,3/2,2)	(2/5,1/2,2/3,1)	0.2113	0.1645
NSIT	(2/5,1/2,1,3/2)	(1,1,1,1)	(2/3,1,3/2,2)	(2/5,1/2,2/3,1)	0.2813	0.1645
NIT	(1/2,2/3,1,3/2)	(1/2,2/3,1,3/2)	(1,1,1,1)	(2/5,1/2,2/3,1)	0.2104	0.1645
DTU	(1,3/2,2,5/2)	(1,3/2,2,5/2)	(1,3/2,2,5/2)	(1,1,1,1)	0.3005	0.1645
$\beta = 0.13$						
D: College's comparisons concerning the sub-criterion C_{14}						
IPU	(1,1,1,1)	(2/9,1/4,2/7,1/2)	(2/7,1/3,2/5,1/2)	(2/5,1/2,2/3,1)	0.2130	0
NSIT	(2,7/2,4,9/2)	(1,1,1,1)	(2/3,1,3/2,5/2)	(2/3,1,3/2,5/2)	0.3023	0.4076
NIT	(2,5/2,3,7/2)	(5/2,2/3,1,3/2)	(1,1,1,1)	(3/2,2,5/2,3)	0.2152	0.4076
DTU	(1,3/2,2,5/2)	(5/2,2/3,1,3/2)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	0.2154	0.1847
$\beta = 0.37$						

Table 6 Fuzzy PWC matrix of colleges concerning the sub-criteria of C_2 and their normalized priorities weights

	IP University	NSIT	NIT Delhi	DTU	LFTA	EA priorities (Celik et al., 2009)
A: College's comparisons concerning the sub-criterion C_{21}						
IPU	(1,1,1,1)	(2/3,1,2,5/2)	(2/5,1/2,2/3,1)	(2/5,1/2,2/3,1)	0.2405	0.0717
NSIT	(2/5,1/2,1,3/2)	(1,1,1,1)	(1,1,1,1)	(2/3,1,2,5/2)	0.3122	0.2164
NIT	(1,3/2,2,5/2)	(1,1,1,1)	(1,1,1,1)	(3/2,2,5/2,3)	0.2360	0.4305
DTU	(1,3/2,2,5/2)	(2/5,1/2,1,3/2)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	0.2136	0.2815
$\beta = 0.51$						
B: College's comparisons concerning the sub-criterion C_{22}						
IPU	(1,1,1,1)	(1/3,2/5,1/2,2/3)	(2,1/2,5/2,3)	(1,3/2,2,5/2)	0.2012	0.4199
NSIT	(1/2,1/3,1/4,1/5)	(1,1,1,1)	(1,2,3,5)	(2/3,1,2,5/2)	0.3701	0.2349
NIT	(2/7,1/3,2/5,1/2)	(1/5,1/3,1/2,1)	(1,1,1,1)	(3/2,2,5/2,3)	0.2003	0.3136
DTU	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	0.1875	0.0316
$\beta = 0.58$						
C: College's comparisons concerning the sub-criterion C_{23}						
IPU	(1,1,1,1)	(1/2,1/3,1/4,1/5)	(1/2,1/3,1/4,1/5)	(1/2,1/3,1/4,1/5)	0.3471	0.5343
NSIT	(1/3,2/5,1/2,2/3)	(1,1,1,1)	(1/2,1/3,1/4,1/5)	(1/2,1/3,1/4,1/5)	0.2457	0.3850
NIT	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	(1,4,4,4)	0.1902	0.0401
DTU	(1,5,5,4)	(1/3, 2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	0.3163	0.0401
$\beta = 0.37$						

Table 7 Fuzzy PWC matrix of colleges concerning the sub-criteria of C_3 and their normalized priorities weights

	IP University	NSIT	NIT Delhi	DTU	LFTA	EA priorities (Celik et al., 2009)
A: Comparisons of colleges concerning the sub-criterion C_{31}						
IPU	(1,1,1,1)	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(2/3,1,2,5/2)	0.1625	0.4313
NSIT	(1/3,2/5,1/2,2/3)	(1,1,1,1)	(1,1,1,1)	(1/3,2/5,1/2,2/3)	0.6798	0.2633
NIT Delhi	(1/3,2/5,1/2,2/3)	(1,1,1,1)	(1,1,1,1)	(1/3,2/5,1/2,2/3)	0.0680	0.0194
DTU	(2/5,1/2,1,3/2)	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	(1,1,1,1)	0.0900	0.2860
$\beta = 0.78$						
B: Comparisons of colleges concerning the sub-criterion C_{12}						
IPU	(1,1,1,1)	(2/9,1/4,1/3,2/5)	(5/2,3,7/2,4)	(1/3,2/5,1/2,2/3)	0.2601	0.3663
NSIT	(5/2,3,4,9/2)	(1,1,1,1)	(1,1,1,1)	(1/3,2/5,1/2,2/3)	0.5358	0.6363
NIT Delhi	(1/4,2/7,1/3,2/5)	(1,1,1,1)	(1,1,1,1)	(1/3,2/5,1/2,2/3)	0.0866	0
DTU	(2/5,1/2,1,3/2)	(2/5,1/2,1,3/2)	(2/5,1/2,1,3/2)	(1,1,1,1)	0.1152	0
$\beta = 0.90$						
C: Comparisons of colleges concerning the sub-criterion C_{13}						
IPU	(1,1,1,1)	(2/9,1/4,1/3,2/5)	(2/3,1,2,5/2)	(2/5,1/2,1,3/2)	0.2420	0
NSIT	(5/2,3,4,9/2)	(1,1,1,1)	(1/3,2/5,1/2,2/3)	(1/3,2/5,1/2,2/3)	0.5634	0.8621
NIT Delhi	(2/5,1/2,1,3/2)	(3/2,2,5/2,3)	(1,1,1,1)	(2/3,1,2,5/2)	0.08347	0
$\beta = 0.22$	(2/3,1,2,5/2)	(3/2,2,5/2,3)	(5/2,1/2,1,3/2)	(1,1,1,1)	0.1112	0.1379

The weights for the priorities computed through the proposed technique named as LFTA which is shown by headline within the columns 'LFTA priorities' in the last columns of each table. Table 8 represents the aggregated weight priorities. Finally, the 'LFTA method' computes 'NSIT' is the rank 1 college, while the EA generates a different outcome that choose 'NIT Delhi' got the second rank. Through this case study, it has been found that results generated using this approach are a more reliable and consistent than provided by the EA. Therefore, we have the reasons to decline the results provided through EA.

Table 8 Accumulation of the overall weights for priorities obtained by LFTA

Overall weight priorities for the ranking of colleges about the decision goal				
Weight	0.4407	0.3121	0.2472	-
IP University	0.23325ss	0.267	0.1244	0.2082
NSIT	**0.27285**	**0.30866**	**0.2736**	**0.285**
NIT Delhi	0.2020	0.20866	0.4264	0.279
DTU	0.2876	0.239	0.1756	0.2340

6 Conclusion

RP is a very significant phase to build optimal judgments. Through the existing research work, it has been noted that no technique does not perform sound for grading the alternatives and go through a various drawbacks like uncertainty, complication, vagueness, and negative value of membership. To eliminate these problems for ranking the alternatives in MCDM, we introduced a novel approach using LFTA that generates positive membership degree and provides a unique best possible priority weight vector. To evaluate the effectiveness, this proposed approach applied on a problem that is 'selection of rank 1 college fully based on various selection criteria' made through students. It proves optimal priorities are exactly similar for the lower triangular elements and the upper triangular elements in the form of PWC matrix. For the future perspective, the difficulty of this technique can be enhanced through PSO and genetic algorithm (GA). Finally, 'NSIT' is rank 1 college that gained highest priority and 'NIT Delhi' got second rank based on various selection criteria.

References

Abu-Taha, R. (2011, July). Multi-criteria applications in renewable energy analysis: A literature review. In *2011 Proceedings of PICMET'11: Technology Management in the Energy Smart World (PICMET)* (pp. 1–8).

Bueyuekoezkan, G., & Ruan, D. A. (2007). Evaluating government websites based on a fuzzy multiple criteria decision-making approach. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 15*(03), 321–343.

Büyüközkan, G., & Berkol, Ç. (2011). Designing a sustainable supply chain using an integrated analytic network process and goal programming approach in quality function deployment. *Expert Systems with Applications, 38*(11), 13731–13748.

Calabrese, A., Costa, R., & Menichini, T. (2013). Using fuzzy AHP to manage intellectual capital assets: An application to the ICT service industry. *Expert Systems with Applications, 40*(9), 3747–3755.

Cebeci, U., & Ruan, D. A. (2007). A multi-attribute comparison of Turkish quality consultants by fuzzy AHP. *International Journal of Information Technology and Decision Making, 6*(01), 191–207.

Celik, M., Er, I. D., & Ozok, A. F. (2009). Application of fuzzy extended AHP methodology on shipping registry selection: The case of Turkish maritime industry. *Expert Systems with Applications, 36*(1), 190–198.

Chan, F. T., & Kumar, N. (2007). Global supplier development considering risk factors using fuzzy extended AHP-based approach. *Omega, 35*(4), 417–431.

Chan, F. T., Kumar, N., Tiwari, M. K., Lau, H. C., & Choy, K. (2008). Global supplier selection: a fuzzy-AHP approach. *International Journal of Production Research, 46*(14), 3825–3857.

Dubois, D. (2011). The role of fuzzy sets in decision sciences: Old techniques and new directions. *Fuzzy Sets and Systems, 184*(1), 3–28.

Govindan, K., Rajendran, S., Sarkis, J., & Murugesan, P. (2015). Multi criteria decision making approaches for green supplier evaluation and selection: a literature review. *Journal of Cleaner Production, 98*, 66–83.

Haghighi, M., Divandari, A., & Keimasi, M. (2010). The impact of 3D e-readiness on e-banking development in Iran: A fuzzy AHP analysis. *Expert Systems with Applications, 37*(6), 4084–4093.

Heo, E., Kim, J., & Boo, K. J. (2010). Analysis of the assessment factors for renewable energy dissemination program evaluation using fuzzy AHP. *Renewable and Sustainable Energy Reviews, 14*(8), 2214–2220.

Ho, W., Xu, X., & Dey, P. K. (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. *European Journal of Operational Research, 202*(1), 16–24.

Jaskowski, P., Biruk, S., & Bucon, R. (2010). Assessing contractor selection criteria weights with fuzzy AHP method application in group decision environment. *Automation in construction, 19*(2), 120–126.

Kahraman, C., Ertay, T., & Büyüközkan, G. (2006). A fuzzy optimization model for QFD planning process using analytic network approach. *European Journal of Operational Research, 171*(2), 390–411.

Kahraman, C., & Kaya, İ. (2010). A fuzzy multicriteria methodology for selection among energy alternatives. *Expert Systems with Applications, 37*(9), 6270–6281.

Kaya, T., & Kahraman, C. (2010). Multicriteria renewable energy planning using an integrated fuzzy VIKOR and AHP methodology: The case of Istanbul. *Energy, 35*(6), 2517–2527.

Kelemenis, A., & Askounis, D. (2010). A new TOPSIS-based multi-criteria approach to personnel selection. *Expert Systems with Applications, 37*(7), 4999–5008.

Khan, J. A., Rehman, I. U., Khan, Y. H., Khan, I. J., & Rashid, S. (2015). Comparison of requirement prioritization techniques to find best prioritization technique. *International Journal of Modern Education & Computer Science*, 7(11).

Khazaeni, G., Khanzadi, M., & Afshar, A. (2012). Fuzzy adaptive decision making model for selection balanced risk allocation. *International Journal of Project Management, 30*(4), 511–522.

Nagpal, R., Mehrotra, D., Bhatia, P. K., & Sharma, A. (2015). Rank university websites using fuzzy AHP and fuzzy TOPSIS approach on usability. *International journal of information engineering and electronic business, 7*(1), 29.

Sadiq, M., & Jain, S. K. (2014). Applying fuzzy preference relation for requirements prioritization in goal oriented requirements elicitation process. *International Journal of System Assurance Engineering and Management, 5*(4), 711–723.

Sadiq, M., & Jain, S. K. (2015). A fuzzy based approach for the selection of goals in goal oriented requirements elicitation process. *International Journal of System Assurance Engineering and Management, 6*(2), 157–164.

Serhani, M. A., El Kassabi, T. H., Ismail, H., & Nujum Navaz, A. (2020). ECG monitoring systems: Review, architecture, processes, and key challenges. *Sensors, 20*(6), 1796.

Sevkli, M. (2010). An application of the fuzzy ELECTRE method for supplier selection. *International Journal of Production Research, 48*(12), 3393–3405.

Shaw, K., Shankar, R., Yadav, S. S., & Thakur, L. S. (2012). Supplier selection using fuzzy AHP and fuzzy multi-objective linear programming for developing low carbon supply chain. *Expert Systems with Applications, 39*(9), 8182–8192.

Sipahi, S., & Timor, M. (2010). The analytic hierarchy process and analytic network process: an overview of applications. *Management Decision, 48*(5), 775–808.

Soh, S. (2010). A decision model for evaluating third-party logistics providers using fuzzy analytic hierarchy process. *African Journal of Business Management, 4*(3), 339–349.

Sun, C. C. (2010). A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods. *Expert Systems with Applications, 37*(12), 7745–7754.

Vaishnavi, B., Yarrakula, K., Karthikeyan, J., & Thirumalai, C. (2017, January). An assessment framework for precipitation decision making using AHP. In *2017 11th International Conference on Intelligent Systems and Control (ISCO)* (pp. 418–421).

Veerabathiran, R., & Srinath, K. A. (2012). Application of the extent analysis method on fuzzy AHP. *International Journal of Engineering Science and Technology, 4*(7), 3472–3480.

Wang, Ying-Ming, & Chin, Kwai-Sang. (2011). Fuzzy analytic hierarchy process: A logarithmic fuzzy preference programming methodology. *International Journal of Approximate Reasoning, 52*(4), 541–553.

Wang, Q., Wang, H. O. N. G., & Qi, Z. (2016). An application of nonlinear fuzzy analytic hierarchy process in safety evaluation of coal mine. *Safety Science, 86,* 78–87.

Ye, J. (2010). Fuzzy decision-making method based on the weighted correlation coefficient under intuitionistic fuzzy environment. *European Journal of Operational Research, 205*(1), 202–204.

Yücel, A., & Güneri, A. F. (2011). A weighted additive fuzzy programming approach for multi-criteria supplier selection. *Expert Systems with Applications, 38*(5), 6281–6286.

Zhü, K. (2014). Fuzzy analytic hierarchy process: Fallacy of the popular methods. *European Journal of Operational Research, 236*(1), 209–217.

Trend Analysis and Predictive Modeling Using Machine Learning Models on Indian Election Historical Dataset

Amit Kumar Yadav and Rahul Johari

Abstract

India has been among the largest democracy around the world, and democratic election process has played an important role in achieving this status. Predicting elections result is an important factor as it influences the market situation at local and global level. This paper had focused on data analytics and machine learning using Python, on historical dataset. Historical datasets of Indian Parliamentary Elections have been taken for a larger time span of 1977–2014 and results of same have been plotted using Python. In this paper, five machine learning models have been used for predicting win or loss for a seat in an election. The models primarily used for this analysis are Gaussian Naive Bayes, extra tree classifier, K-nearest neighbors classifier (KNN), logistic regression and decision tree classifier. In result section, results of five model used for study were evaluated and compared. This study had depicted that decision tree classifier provided comparatively good accuracy score among the chosen five models.

Keywords

Machine learning (ML) • Logistic regression • Decision tree • Data analytics • Election • Naive Bayes • Predictive modeling • KNN

1 Introduction

India is among the largest democratic country and prediction of election results is important as it has an impact over local and global market significantly. Machine learning had grown out from artificial intelligence and uses past information for training the models which further could be utilized for prediction and classification purposes. Past information from which learning happened was referred as experience. As the size of training sample increase, prediction become more accurate. Prediction also depends on quality of labels assigned. This paper had worked on trend analysis and predictive modeling using machine learning models. This paper is organized in different sections, in this section, it had provided brief introduction about election and machine learning. Section 2, literature survey, it was found that prediction about elections has been identified as significant and challenging topic for research. In Sect. 3, problem statement of study has been elaborated for better understanding. Further, as a part of Sects. 4 and 5, methodology adopted and experimental setup are discussed. In Sect. 6, description of machine learning models and their implementation along with main measures for evaluation has been presented. Machine learning models and trend analysis graphs have been drawn using Python coding on Jupyter Notebook interface. Section 7 describes result and evaluation with corresponding diagrams followed by conclusion and future scope.

2 Literature Survey

Prediction has been done in multiple domains using different methods in past. In this, reference related work has been identified using literature survey method under four broad perspectives. The survey has been conducted on research papers focusing toward technology adoption in election scenario, papers based on label dataset, papers focusing

A. K. Yadav (✉) · R. Johari
SWINGER (Security, Wireless, IoT Network Group of Engineering and Research) Lab@USICT, GGSIP University, Delhi, India
e-mail: amityadav.india@gmail.com

R. Johari
e-mail: rahul@ipu.ac.in

toward prediction of election results and finally papers on Indian Election.

Study conducted by Sharma and Moh (2016) had analyzed trends in Indian General Election 2014 and during their work researcher used supervised learning approach like Naïve Bayes classifier, support vector machines (SVM) and dictionary-based unsupervised learning approach. Study conducted by Novaković et al. (2017) on evaluation of machine learning models had identified that accuracy, confusion matrix, precision, F-measure and ROC curve are significant parameters while predicting results. Praciano et al. (2018) had worked on Brazilian Election using four machine learning algorithms and identified that SVM had provided comparatively better result as per performance indices. Study conducted by researchers (Zolghadr et al., 2018) had applied SVM and artificial neural network (ANN) as learning techniques on US Presidential election. Initially, preprocessing and transformation performed on dataset and then it had been identified that SVM provide good predictive results. Researcher had used regression as a benchmark for comparison of results. As a part of study, they had also recommended to use other approaches for better accuracy. Vijayan and Mohler (2018) had forecasted the retweet count using graph convolution neural network. Tweets of presidential election in Kenya and South Africa were used as a dataset for forecasting results. Results had shown 15% better precision than popular statistical model, SEISMIC. With an aim toward taking their work further and using multiple GPU to expand their work, researcher Sokolova and Perez (2018) have performed social network analysis using tweets as dataset on French Presidential Election. Hashtags graph were created to analyze the Twitter activities relevant to left-wing and right-wing parties. Fernquist et al. (2018) as part of their study examined bots influences on Swedish General Election on Twitter. Random forest had outperformed other models, so it was used for classification. Djouvas et al. (2018) found voting advice application had been improved using three supervised machine learning techniques and SVM had outperformed Naïve Bayes and feed forward neural networks models. Political profile augmentation had provided significant improvement in system capability. Campanale and Caldarola (2018) worked on political inclination of Twitter users in election campaigns. This work aimed Italian Constitutional Referendum 2016 and used Naive Bayes multinomial text classification algorithm which provided promising results. Researcher had also recommended improving accuracy using semantic-based approaches in order to determine the text polarization. Rojas et al. (2018) in their study had analyzed the use of social media by women in politics to influence political and social reality. It had been identified

that women used technological platform as a powerful tool to counteract the messages on traditional media. Dos Santos et al. (2019) worked on predicting election sentiment using label dataset taken from different domain based on similarities among the datasets. It had been noticed that performance of classifier improved with combined similar dataset and degraded when combined with dissimilar dataset. Miranda et al. (2019), worked on sentiment analysis using machine learning and WordNet approach for Indonesian Election. Naive Bayes classifier was used for performing tweet sentiment classification. The study conducted by Gupta and Kumar (2019) had discussed about learning techniques on labeled dataset of tweets and the proposed system was validated using Punjab Election 2017 dataset. During their study, five machine learning models were used like maximum entropy, SVM, NB, Bernoulli NB and multinomial NB. Recurrent neural network, convolutional neural network and three-layer perceptron were used as three deep learning models. They also recommended to work on improving accuracy using different techniques. Researchers Febriana and Budiarto (2019) had built a hate speech detection model using Indonesian language tweets on Twitter. Topic modeling was applied using LDA algorithm and each tweet is allocated with polarity score using sentiment analysis model. Singh et al. (2019) used machine learning algorithms for predicting stock prices using historical data. Learning models used were decision trees, SVM, random forest, ensemble methods and hybrid methods. Alves et al. (2019) work was based on Brazilian Presidential Election 2018 and evaluated deep learning as a best structure for fake news detection. Agarwal et al. (2019) had worked toward finding outcome of the Indian General Election 2019 using deep learning approach. In their study, researchers had used tweets related to two main national parties in India, and they further performed opinion analysis on classified data.

3   Problem Statement

As highlighted by researchers Zolghadr et al. (2018) in their study, it has been identified that it is important to predict about the election as it influences the market situation. Due to complex election process, it was complicated to perform modeling on election as concluded by researcher Zolghadr et al. (2018). Study conducted by Praciano et al. (2018) had mentioned that various researchers were trying to predict about election using different methods in different countries. Mainly sentiment analysis and machine learning methods were used over Twitter dataset to predict about election but results shown up models had low accuracy scores. During

literature survey, it was found that there was no study which used historical dataset with larger time span to perform data analytics for Indian Election result prediction. In this paper, historical datasets of Indian Parliamentary Elections had taken and used to found interesting facts. This work focused on data analytics and machine learning using Python and graphs were plotted to provide with better insight into the dataset to depict information. Further, work was performed on implementation of machine learning models for election result prediction and compared those machine learning models over evaluation parameters. Based on literature survey, five machine learning models were used for prediction like Gaussian Naive Bayes, extra tree classifier, K-nearest neighbors classifier (KNN), logistic regression and decision tree classifier.

4 Methodology Adopted

During study, the first literature survey was performed to gain insight about Indian Election and machine learning models. Five machine learning models were identified during literature survey. While doing survey, information was gathered from research journal of IEEE and other reputed journals. Secondary data regarding Indian Parliamentary Elections 1977, 1980, 1984, 1989, 1991, 1996, 1998, 1999, 2004, 2009 and 2014 were downloaded from Election Commission of India Web site[1] and Harvard Dataverse (Bhavnani, 2017). It contained 73,081 rows and 13 variables. Jupyter Notebook was used as a Python programming tool to perform analysis on Indian Election dataset and different plots were drawn for analysis. Flowchart given in Fig. 1 shows the steps taken during application of machine learning models on election dataset.

5 Experimental Setup-Dataset and Tools

Historical dataset taken from sources—Election Commission of India and Harvard Dataverse (Bhavnani, 2017). Dataset comprise of details regarding election in 1977, 1980, 1984, 1989, 1991, 1996, 1998, 1999, 2004, 2009 and 2014. Laptop and system were used to do the Python programming which had below-mentioned configuration: Software used were Anaconda Navigator 1.9.7, Python 3.4.7 and Jupyter Notebook server 6.0.1. System configurations were RAM-8 GB, Processor i3-6006U, CPU-2.00 GHz, Operating System (OS) 64 bit and Window 10 Home.

6 Models Description and Implementation

As per the literature survey, supervised learning techniques provided good prediction results so we selected five supervised learning models for our prediction analysis. This section describe the models used in paper for prediction of election results. Candidate probability of wining can easily be predicted using historical dataset based on individual performance and party performance on particular seat as recorded in earlier elections. Finally, the implementation of machine learning models is also provided in algorithm format along with their evaluation parameters.

6.1 Decision Tree Classifier

This model used by researchers comes under supervised machine learning technique. It has decision node and leaf nodes which represent decision and outcome, respectively. It has no pre-assumption related to dataset distribution. Decision tree has uses two measures:

Entropy
Entropy controls how decision tree split based on information gain. Node with highest information gain value to lesser value put in decision tree from top to bottom manner.

Mathematical expression for entropy with pi as ratio of items of reach label in dataset and information gain was given as followed:

$$\text{Entropy} = -\sum_{i=1}^{n} pi * \log(pi) \tag{1}$$

$$\text{Information Gain} = \text{Entropy of Parent Node}$$
$$- \text{weighted average} * \text{Entropy of children} \tag{2}$$
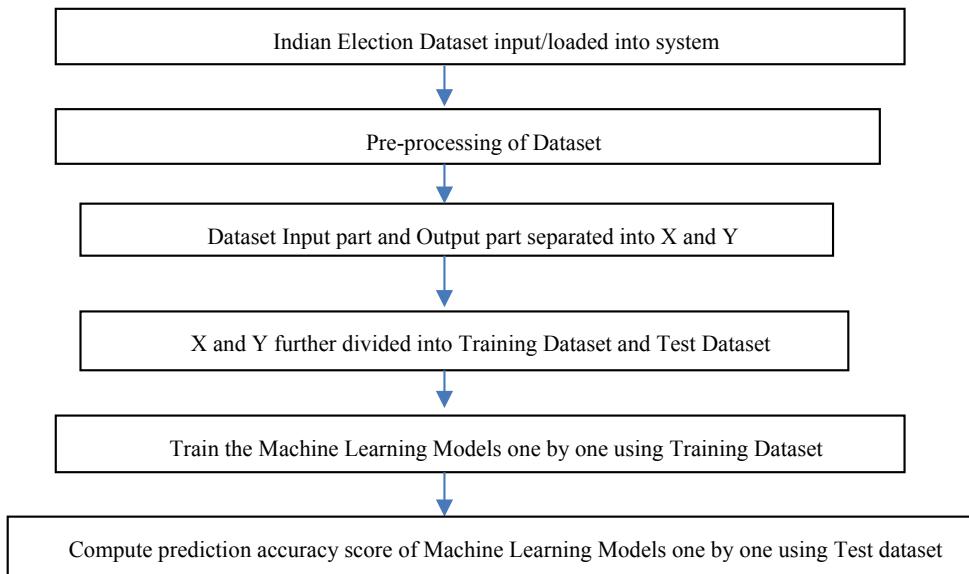
Gini Index
This has measured the homogeneity of the data. If Gini Index value equals to zero, it signifies that data was homogenous. Some main decision tree algorithms were CART, ID3, CHAID and ID4.5. Mathematical calculation with pi as ratio of items of each label in dataset given as followed:

$$\text{Gini Index} = 1 - \sum_{i=1}^{n} pi^2 \tag{3}$$

---

[1]https://eci.gov.in/statistical-report/statistical-reports/.

Fig. 1 Flowchart showing steps to train and test ML models using election dataset

Indian Election Dataset input/loaded into system

Pre-processing of Dataset

Dataset Input part and Output part separated into X and Y

X and Y further divided into Training Dataset and Test Dataset

Train the Machine Learning Models one by one using Training Dataset

Compute prediction accuracy score of Machine Learning Models one by one using Test dataset

6.2 Logistic Regression

Input features, X, were combined to predict output feature y. Equation was created with output feature on left side and input features with constant or intercept and coefficients on right side. Logistic regression differs from linear regression in modeling, as output modeled with binary values instead of numeric value. Logistic regression equation was as followed:

$$y = \frac{e^{constant\ +\ coefficent*X}}{1 + e^{constant\ +\ coefficent*X}} \qquad (4)$$

Coefficient and constant were learned from the training data and associated with each feature of input data.

6.3 Extra Tree Classifier

Extremely randomized trees classifier (extra trees classifier) has similarity with random forest classifier but differs in way of construction of decision tree in forest with lesser computational cost. In this learning technique, splits were selected randomly to create decision tree independent of output. Random trees generated in forest whose results were aggregated to provide the classifications result.

6.4 K-Nearest Neighbors Classifier (KNN)

KNN worked with assumption that similar data present closer to each other. To find out the distance with other nodes, it used measurement of Euclidean distance. If there

was a reference dataset with two features $x2$ and $y2$, then Euclidean distance for new data point with feature values $x1$ and $y1$ was calculated as follows:

$$\text{Euclidean Distance} = \sqrt{(x1 - x2)^2 + (y1 - y2)^2} \qquad (5)$$

New data point was then kept in class with lesser Euclidean distance. K value signifies that how many nearest neighbors with least Euclidean distance were used for classification. Classification is done on the basis of majority of nearest neighbor class used for reference. This algorithm was slower with larger dataset.

6.5 Gaussian Naive Bayes

Gaussian Naive Bayes was one of variant of Naïve Bayes classifier. This had assumption about data distribution and used for numeric, data which have features continuous in nature. Probability density function of Gaussian Naïve Bayes has been calculated as follows with training data feature x, μ as mean of x and $\sigma2$ as variance.

$$f(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (6)$$

6.6 Model Implementation

Input: Dataset was loaded to the Jupyter Notebook using Python coding
Output: Tabular representation of evaluation measurement

Begin

{

Step1: Perform data cleaning and preprocessing on the dataset.

Step2: Data was divided into Input X and Output Y

Step3: Random function was used while Input X and Output Y further divided into two parts for Training and Testing purposes i.e. Train_X and Train_y; Test_X and Test_y. Train_X and Test_X were 71832×13 matrix structure whereas Train_y and Test_y were 71832×1 matrix i.e. one-dimensional vector

Step4: Input Train_X and Train_y to train each of five models one by one.

Step5: Test the trained models one by one using Test_X and Test_y

Step6: Record the evaluation measures in vectors named accuracy, precision, recall, F1 score and confusion matrix

Step7: Display measures in tabular format

}

End

Main challenge during research work was to have fields on common data format and consolidate data over a longer time span. Filling missing values was also time-consuming work. Dataset was preprocessed and transformed for training the learning models. Evaluating criteria for machine learning models described as per scholars (Dos Santos et al., 2019; Mohri et al., 2018; Miranda et al., 2019) were accuracy, precision, recall and F-score.

7 Results and Evaluation

Over a period from 1977 till 2014, overall winning and lost percentage were computed as 8.12% candidates won; however, 91.88% candidates had lost in the election process (depicted through Fig. 2). This shows a very less winning vs losing ratio of around 8:92. Hence, the candidate had very less chance to won the Indian elections.

Category-wise bar plot, Fig. 3, shows that general, scheduled caste and scheduled tribe candidates winning percentage were 8.1%, 11.7% and 16.3%, respectively. So, scheduled tribe candidates had more winning percentage as compared to general and schedule caste. Gender-wise bar plot (Fig. 4) shows win vs lost count in respect of male, female, transgender and None Of The Above (NOTA). Male, female and transgender had winning percentage of 8.6%, 14.3% and 0%, respectively. Female gender had more winning percentage (14.3%) as compared to male and transgender, as shown in Fig. 4.

Top five states identified in term of female candidate's counts were shown in Table 1. Uttar Pradesh was on first
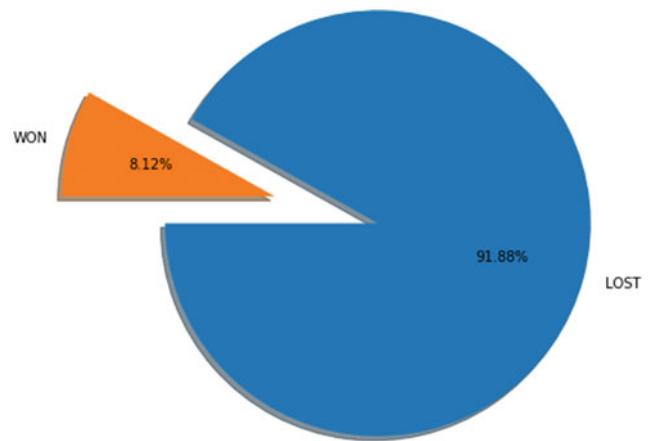

Fig. 2 General election winning–losing percentage (1977–2014)

place in term of female candidate count with 694 as total count which was more than double of Maharashtra, as shown in Table 1.

Top five states with elected female parliamentarian count is shown in Table 2. Uttar Pradesh was on first place in term of elected female candidates or female winning candidate count with 87 as total count. Yearwise all gender count from 1977 till 2014 (Fig. 5) shown maximum number of male candidates contested elections in the year 1996 with count of 13,341. Whereas for female candidate's count (number of female candidates were 668) was maximum in 2014. NOTA and transgender were also introduced from year 2014 with count 542 and 6, respectively.

Number of parties were showing increasing trend from 1977 till 2014, as shown in Fig. 6. This clearly shows parties were losing trust of Indian citizens/voters with time. As parties were less trust worthy, and therefore new parties were formed to win trust of Indian citizens/voters. Top ten parties as per total vote share from 1977 to 2014 is shown in Fig. 7. Indian National Congress (INC) had maximum vote share of about 28% followed by Bharatiya Janata Party (BJP) with vote share of about 19%. Whereas, other parties had 5% or lesser vote share. So, INC and BJP were two big parties as per vote share analysis.

Predictive modeling work performed using five machine learning models—decision tree classifier, logistic regression, extra tree classifier, K-nearest neighbors classifier (KNN) and Gaussian Naive Bayes. Results shown good accuracy score of more than 0.939 means 93.9% prediction were correct when applied over testing data, and among five models, decision tree classifier provided comparatively good accuracy score of about 0.952, as shown in Fig. 8. However, the precision score was higher for Gaussian Naïve Bayes model in comparison with other models means lesser chances to predict false wining. Precision value for Gaussian

**Fig. 3** Category-wise winner (1) and lost (0) number of candidates (1977–2014)
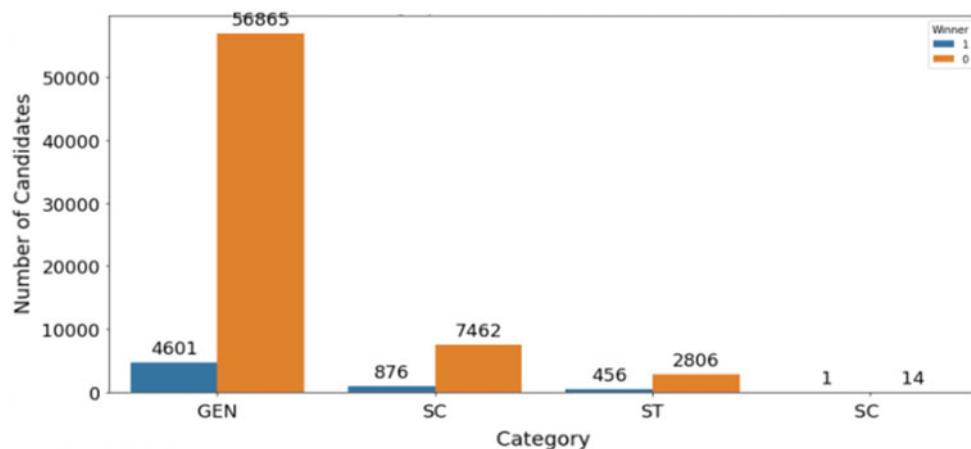
**Fig. 4** Gender-wise winner count (1977–2014)
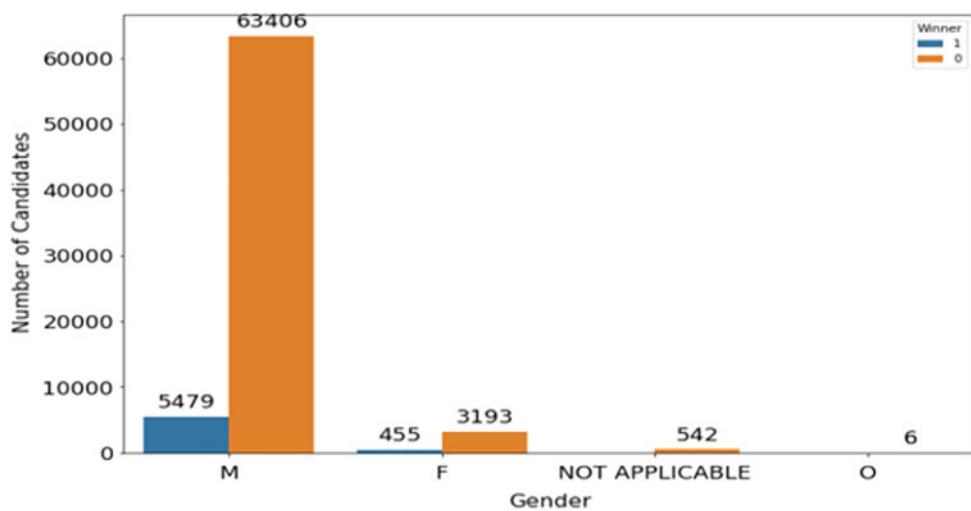
Table 1 Top five states with female candidates count (1977–2014)

S. No.	State name	Number of female candidates
1	Uttar Pradesh (UP)	694
2	Maharashtra	323
3	Madhya Pradesh (MP)	300
4	Andhra Pradesh	285
5	Bihar	285

Table 2 Top five states with elected female parliamentarian count (1977–2014)

State name	Rank based on count	Number of elected females
Uttar Pradesh (UP)	1	87
West Bengal	2	52
Bihar	3	41
Madhya Pradesh (MP)	4	38
Maharashtra	5	35

Fig. 5 Yearwise all gender candidate's count (1977–2014)
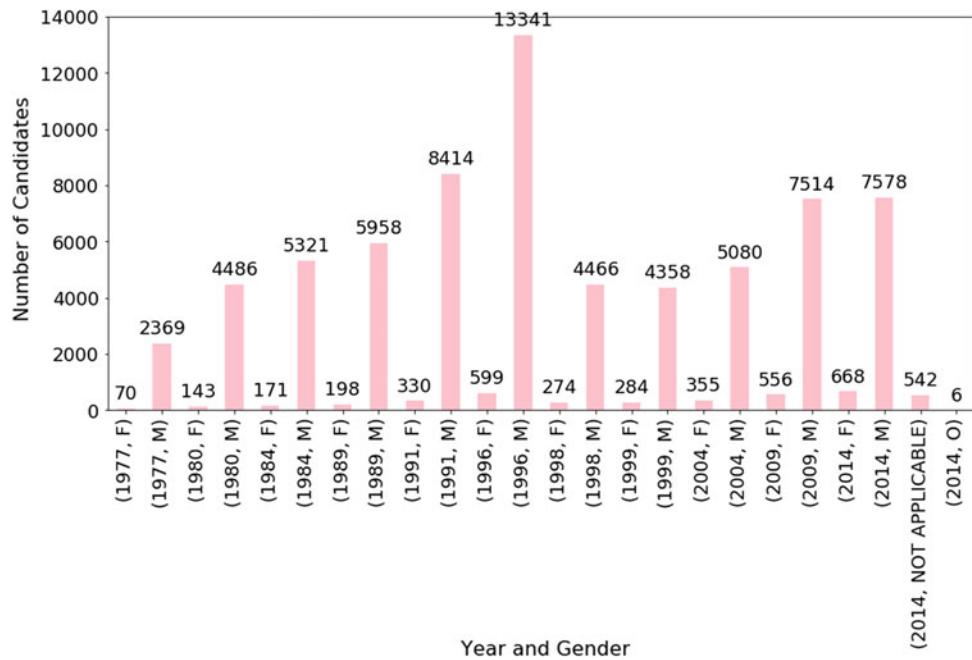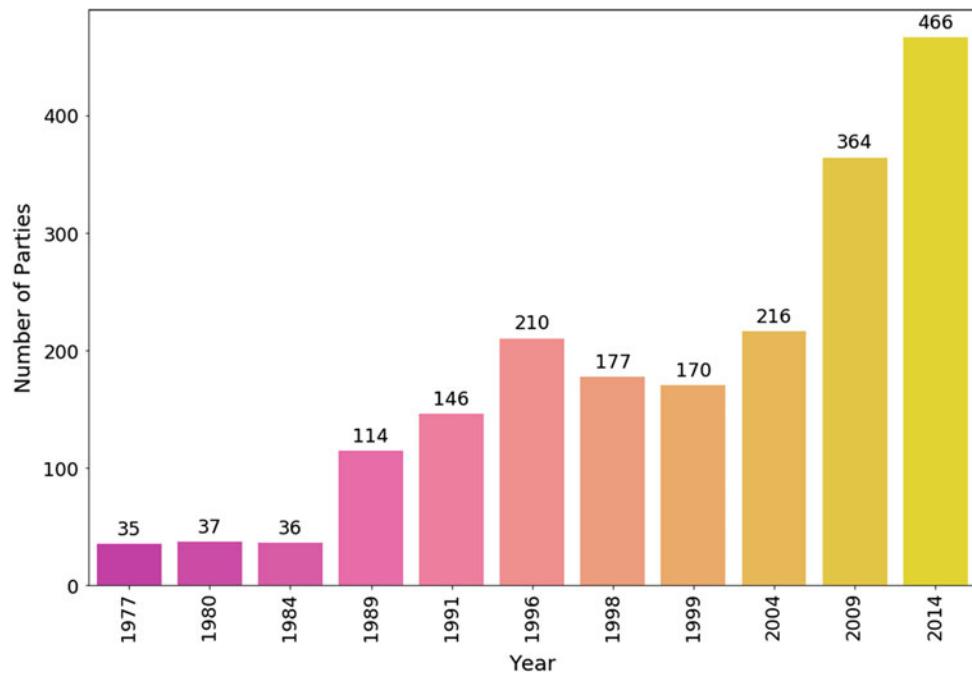
Fig. 6 Yearwise all party count (1977–2014)

Naïve Bayes model was 0.855. Recall for higher score for logistic regression means lesser chance for wrongly predicting status as lost instead of winner for seat. *F*1 score was higher for decision tree with value 0.72 which considered value of both, precision and recall, and higher score signifies model was good as it had lesser chance for both false winning and false lose. Confusion matrix which provides all combinations of true and false counts in matrix format for each model were also displayed in Fig. 8.

8 Conclusion

Historical datasets of Indian Parliamentary Elections successfully found some interesting facts about Indian election. Winning vs losing ratio was around 8:92. Hence, candidate had very less chance to win in the Indian elections. Scheduled tribe candidates had more winning percentage as compared to general and scheduled caste. Female gender had

Fig. 7 Top ten parties vote share (1977–2014)

logistic regression and decision tree models, respectively. So, historical dataset was useful as it utilization with learning models had shown good probability for predicting about seat wining status.

This work had contributed toward providing trends and comparative study of different machine learning models predictability on Indian Election historical dataset. This work is useful for researcher working in prediction modeling on election labeled dataset in developing countries. In future work, additional fields like criminal record, assets and liability of a candidate will be included in dataset to perform data analytics including these parameters and same will be compared for the improvement in prediction accuracy scores. For preprocessing, new normalization techniques will be explored and will be applied on dataset to see the impact on accuracy score of machine learning models. For further study, prediction modeling on Indian Election will be tried using recent machine learning and deep learning algorithm.

References

Agarwal, A., Toshniwal, D., & Bedi, J. (2019, September). Can Twitter help to predict outcome of 2019 Indian General Election: A deep learning based study. In P. Cellier, K. Driessens (eds.), *Machine learning and knowledge discovery in databases. ECML PKDD 2019. Communications in computer and information science* (Vol. 1168, pp. 38–53). Cham: Springer.

Alves, J. L., Weitzel, L., Quaresma, P., Cardoso, C. E., & Cunha, L. (2019, October). Brazilian Presidential Elections in the era of misinformation: A machine learning approach to analyse fake news. In I. Nyström, Y. Hernández Heredia, V. Milián Núñez (eds.), *Progress in pattern recognition, image analysis, computer vision, and applications. CIARP 2019. Lecture Notes in Computer Science* (Vol. 11896, pp. 72–84). Cham: Springer.

Bhavnani, R. R. (2017). India National and State election dataset. https://doi.org/10.7910/DVN/26526 HarvardDataverse Network V2.

Campanale, M., & Caldarola, E. G. (2018, August). Revealing political sentiment with Twitter: The case study of the 2016 Italian constitutional referendum. In *2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*, Barcelona (pp. 861–868). IEEE.

Djouvas, C., Antoniou, A., & Tsapatsoulis, N. (2018, September). Improving social vote recommendation in VAAs: The effects of political profile augmentation and classification method. In *2018 13th International Workshop on Semantic and Social Media Adaptation and Personalization (SMAP)*, Zaragoza (pp. 1–6). IEEE.

more winning percentage as compared to male and transgender. Top five states in term of female candidates and elected female parliamentarian were found and Uttar Pradesh was on top position in both. Maximum numbers of male and female candidates contested elections in 1996 and 2014, respectively. NOTA and transgender were also introduced from year 2014. The increasing trend of number of parties was highlighted indicating losing trust of Indian citizens/voters with time on existing political parties. So, new smaller as well as regional parties emerged to win trust of Indian citizens/voters. INC and BJP were on first two positions among top ten parties as per total vote share from 1977 to 2014.

Predictive modeling work was performed using five machine learning models—decision tree classifier, logistic regression, extra tree classifier, K-nearest neighbors classifier (KNN) and Gaussian Naive Bayes. All models' results have shown good accuracy score of more than 0.939, and among five models, decision tree classifier provided comparatively good accuracy score of about 0.952. Precision, Recall and $F1$ scores were higher for Gaussian Naïve Bayes,

Fig. 8 Screenshot of measures for evaluation of five machine learning models

	Model Name	Accuracy	Precision	Recall	F1 score	Confusion Matrix
1	DecisionTreeClassifier	0.952979	0.730926	0.703722	0.717066	[[21546, 529], [605, 1437]]
0	LogisticRegression	0.950740	0.649542	0.719032	0.682523	[[21652, 689], [499, 1277]]
2	ExtraTreeClassifier	0.946386	0.680061	0.668166	0.674061	[[21487, 629], [664, 1337]]
4	KNeighborsClassifier	0.945723	0.653611	0.671720	0.662542	[[21523, 681], [628, 1285]]
3	GaussianNB	0.939835	0.855036	0.590446	0.698525	[[20985, 285], [1166, 1681]]

Dos Santos, J. S., Paes, A., & Bernardini, F. (2019, October). Combining labeled datasets for sentiment analysis from different domains based on dataset similarity to predict electors sentiment. In *2019 8th Brazilian Conference on Intelligent Systems (BRACIS)*, Salvador, Brazil (pp. 455–460). IEEE.

Election Commission of India. https://eci.gov.in/statistical-report/statistical-reports/.

Fernquist, J., Kaati, L., & Schroeder, R. (2018, November). Political bots and the Swedish general election. In *2018 IEEE International Conference on Intelligence and Security Informatics (ISI)*, Miami, FL (pp. 124–129). IEEE.

Febriana, T., & Budiarto, A. (2019, August). Twitter dataset for hate speech and cyberbullying detection in Indonesian language. In *2019 International Conference on Information Management and Technology (ICIMTech)* (Vol. 1, pp. 379–382). IEEE.

Gupta, Y., & Kumar, P. (2019, February). Real-time sentiment analysis of tweets: A case study of Punjab elections. In *2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)* (pp. 1–12). IEEE.

Mohri, M., Rostamizadeh, A., & Talwalkar, A. (2018). *Foundations of machine learning*. MIT Press.

Miranda, E., Aryuni, M., Hariyanto, R., & Surya, E. S. (2019, August). Sentiment analysis using sentiwordnet and machine learning approach (Indonesia general election opinion from the twitter content). In *2019 International Conference on Information Management and Technology (ICIMTech)* (Vol. 1, pp. 62–67). IEEE.

Novaković, J. D., Veljović, A., Ilić, S. S., Papić, Ž, & Milica, T. (2017). Evaluation of classification models in machine learning. *Theory and Applications of Mathematics and Computer Science, 7*(1), 39–46.

Praciano, B. J. G., da Costa, J. P. C. L., Maranhão, J. P. A., de Mendonça, F. L. L., de Sousa Júnior, R. T., & Prettz, J. B. (2018, November). Spatio-temporal trend analysis of the Brazilian elections based on Twitter data. In *2018 IEEE International Conference on Data Mining Workshops (ICDMW)*, Singapore (pp. 1355–1360). IEEE.

Rojas, M. R., & Boguslavskaya, V. V. (2018, April). The use of new technologies by women in politics in the 2018 elections in Russia and Colombia. In *2018 IEEE Communication Strategies in Digital Society Workshop (ComSDS)* (pp. 46–48). IEEE.

Singh, S., Madan, T. K., Kumar, J., & Singh, A. K. (2019, July). Stock market forecasting using machine learning: Today and tomorrow. In *2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)*, Sarawak, Malaysia (Vol. 1, pp. 738–745). IEEE.

Sokolova, K., & Perez, C. (2018, August). Elections and the twitter community: The case of right-wing and left-wing primaries for the 2017 French presidential election. In *2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*, Barcelona (pp. 1021–1026). IEEE.

Sharma, P., & Moh, T. S. (2016, December). Prediction of Indian election using sentiment analysis on Hindi Twitter. In *2016 IEEE International Conference on Big Data (Big Data)* (pp. 1966–1971). IEEE.

Vijayan, R., & Mohler, G. (2018, October). Forecasting retweet count during elections using graph convolution neural networks. In *2018 IEEE 5th International Conference on Data Science and Advanced Analytics (DSAA)* (pp. 256–262). IEEE.

Zolghadr, M., Niaki, S. A. A., & Niaki, S. T. A. (2018). Modeling and forecasting US presidential election using learning algorithms. *Journal of Industrial Engineering International, 14*(3), 491–500.

Comparative Analysis of Transform Domain Watermarking System Based on Performance Measures

Namita Agarwal, Amit Kumar, and Pradeep Kumar Singh

Abstract

In last few decades, data security has been a challenging issue to protect the copyright information and integrity of digital products. So digital watermarking is founded as one of the talented methods to defend digitized media. This paper defines functioning of major transform domain methods such as discrete cosine transform (DCT), quaternion Hadamard transform (QHT), discrete wavelet transform (DWT), discrete contourlet transform (DCT), and many more are discussed. Comparison of these techniques based on peak signal-to-noise ratio (PSNR) and normalized correlation (NC) is discussed in this paper. Various types of attacks are also evaluated on these techniques.

1 Introduction

With the development of technology, multimedia data require notarization, and copyright protection has converted a continuous as well as frequent need for securing the media content (Horng et al., 2014). Information technology has improved the replication, updation and circulation of media content in current eras (Tao et al., 2014). To secure the multimedia data from unauthorized person, some prominent method is needed. Digital watermarking is the new, prevalent and well-organized system for multimedia data security. In this method, a watermark is inserted into any multimedia content to secure it from unauthorized usage. Some probable applications of digital watermarking are broadcast monitoring, tamper detection, chip and hardware security, E-governance, copyright protection, fingerprinting, health care, digital cinema and content authentication are shown in Fig. 1 (Agbaje et al., 2015; Singh & Singh, 2017). Security, capacity, robustness, imperceptibility and computational complexity are foremost characteristics of digital watermark (Singh et al., 2015).

The watermarking method is a combination of three different things, named as (i) the watermark, (ii) the embedding section and (iii) the extraction section. In embedding procedure, the algorithm inserted the watermark into the cover image. However, at extraction process, the algorithm extracts the watermark. For image watermarking, two vital necessities are there; one is visibility that means by inserting the watermark into cover image visual quality of watermarked image should not be wrecked. Other is robustness, which means the watermark should be proficient to resist different kinds of attacks (Shivani & Senapati, 2017). Digital watermarking is distinguished into two domains: One is spatial, and another is transform domain. The outcome of spatial domain system is straightforward and mathematically uncomplicated. Some spatial domain techniques are spread spectrum and patchwork (Tao et al., 2014). However, transform domain system provides more robust and imperceptible results (Shivani & Senapati, 2017).

The watermark embedding and extraction process is represented in Fig. 2. The watermark embedding is combination of original media, a secret image called as watermark and secret key, and it produces the watermarked data. In watermark extraction, the same procedure is imposed to watermarked image to obtain the original data.

N. Agarwal (✉) · A. Kumar
Jaypee University of Information Technology, Waknaghat, India
e-mail: namita312@gmail.com

P. K. Singh
ABES Engineering College, Ghaziabad, UP, India
e-mail: pradeep_84cs@yahoo.com
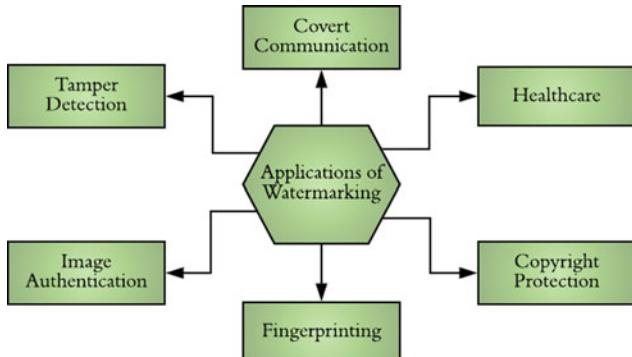
Fig. 1 Digital watermarking applications (Agbaje et al., 2015)
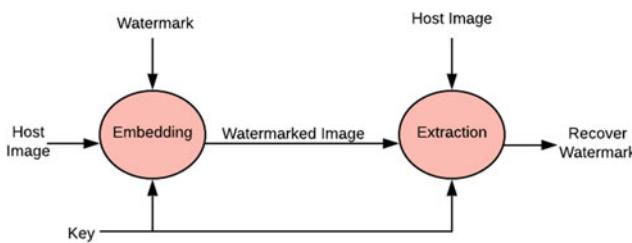
Fig. 2 Embedding and extraction process of watermarking

2 Methodology

The anticipated watermarking system is grounded on DWT, DCT, QHT and other transform domain procedures. Here a concise description of these methods is described at further subheadings.

2.1 Discrete Wavelet Transform

Discrete wavelet transforms (DWT) convert a discrete time signal to discrete wavelet illustrations (Totla & Bapat, 2013). A signal is decomposed into two fragments that are high frequencies and low frequencies. At every stage, wavelet decomposition has four different frequencies. Here, LL denotes the lower frequency band, and LH, HL and HH

sub-bands imply to horizontal, vertical and diagonal high-frequency band (Daphal et al., 2018) (Fig. 3).

2.2 Singular Value Decomposition

SVD is one of the most important operative mathematical evaluation tools used to evaluate matrices/images (Chang et al., 2005). In this transformation, a matrix could have decomposed into three different sizes like original matrix. Suppose I is an input image, then SVD of I can be signified by

$$SVD(I) = USV^T$$

where U and V are left and right $N * N$ orthogonal matrices, and S represents the diagonal matrix of same size (Fan et al., 2008). The key advantage of SVD in terms of singular values of matrix/image has great steadiness to distinguish when a minor trepidation is created in the image of the singular value does not change meaningfully (Singh & Singh, 2017).

2.3 Discrete Cosine Transform
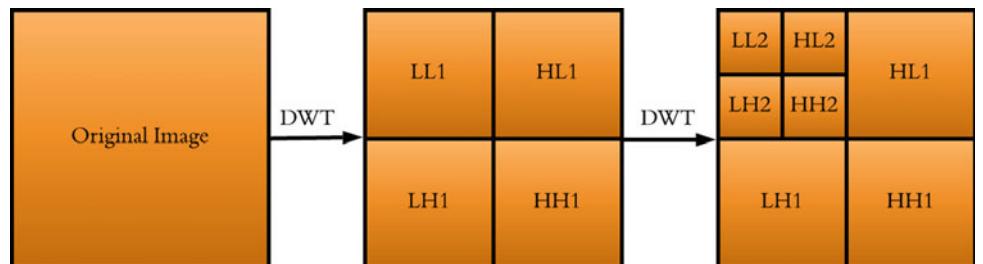
The basic nature of DCT is signal breakdown that switches images from spatial domain to transform domain (Priya et al., 2018). It is frequently used for image and signal processing because of its effective energy compaction property (Lin et al., 2010). The equation of 2D-DCT transform is described as follows:

$$F(m,n) = c(m)c(n)\frac{2}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}f(x,y)$$
$$\cos\frac{(2x+1)m\pi}{2N}\cos\frac{(2y+1)n\pi}{2N}$$

where $x, y, m, n = 0, 1, 2, \ldots, N-1$, and

$$c(m) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } \in = 0 \\ 1 & \text{Otherwise} \end{cases}$$

Fig. 3 DWT decomposition

the equation of inverse DCT (IDCT) transform is provided below

$$f(x,y) = \frac{2}{N} \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} c(m)c(n)F(m,n)$$
$$\cos\frac{(2x+1)m\pi}{2N} \cos\frac{(2y+1)n\pi}{2N}$$
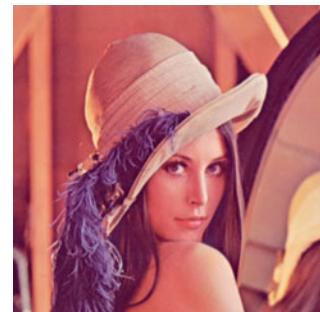
2.4 Quaternion Hadamard Transform

QHT is a combination of quaternion revelation and Hadamard transformation. The quaternion number represents that it does not drop any colour information (Prabha et al., 2019). The Hadamard is a non-sinusoidal, orthogonal alteration that decays an image or signal into a group of orthogonal, rectangular waveforms called Walsh functions. Earlier findings (Li et al., 2018) give us a clear idea that Hadamard transform provides modest working, low computational cost and simplicity of hardware functioning and also comfortable for digital watermarking. It has two basic properties; first is elements that are real and other is row and column orthogonal with respect to one another. Thus, $H = H* = H^T = H^{-1}$ (Li et al., 2018) where H represents Hadamard matrix and $H*$ is conjugate matrix, H^T denotes transpose of a matrix and H^{-1} is inverse Hadamard matrix.

2.5 Discrete Curvelet Transform

DCuT is a multiresolution transformation, and it is used for the sparse depiction of the image with geometrical design. It is developed by Candes (Borra et al., 2019), and it obtains many curvelet sub-bands with many frequency constants. As it plays a significant role in image processing that it shows the image in the form of curves or edges (Singh & Singh, 2017).

$$C^D(j,l,k) = \sum_{0 \le x,y < n} f(x,y)\overline{\theta_{j,l,k}^D(x,y)}$$

where digital curvelet waveform is $\theta_{j,l,k}^D$ (D stands for digital); $j = 0, 1, 2, \ldots$ is scaling parameter; orientation variable $l = 0, 1, 2\ldots$, and $k = (k1, k2) \in Z^2$ stands for translation boundary. The scale parameter relies on the size of the image and is measured as $\log_2 (\min(M, N)) - 3$, where M, N denotes the row and column of the image matrix. The orientation variable is set to a multiplier of 4, so the infringement value is 16 for orientation variable (Thanki et al., 2019).

2.6 Discrete Contourlet Transform

DCoT gives multiresolution-, local- and direction-dependent enlargement of images using pyramidal directional filter banks (Jayalakshmi et al., 2006). Contourlet transform has computational complexity $O(n^2)$ for $n \times n$ data. Contourlet uses less coefficients as compared to wavelets in same computational complexity. Firstly, the Laplacian pyramid (LP) (Burt & Adelson, 1983) developed can be used to catch the point disconnectedness. The LP decomposition generally utilizes orthogonal filter banks and downsample by 2 in each of the dimension [i.e., the integer sampling matrix M = diag (2, 2)]. The contourlets take advantage of indices $j, k, n,$ and l ($j \in \mathbb{Z}, n \in \mathbb{Z}^2$) to signify scale, direction, location, and decomposition level, respectively; m is also used to symbolize location (Shan et al., 2009).

3 Analysis

This comparative analysis of transform domain techniques uses multiple conventional images such as Lena, Barbara, Pepper and Baboon as cover image. The size of cover image

Fig. 4 **a**, **c** Original Lena and Baboon image (size 512 × 512), **b** watermark image (64 × 64)

(a)　　　　(b)　　　　(c)

Fig. 5 d Watermarked image, **e** extracted watermark

is taken as 512×512, and the secret image is copyright symbol with size of 64×64 (Figs. 4, 5 and Table 1).

For qualitative evaluation of algorithms, performance parameters like PSNR and NC are taken into consideration. Peak signal-to-noise ratio (PSNR) is calculated within cover and secret image and can be described as follows (Singh & Singh, 2017; Singh et al., 2015):

$$PSNR = 10 \log_{10} \frac{(255)^2}{MSE}$$

where MSE can be determined by following equation

$$MSE = \frac{1}{M \times N} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} \left(f(m,n) - \hat{f}(m,n) \right)^2$$

where f and $\hat{f}$ are two images with magnitude of $M \times N$ in which primary image is original image and second is agreeing watermarked image. If original and watermarked image looks similar, then good imperceptibility is achieved (Table 2).

The NC is another standard parameter that is used to evaluate the robustness by measuring the resemblances between original and extracted watermarks. The normalized correlation can be assessed from the following equation:

$$NCC = \frac{\sum_i \sum_j ow(i,j)ew(i,j)}{\sum_i \sum_j ow^2(i,j)}$$

Here, ow and ew define the original and extracted watermarks (Tables 3 and 4).

4 Conclusion

This paper shows the comparative analysis of different transform domain watermarking techniques in normal and noisy environment. It is found these identical techniques have capability to resist in noisy environment. Experimental

Table 1 Performance evaluation of DWT, DCT and SVD

S. No.	Image	DWT		DCT		SVD	
		PSNR	NCC	PSNR	NCC	PSNR	NCC
1	Lena	50.88	0.9974	48.12	0.9956	51.26	0.9924
2	Barbara	50.89	0.9974	48.13	0.9958	51.24	0.9923
3	Pepper	50.87	0.9973	48.15	0.9955	51.23	0.9921
4	Baboon	50.89	0.9974	48.14	0.9956	51.25	0.9923

Table 2 Performance evaluation of QHT, DcurvT and Dcont

S. No.	Image	QHT		DCurvT		DConT	
		PSNR	NCC	PSNR	NCC	PSNR	NCC
1	Lena	53.77	0.9993	52.89	0.9988	51.97	0.9959
2	Barbara	53.76	0.9995	52.85	0.9984	51.95	0.9962
3	Pepper	53.76	0.9996	52.88	0.9985	51.96	0.9962
4	Baboon	53.78	0.9994	52.88	0.9985	51.95	0.9963

Table 4 Performance evaluation of QHT, DCurT and DConT with attacks

Images	Attacks	QHT		DCurvT		DConT	
		PSNR	NCC	PSNR	NCC	PSNR	NCC
Lena	JPEG (90)	38.66	0.9882	36.15	0.9827	35.76	0.9791
	Salt and Pepper (0.01)	38.57	0.9872	36.55	0.9842	35.55	0.9782
	Gaussian Noise (0.01)	38.47	0.9865	36.88	0.9856	35.14	0.9765
	Rotation	38.59	0.9879	35.98	0.9799	34.99	0.9749
Barbara	JPEG (90)	38.69	0.9885	36.05	0.9815	35.82	0.9795
	Salt and Pepper (0.01)	38.55	0.9869	36.61	0.9844	35.55	0.9782
	Gaussian Noise (0.01)	38.47	0.9867	36.85	0.9851	35.15	0.9769
	Rotation	38.56	0.9871	35.98	0.9799	35.01	0.9755

Table 3 Performance evaluation of DWT, DCT and SVD with attacks

Images	Attacks	DWT		DCT		SVD	
		PSNR	NCC	PSNR	NCC	PSNR	NCC
Lena	JPEG (90)	34.92	0.9735	34.14	0.9692	33.81	0.9659
	Salt and Pepper (0.01)	34.75	0.9722	34.08	0.9681	33.65	0.9647
	Gaussian Noise (0.01)	34.53	0.9711	33.95	0.9675	33.52	0.9639
	Rotation	34.49	0.9706	33.88	0.9661	33.45	0.9629
Barbara	JPEG (90)	34.88	0.9731	34.14	0.9692	33.79	0.9655
	Salt and Pepper (0.01)	34.75	0.9722	34.09	0.9685	33.65	0.9647
	Gaussian Noise (0.01)	34.51	0.9708	33.92	0.9669	33.55	0.9645
	Rotation	34.45	0.9701	33.88	0.9661	33.42	0.9615

performance indicates that the presented technique achieves virtuous robustness and imperceptibility. It is also robust against many attacks such as Salt and Pepper, Gaussian noise, JPEG and rotation attacks. In addition to this in future work, we can test this technique for video watermarking.

References

Agbaje, M. O., Awodele, O., & Ogbonna, A. C. (2015). Applications of digital watermarking to cyber security (cyber watermarking). In *Proceedings of Informing Science and IT Education Conference (InSITE)* (pp. 1–11).

Borra, S., Thanki, R., Dey, N., & Borisagar, K. (2019). Secure transmission and integrity verification of color radiological images using fast discrete curvelet transform and compressive sensing. *Smart Health, 12,* 35–48.

Burt, P. J., & Adelson, E. H. (1983). The Laplacian pyramid as a compact image code. *IEEE Transactions on Communications, 31,* 532–540.

Chang, C. C., Tsai, P., & Lin, C. C. (2005). SVD based digital image watermarking scheme. *Pattern Recognition Letters, 26*(10), 1577–1586.

Daphal, S. D., Aher, P. K., Galande, S. B., & Jagtap, S. K. (2018). Comparison of key transform domain watermarking methods based on performance measures. In *International Conference on Communication, Information and Computing Technology (ICCICT) IEEE* (pp. 1–6).

Fan, M. Q., Wang, H. X., & Li, S. K. (2008). Restudy on SVD based watermarking scheme. *Applied Mathematics and Computation, 203* (2), 926–930.

Horng, S. J., Farfoura, M. E., Fan, P., Wang, X., Li, T., & Guo, J. M. (2014). A low cost fragile watermarking scheme in H.264/AVC compressed domain. *Multimedia Tools and Applications, 72*(3), 2469–2495.

Jayalakshmi, M., Merchant, S. N., & Desai, U. B. (2006). Digital watermarking in contourlet domain. *International Conference on Pattern Recognition, 3,* 861–864.

Li, J., Yu, C., Gupta, B. B., & Ren, X. (2018). Color image watermarking scheme based on quaternion Hadamard transform and Schur decomposition. *Multimedia Tools and Applications, 77*(4), 4545–4561.

Lin, S. D., Shie, S. C., & Guo, J. Y. (2010). Improving the robustness of dct-based image watermarking against JPEG compression. *Computer Standards and Interfaces, 32*(1), 54–60.

Prabha, K., Vaishnavi, M. J., & Sam, I. S. (2019). Quaternion Hadamard transform and QR decomposition based robust color image watermarking. In *International Conference on Trends in Electronics and Informatics (ICOEI) IEEE* (pp. 101–106).

Priya, S., Varatharajan, S., Manogaran, G., Sundarasekar, R., & Kumar, P. M. (2018). Paillier homomorphic cryptosystem with poker shuffling transformation based watermarking method for the secured transmission of digital medical images. *Personal and Ubiquitous Computing, 22*(5–6), 1141–1151.

Shan, H., Ma, J., & Yang, H. (2009). Comparison of wavelets, contourlets and curvelets in seismic denoising. *Journal of Applied Geophysics, 69,* 103–115.

Shivani, J. L. D., & Senapati, R. K. (2017). Robust image embedded watermarking using DCT and listless SPIHT. *Future Internet, 9*(3), 1–16.

Singh, A. K., Kumar, B., Dave, M., & Mohan, A. (2015). Robust and imperceptible dual watermarking for telemedicine applications. *Wireless Personal Communications, 80*(4), 1415–1433.

Singh, D., & Singh, S. K. (2017). DWT-SVD and DCT based robust and blind watermarking scheme for copyright protection. *Multimedia Tools and Applications, 76*(11), 13001–13024.

Tao, H., Chongmin, L., Zain, J. M., & Abdalla, A. N. (2014). Robust image watermarking theories and techniques: A review. *Journal of Applied Research and Technology, 12*(1), 122–138.

Thanki, R., Kothari, A., & Trivedi, D. (2019). Hybrid and blind watermarking scheme in DCuT-RDWT domain. *Journal of Information Security and Applications, 46,* 231–249.

Totla, R. V., & Bapat, K. S. (2013). Comparative analysis of watermarking in digital images using DCT and DWT. *International Journal of Scientific and Research Publications, 3*(2), 1–4.

ICT Technologies for Intelligent Applications

Emotion AI: Integrating Emotional Intelligence with Artificial Intelligence in the Digital Workplace

Simran Kaur and Richa Sharma

Abstract

The recent advancements in artificial intelligence (AI) and digital transformation have led to a paradigm shift in the interact pattern of people with technology. With the adoption of artificial intelligence (AI) in all business processes, the biggest challenge being faced by organizations is the integration of artificial intelligence (AI) with emotional intelligence (EI). There is no denying the fact that as more and more technology is being involved, and it has become a two-way process. Human beings are trained to work with technology and the technology is taught to relate to people. An extensive secondary research is conducted to comprehend the digital transformations at workplace and explore the evolving concepts of AI and how will it connect with the emotions of the 'Analog' being applications. Through this paper, we will try to bring forth how artificial intelligence is being used as a support system to emotional intelligence and the emerging concept of emotion AI.

Keywords

Artificial intelligence • Emotional intelligence • AI • EI • Emotion AI

1 Introduction

AI refers to the use of technology and automation in doing tasks that require some degree of intelligence to accomplish (EY homepage, 2018). The use of automation and AI in business processes has led to increased productivity and efficiencies. The recent advances in AI technology in this digital era have streamlined business processes and helped in increasing employee and organizational capabilities. Their greatest support is in the area of recruitment, talent acquisition, employee development, payroll, reporting, self-service transactions, customer retention and so on. AI technologies are skilled at mastering the human cognitive capabilities that simple software cannot but emotional intelligence is one such area where AI is still in its nascent stages, making it the most valued skill in today's technological era. Although automated systems allow a more personalized and interactive HR experience both for the employer and the employee, still in this digital transformation, the tough job is 'We' the analog people. The tide of digitalization has taken the entire workspace in its storm and the fear of being replaced by machines haunts the most capable of human resource. AI is taking a crucial turn by integrating emotional intelligence with the advanced AI. Today, AI is just not restricted to Apple's Siri with Ex Machina, it is even more than a Chatbot which comes up on an organization's intranet to solve your queries or help you with new projects. The world where machines could interpret and respond to human emotions is no more virtual. The emerging concept of emotion AI or artificial emotional intelligence is already being used to develop systems that are capable of recognizing and simulating human emotions and adapt their behavior to give a suitable response to these emotions.

2 Research Objectives

This research has been carried out with the following objectives:

1. To study the application of artificial intelligence in different organizational processes.

S. Kaur (✉) · R. Sharma
Amity University, Noida, Uttar Pradesh, India
e-mail: login.simran@gmail.com

R. Sharma
e-mail: rsharma25@amity.edu

2. To study the evolving concept and applications of emotional artificial intelligence.
3. To propose a framework for integrating artificial intelligence with emotional intelligence.

3 Literature Review

John Mc Carthy, an American computer and cognitive scientist and his colleagues Turing, Minsky, Newell and Herb Simon organized the Dartmouth Conference in 1956 (Roberts, 2016) which established AI as a field. Through this conference, Mc Carthy explained "that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it." He is also credited to have coined this term "Artificial Intelligence" (Cukier, 2019). The definition from Technopedia gives a reasonably good explanation of AI "Artificial Intelligence is an area of computer science that emphasizes the creation of intelligent machines that work and act like machines" (Technopedia, 2020).

With the advancement in technology and innovations, AI is taken over all the possible functions starting from smartphones apps to voice-enabled assistants so the usage of AI to ease the job of professionals in financial, health and safety services, and education is greatly promoted. As stated by Geetha, R., & Bhanu, S. R. D in their research paper on 'Recruitment through Artificial Intelligence', Jonathan Kestenbaum, executive director of Talent Tech Labs, a talent acquisition consultant in New York, has agreed to the fact that impact of AI on work may lead to anxiety in HR professionals but he positively affirms that implementing AI softwares would definitely eliminate mundane tasks and would prove to be a problem solver for HR (Geetha, & Bhanu, 2018).

AI is being efficiently used in writing job descriptions (JDs), matching them with applications received, screening of candidates using expert systems, employee education at the time of onboarding, training and learning, compensation designing, performance and potential appraisal (Copeland, 2016; Unahabhokha et al., 2007; A report by EY on The new age artificial intelligence for human resource opportunities and functions). David Mallon, Vice President and analyst at Bersin states that handling routine tasks and services will soon be taken up by computer-enabled robots or robotic process automation (RPA). Human efforts will be largely replaced by RPAs having capability of imitating human skills (Hagginbottom, 2018). The impact of AI on management functions and marketing strategies has been studied by Davenport et al. (2020). He concluded that AI will affect major shifts in formulation and implementation of marketing strategies and consumer behavior. Rai (2020) has focused on the need to look behind the "black box" of marketing and explain the functioning and rationale behind sales and service driven by AI.

The emerging area of AI is emotion AI, better known as artificial emotional intelligence or affective computing which is being widely used in areas like health care, advertising, customer service and market research. It is the application of technology to study non-verbal cues of humans like their facial expressions, their postures, gestures, body language, tone and pitch of voice to analyze their emotional state.

A professor at the Hebrew University, Jerusalem Dr. Yuval Noah Harari has written in his bestselling book 'Homo Deus' that humans are nothing but a collection of biological algorithm shaped through million years of evolution. He further postulated that there are chances that organic algorithms can be replicated and taken over by non-organic algorithms. The above-stated views have also been strengthened by Dr. Max Tegmark, Professor at MIT in Boston in his book Life 3.0: Being Human in the age of Artificial Intelligence. Understanding it better leads to the conclusion that computers will be able to better manipulate and analyze human emotions than humans themselves.

4 Methodology

In this study, the authors have used qualitative and exploratory method to study the applications of AI in organizational settings. It is a conceptual study based on review of literature. Systematic literature review was done to gain deeper insights into the concept of emotional artificial intelligence and its applications in modern organizations. Systematic literature review ensures high quality of the review process and outcomes along with providing a framework that helps the researchers integrate the past findings with the existing knowledge.

The collection of related information was done through Scopus and Web of science portals with relevant contents of academic and scientific journals and papers presented at conferences using keywords like artificial intelligence, emotional intelligence, applications of artificial intelligence and emotional artificial intelligence.

5 AI as an Aid in Organizational Processes

Artificial intelligence has revolutionized the way different processes used to be conducted. Automation has helped save time and effort by streamlining various repetitive tasks, thus, allowing the workforce to devote them to more productive and creative tasks. The most common uses of AI can be seen in the areas discussed below by the authors.

5.1 Talent Acquisition

The widespread application of AI in HR is evident in acquisition of talent. The use of technology and new functionalities like screening questions, online platform for video interviews and Web portals for resume shortlisting has proved to be a great bliss for the recruiter. This augmented intelligence not only allows recruiters to be more proactive in hiring but also save time and cost. AI has impacted the recruitment process tremendously by enabling the recruiter to systematically align candidate's profile and match skill set appropriately with the industry requirement. (Geetha & Bhanu, 2018)

Although the shift toward technology-driven recruitment was need based and started in big organizations but with the world going digital, even the small start-ups have adopted technology in their various HR functions like posting jobs on job portals, using applicant tracking system and Chatbots to communicate with the candidates and narrow down the search and virtual interviews. Although Alan Stukalsky, Chief digital officer at Randstad US opines that the use of Chatbots in recruitment is at nascent stage. Automated computer-enabled tools have streamlined the entire recruitment process from designing job descriptions to screening candidates, maintaining databases, scheduling interviews and dealing with job seekers' queries. (Biswas, 2018). The authors have found out the different AI tools used in recruitment and represented in the form of the following Fig. 1.

5.2 Onboarding

After recruitment, artificial intelligence tools give the new candidate a better joining experience as the formalities can be done electronically, avoiding unnecessary paperwork. AI integrated systems introduce the new employee to the company virtually, providing all information regarding the rules and regulations, his job profile, his team and the company's hierarchy through a well-integrated application. It also enables customization of the process to better suit the individual candidate. Onboarding is a vital process as the initial treatment lays the foundation of a long term relationship between the employer and the employee. Although it has been stated that the role of AI is more of a facilitator that supports HR to complete tasks in less time, thus, saving time for more crucial roles that involve creative thinking and psychological understanding (Lawler & Elliot, 1996). The role of AI in onboarding has been depicted by the authors in the following Fig. 2.

5.3 Training and Learning

Along with recruitment and selection, companies are leveraging AI technologies with e-learning platforms to assess and enhance employee's skills. AI integrated systems can help the organizations in keeping pace with the new innovations and technology by training the employees in various domains. AI-enabled tools for training and development will help in enhancing job satisfaction among employees (Jain, 2016).

AI technology can be used to analyze data collected from years of experience and positions held and generate training need assessment data. It can create appropriate learning programs tracking employee's activities and also recommend videos or learning programs based on job requirements. The e-learning platforms help employees learn new skills and enhance their existing capabilities at their own comfortable pace and place. However, some issues relative to attitude and behavior of employees require the involvement of human being for handling the situation better (Hooda, 2018).

Additionally, an AI system can be integrated with an algorithm that determines career path for individuals on the basis of their training. Following are the advanced uses of AI in learning and development of employees (Fig. 3).
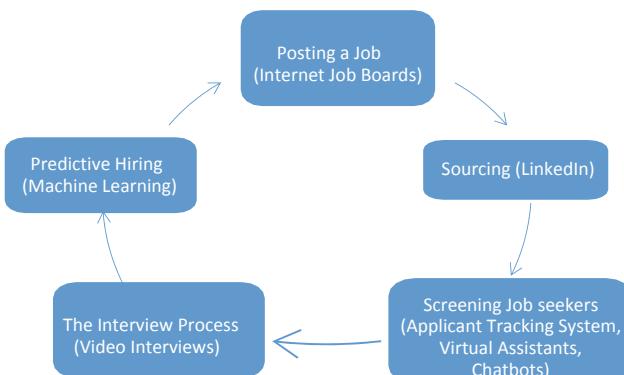

Fig. 1 AI at different stages in the entire hiring process. *Source* Self
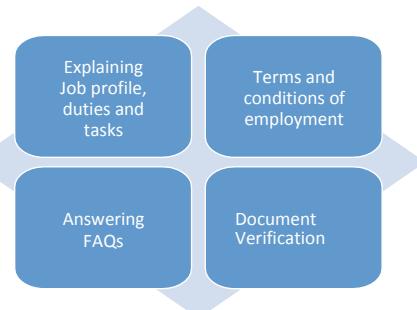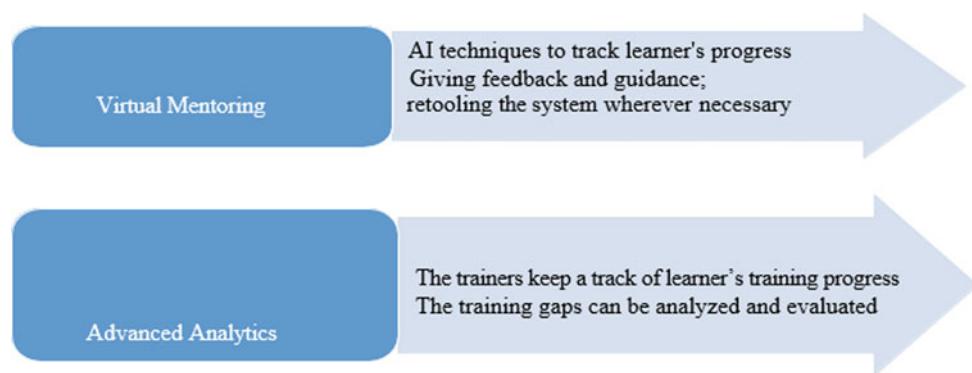
Fig. 2 Role of AI in onboarding of employees. *Source* Self

Fig. 3 Two dimensions of AI assistance in training and learning. *Source* Self

5.4 Decision Making

AI has the power to augment human intelligence and enable smart decision making. AI-enabled systems have proved to be a great support to HR department in retaining and maintaining their employees by tracking the mental and emotional well-being of their employees along with their work contributions. Technology can be used to observe and analyze employee's mood before and after a client's call. This data furthers help in their appraisal and job rotation by posting employees on job which they can handle best. AI can detect anxiety in person's behavior and tone and help the employers decide if they must intervene to make things smooth. It furthers help in making decision as regards their training. According to McKinsey Global Institute's research, "AI could deliver an additional output of $13 trillion to the world economy by 2030, which would boost global GDP by nearly 1.2% a year. Acting as a capital-hybrid, AI can aid the growth of both the economy and humans. It will definitely have a revolutionary impact on the decision-making process."

The authors have tried to depict the different AI tools used for decision making through the following model (Fig. 4).

6 Emotion AI

6.1 Emotion AI Explained

Emotion AI or artificial emotional intelligence is one of the recent advancements of AI in which machines capture and evaluate the non-verbal cues of the living beings like their postures, facial expressions, gestures, and tone of voice to analyze their emotional state. It is also known as affective computing and now its rapidly being used in the field of advertising, health care, customer service and recruitment. This powerful subset of AI can measure, understand, simulate and react to human emotions on a metric which includes anger, fear, happiness, sadness and surprise. Machines may
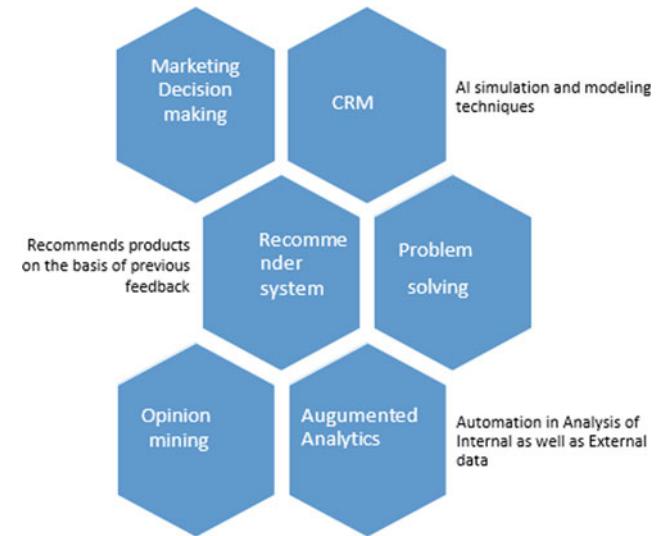
Fig. 4 Role of AI in decision making. *Source* Self

not be able to imitate humans completely but they have their own capabilities. A computer interface was developed by Takeuchi and Nagao in which facial synthetic displays were added to make the interaction more efficient (Takeuchi & Nagao, 1992). In another research by Bichshel and Pentland, it was emphasized that the man–machine interaction could also be improved by automatic interpretation of facial expressions and gestures (Bichshel & Pentland, 1993).

As explained by MIT Sloan professor Erik Brvnjolfsson, the machines are capable of capturing voice inflections and correlating them with stress or anger. They can even recognize images and micro-expressions on the face of people.

Javier Hernandez, a research scientist at MIT Media Lab (Affective Computing group) states that AI allows a true man–machine interface.

6.2 Areas Where Emotion AI Is Used

Emotional AI technology can help in better understanding of the customers by capturing the emotional reactions like

analysis of voice patterns, decoding facial expressions, capturing eye movements and measuring neurological responses (Harvard Business Review, 2019). The concept of artificial emotional intelligence has already been operationalized in many areas and industries. AI has significantly impacted industries like Healthcare, Cybersecurity and Retail (Eubanks, 2018). The most common applications can be seen in the fields of sports, entertainment, retail and health care.

6.2.1 Sports

AI is playing an important role in redefining customer service and shaping the spectator's experience in stadiums like Little Caesars in Detroit and NRG stadium in Houston by answering queries related to seats, food vendors, restrooms, and in stadium entertainment options using smart Chatbots. Facial coding can be used to collect data about the layout of venue and the stadium experience which fans respond to.

Athlete's distance, speed, stress, speed and heart rate can be monitored by wearable tech devices. This has revolutionized the sportsmen performance by predicting outcomes, minimizing risk and assisting in real-time decision making. It is application can be seen at Wimbledon where AI is used to interpret match related data, audience interaction and reactions of players to decide what content must be included in highlights, thus, saving human efforts and time for more creative aspects.

6.2.2 Entertainment

Emotion AI can be used both in production and after release response of the shows, movies or series. There are algorithms used in production enhancing the looks of an animated character to create a real look alike. Delivering personalized content in low cost and less time enhances audience engagement also. Similarly, algorithms are used in analyzing viewer's response to certain shows by capturing their responses to different characters and special effects. Emotion sensing technology is also used to sense a player's facial expressions for symptoms of stress while playing certain games. Exposing players to a virtual stressful situation prepares them to handle such real-life situations with ease.

6.2.3 Retail

Customer engagement largely depends on their emotional connect with the retail store. Computer vision, facial recognition and emotional analytics enable marketers to determine the emotions of the shoppers toward different products or the areas of the outlet. The eye movement scanners and cameras detect the facial expressions of the shoppers which are then analyzed using analytical components of AI. It further helps in setting prices, packaging, advertising and branding products. This emotional data can be used along with traditional ways of customer feedback in the gaining competitive edge.

6.2.4 Healthcare

AI-driven technology is being used in health care to determine the anxiety, stress levels, depression and heart rate of people through wearable devices and mobile apps. There are apps like Companion Mx which is capable of listening to a human voice over a telephone call and can detect anxiety and mood swings through the tone. Such apps improve self-awareness and improve stress management capacity. There are wearable devices that are used in treatment of mental illnesses, which monitor a person's heartbeat to gauze situations like stress, pain or frustration. The bioessence wearable device developed at MIT Media Lab releases scent to adjust the negative emotions if stress or pain is detected by it.

## 7 Emotion AI: Will AI Substitute EI?
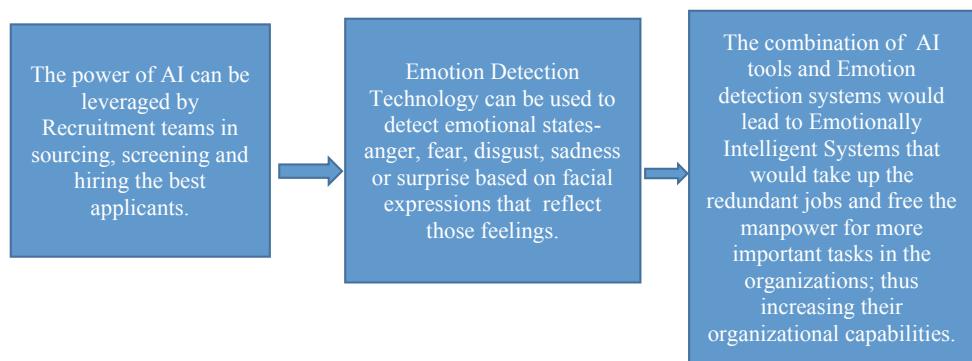
The future of artificial emotional intelligence shows businesses using emotion analytics in decision making using multimodal emotion recognition and an emotion chip. Organizations have started focusing on matching AI and human emotionally to motivate and train people to work with new technology. The application of AI in improving business operations is recognized but the emotional abilities and human intelligence still play a dominant role in managing employees and customers. AI, if used in ways that augment humans instead of replacing them, can be more effective (Davenport, et al. 2020). Although AI acts as a buffer but is not likely to replace human beings, as customers still prefer to interact with employees more than robots or machines (Prentice, 2020).

R&D is being done to decode the science of building relationships and to incorporate AI with appropriate emotions to suitably interact with the analog human being. From past many years, organizations have been using AI to gain insights into people's behavior and leveraging these people analytics in innovative ways to gain competitive edge.

Additionally, a stronger digital IQ will move the business to a deeper "unconscious level of information." (EY homepage, 2018) Automated learning machines can be made to simulate human behavior by analyzing and consolidating people's statements, actions and intents on social media and their moods and reactions to different events. That gives a new dimension to the strategic application of emotion AI in the workplace to create a right combination of man and machine in the job space.

Based on the study, the researchers have tried to propose a framework integrating the application of AI with EI, thus, depicting the future of emotion AI as it improves not only

Fig. 5 Integration of AI with EI with special reference to recruitment. *Source* Self

The power of AI can be leveraged by Recruitment teams in sourcing, screening and hiring the best applicants.

Emotion Detection Technology can be used to detect emotional states-anger, fear, disgust, sadness or surprise based on facial expressions that reflect those feelings.

The combination of AI tools and Emotion detection systems would lead to Emotionally Intelligent Systems that would take up the redundant jobs and free the manpower for more important tasks in the organizations; thus increasing their organizational capabilities.

the "doing jobs" but also the "thinking jobs". This framework has been made taken special reference of the application of this concept in recruitment (Fig. 5).

The concept of artificial emotional intelligence is being propagated rapidly and the companies that will be effectively able to imply this empathy and contextual understanding into their technologies will obviously be at the forefront in this age of technological advancement.

Although the use of AI-based technologies has swayed the entire workspace from detection of emotions of employees while performing certain tasks to detection of emotions in shoppers as they respond to certain products or services, the far reaching review of emotion research states that the science underlying these technologies is flawed and cannot be relied upon. The business of emotion detection has moved beyond science fiction to a $20 billion industry.

The problem with this would be predicting the emotional state of the people just from their facial expressions is not reliable. AI may not be able to draw correct conclusion in interpreting emotions as it may not be adapted to understand cultural differences, a smile may mean different things in different ethnicities (Harvard Business Review homepage, 2019). A group of scientists under Association of Psychological Science reviewed more than 1000 studies on this idea for 2 years and concluded that the relationship between facial expressions and emotions is convoluted, nebulous and far from universal. Moreover, humans tend to instinctively draw on other gestures such as body language, tone or pitch of voice to complete their emotional assessment but majority of emotion detection AI draw inferences mainly by mapping facial expressions only (Beck, & Libert, 2017). Such technological limitations are risky as they may draw faulty conclusions of the people in question. Certain human skills like social understanding, empathy and persuasion will prove to be real differentiators as artificial intelligence takes over the other functions. The companies should be making and training their programs to consider other aspects also like body positioning, vocal characterization and situational context like human beings.

References

Beck, M., & Libert, B. (2017). The rise of AI makes emotional intelligence more important. *Harvard Business Review, 15*.

Bichsel, M., & Pentland, A. P. (1993). Automatic interpretation of human head movements. In *13th International Joint Conference on Artificial Intelligence (IJCAI), Workshop on Looking At People*, Chambery France.

Biswas, S. (2018). Employee experience, jobs and skills: How AI will impact HR. In HR Technologist. Retrieved from https://www.hrtechnologist.com/articles/digitaltransformation/employee-experience-jobs-and-skills-how-ai-will-impact-hr/ on 20th November, 2018.

Burgess, A. (2017). *The executive guide to artificial intelligence: How to identify and implement applications for AI in your organization*. Berlin: Springer.

Cukier, K. (2019). Ready for robots: How to think about the future of AI. *Foreign Affairs, 98,* 192.

Davenport, T., Guha, A., Grewal, D., & Bressgott, T. (2020). How artificial intelligence will change the future of marketing. *Journal of the Academy of Marketing Science, 48*(1), 24–42.

Duchessi, P., O'Keefe, R., & O'Leary, D. (1993). A research perspective: Artificial intelligence, management and organizations. *Intelligent Systems in Accounting, Finance and Management, 2*(3), 151–159.

Eubanks, B. (2018). *Artificial intelligence for HR: Use AI to support and develop a successful workforce*. Kogan Page Publishers.

EY homepage. (2018). The new age: Artificial intelligence for human resource opportunities and functions. Retrieved from https://www.ey.com/Publication/vwLUAssets/EY-the-new-age-artificialyintelligence-for-human-resource-opportunities-and-functions/$FILE/EY-the-new-ageartificial-intelligence-for-human-resource-opportunities-and-functions.pdf on 19th November, 2018.

Geetha, R., & Bhanu, S. R. D. (2018). Recruitment through artificial intelligence: A conceptual study. *International Journal of Mechanical Engineering and Technology, 9*(7), 63–70.

Hagginbottom, K. (2018). The impact of AI on the HR profession. In *Forbes online magazine*. Retrieved from https://www.forbes.com/sites/karenhigginbottom/2018/06/14/the-impact-of-ai-on-the-hrprofession/#7364c0e391ca on November 21st, 2018.

Harvard Business Review homepage. (2019). https://hbr.org/2019/11/the-risks-of-using-ai-to-interpret-human-emotions, last accessed November 18, 2019.

Hooda, S. (2018). 5 ways HR will be affected by artificial intelligence. In *People Matters*. Retrieved from https://www.britannica.com/technology/artificial-intelligence on November 21st, 2018.

Jain, S. (2016). Big data analysis: Changing the way. *International Journal of Research in Advanced Engineering and Technology, 2*(6), 34–36.

Kaiser, S., & Wehrle, T. (1994). Emotion research and AI: Some theoretical and technical issues. *Geneva Studies in Emotion and Communication, 8*(2), 1–16.

Kuzior, A., Kwilinski, A., Tkachenko, V., & Tkachenko, V. (2019). Sustainable development of organizations based on the combinatorial model of artificial intelligence. *Entrepreneurship and Sustainability Issues, 7*(2), 1353–1376.

Lawler, J. J., & Elliot, R. (1996). Artificial intelligence in HRM: An experimental study of an expert system. *Journal of Management, 22*(1), 85–111.

Liebowitz, J. (2001). Knowledge management and its link to artificial intelligence. *Expert Systems with Applications, 20*(1), 1–6.

Martınez-Miranda, J., & Aldea, A. (2005). Emotions in human and artificial intelligence. *Computers in Human Behavior, 21*(2), 323–341.

Mayer, J. D. (2006). A new field guide to emotional intelligence. *Emotional Intelligence in Everyday Life, 2*(1), 3–26.

Minsky, M. (2007). *The emotion machine: Commonsense thinking, artificial intelligence, and the future of the human mind*. Simon and Schuster.

MIT Management Sloan School homepage. https://mitsloan.mit.edu/ideas-made-to-matter/emotion-ai-explained, last accessed March 8, 2019.

Prentice, C., Dominique Lopes, S., & Wang, X. (2020). Emotional intelligence or artificial intelligence–an employee perspective. *Journal of Hospitality Marketing and Management, 29*(4), 377–403.

Rai, A. (2020). Explainable AI: From black box to glass box. *Journal of the Academy of Marketing Science, 48*(1), 137–141.

Rana, D. (2018). *The future of HR in the presence of AI: A conceptual study*, November 24, 2018.

Rathi, R. A. (2018). Artificial intelligence and the future of hr practices. *IJAR, 4*(6), 113–116.

Roberts, J. (2016). Thinking machines: The search for Artificial Intelligence. *Distillations*. https://www.sciencehistory.org.

Salovey, P., & Mayer, J. D. (1990). Emotional intelligence. *Imagination, Cognition and Personality, 9*(3), 185–211.

Shrestha, Y. R., Ben-Menahem, S. M., & Von Krogh, G. (2019). Organizational decision-making structures in the age of artificial intelligence. *California Management Review, 61*(4), 66–83.

Takeuchi, A., & Nagao, K. (1992). *Communicative facial display as a new conversational modality*. Tech. Report SCSL-TR-92-019. Tokio: Sony Computer Science Laboratory.

Technopedia. (2020). Artificial intelligence definitions. https://www.techopedia.com/definition/190/artificial-intelligence-ai. Retrieved on January 28, 2020.

Unahabhokha, C., Platts, K., & Tan, K. H. (2007). Predictive performance measurement system: A fuzzy expert system approach. *Benchmarking: An International Journal, 14*(1), 77–91.

Upadhyay, A. K., & Khandelwal, K. (2018). Applying artificial intelligence: Implications for recruitment. *Strategic HR Review*.

Van Esch, P., Black, J. S., & Ferolie, J. (2019). Marketing AI recruitment: The next phase in job application and selection. *Computers in Human Behavior, 90*, 215–222.

Yano, K. (2017). How artificial intelligence will change HR. *People and Strategy, 40*(3), 42–47.

Prevent Overfitting Problem in Machine Learning: A Case Focus on Linear Regression and Logistics Regression

Udai Bhan Trivedi, Milind Bhatt, and Prerna Srivastava

Abstract

Supervised machine learning algorithms often suffer with overfitting during training steps which prevent it to perfectly generalizing the models. Overfitting is modelling concept in which machine learning algorithm models training data too well but not able to repeat the same accuracy on the testing data set. In this paper, we focus on regularization, which can help models to avoid overfitting problem with special focus on supervised learning algorithm, i.e. linear regression, logistic regression and neural network. Proposed regularization strategy guaranteed models performance and generalized for test data set by proper selection of features, and identifying less and more important features for data modelling purpose.

Keywords

Machine learning • Regularization • Feature selection • Overfitting • Smoothing

1 Introduction

Overfitting is modelling concept in which machine learning algorithm models training data too well but not able to repeat the same accuracy on the testing data set.

During the training of data sets, sometimes, model learns noise and fluctuation present in training data and try to apply same on unseen testing data, which in negatively impact the model. Overfitting allows noise and random fluctuation in training data to learn as a concept and adopt at model design stage (Nasr & Shokri, 2018)[1] (Figs. 1 and 2).

The commonly used methodologies to avoid overfitting are (1) pruning, (2) cross-validation, (3) early stopping, and (4) regularization.

2 Background and Related Works

Machine learning model can model well by identifying the more numbers of features during training phase but fails to generalize on testing data set. More numbers of features present in the algorithm will be punished with overfitting. It is very difficult to find out which features to drop, and this problem is even become more worse as the features present in modelling phase is informative in nature.

Machine learning (ML) regularization is process of regularizing the parameters by discourages the learning of a more complex features by shrinking the coefficient of these features to zero. Some of the research paper dealing with regularization was reviewed

Srivastava et al. (2014) in their research paper "**Dropout: a simple way to prevent neural networks from overfitting**" has discussed idea to randomly drop units from neural network during model building. Randomly dropping units from neural network reduces models from overfitting on the training data and gives edges over other regularization methods.

Guoliang Kang, Jun Li, and Dacheng Tao, "**Shakeout: A New Approach to Regularized Deep Neural Network Training**" have presented a new regularization approach known as shakeout. In this approach, models do not randomly discard the dropout at training stage. Shakeout propagates each unit contribution to next layer by randomly choosing them with reverses or enhances. Finally, authors

---

[1]https://www.geeksforgeeks.org/machine-learning/.

U. B. Trivedi (✉) · M. Bhatt · P. Srivastava
PSIT College of Higher Education, Kanpur, 209305, India
e-mail: udaibhantrivedi@gmail.com

M. Bhatt
e-mail: bca@psit.ac.in

P. Srivastava
e-mail: prerna_srivastava@yahoo.co.in

Fig. 1 Graph between size of house and its price **a**, **b** high bias plot line underfit and **c** high variance plot over fit[3]


$\theta_0 + \theta_1 x$

High bais (underfit)

$\theta_0 + \theta_1 x + \theta_2 x^2$

High bais (underfit)

$\theta_0 + \theta_1 x + \theta_2 x^2 + \theta_2 x^2 + \theta_2 x^2$

High variance (overfit)
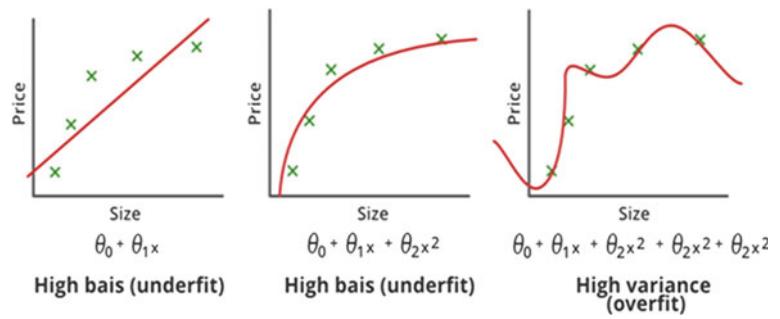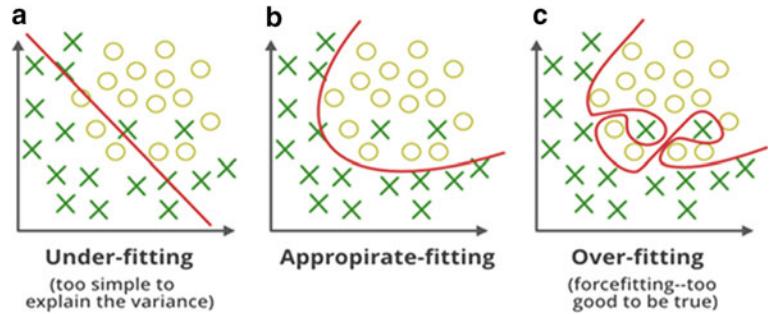
Fig. 2 Three cases **a** underfitting, **b** appropriate fitting, **c** overfitting[3]

Under-fitting
(too simple to explain the variance)

Appropirate-fitting

Over-fitting
(forcefitting--too good to be true)

also establish that how shakeout is superior that drop out in his research contribution.

Chandrashekar, G., & Sahin, F. Int. J in their research paper "**A survey on feature selection methods**" discussed plenty of feature selection methods due to hundreds of variables with large dimension are available. Feature selection methods will further smooth the loss function.

Benyamin Ghojogh and Mark Crowley from University of Waterloo, Waterloo, Canada in their research paper "**The Theory Behind Overfitting, Cross Validation, Regularization, Bagging, and Boosting: Tutorial**" authors define variance, mean squared error, covariance, and bias of both random variables and classification/predictor models. They formulated the true and generalization errors of the model for both training and validation/test instances and the paper also discussed overfitting, underfitting, and generalization using the obtained true and generalization errors.

Xue Ying in his research paper "**An Overview of Overfitting and its Solutions**" Author discussed about overfitting and its causes and possible solutions. The paper discussed numbers of strategies to overcome the problem of overfitting. Some of the strategy which was discussed in the papers are

(1) "Early stopping"—in this approach, we early stop training of models, even before the optimization of performance.

(2) "Network reduction"—this strategy is focused on exclusion of noise in training data itself.

(3) "Data expansion"—this strategy is fine-tuning the hyper-parameters sets by providing large number of data sets during training.

(4) "Regularization"—this strategy uses the concept of feature selection. Algorithm deals with identifying more and less useful features and make model (loss function) smoother for prediction on test data sets.

3 Regularization: Linear Regression and Logistic Regression

Linear Regression is one of the simplest and widely used statistical techniques for predictive modelling supposing that we have observations (i.e. targets) $Y = (Y_1, \ldots, Y_n) \varepsilon R^n$ and a set of explanatory variables (i.e. predictors) $(X_1, \ldots, X_n) \varepsilon R^n$. We build a linear model $Y = X\beta^*$, where $\beta^* = (\beta_1^*, \ldots, \beta_n^*) \varepsilon R^n$ are the coefficients of each predictor Y given as a weighted sum of the predictors, with the weights being the coefficients. To determine which is the optimal $\beta \in R^n$, utilizing the least squares, the problem can be mathematically model as (Caruana et al., 2001; Golub et al., 1979).

$$\hat{\beta} = \operatorname*{argmin}_{\beta} \sum_{i=1}^{n} (y_i - \beta x_i)^2 = \operatorname*{argmin}_{\beta} \|y - \beta x\|_2^2 \quad (1)$$

where β is the optimal β that minimizes the sum of squared errors (SSE) We can add an intercept term β_0 for capturing noise not caught by predictor variable. Again, we estimate $\hat{\beta}_0, \hat{\beta}_1$ using least square error (SSE) (Bramer, 2002).[4]

$$\hat{\beta}_0, \hat{\beta}_1 = \underset{\beta_0, \beta_1}{\operatorname{argmin}} \sum_{i=1}^{n} (y_i - \beta_0 - \beta_1 x_i)^2 = \underset{\beta_0, \beta_1}{\operatorname{argmin}} \|y - \beta_0 1 - \beta_1 x\|_2^2 \tag{2}$$

where $\hat{\beta}$ are the optimal coefficients β_1, β_2, …, β_p of the predictors x_1, x_2, …, x_p that minimize the above sum of squared

$$\hat{\beta} = \underset{\beta \in \mathbb{R}^p}{\operatorname{argmin}} \left\| y - X\hat{\beta} \right\|_2^2 \tag{3}$$

Shrinks the magnitude of coefficients

Bias: error from erroneous assumptions about the training data

- **High bias (underfitting)**—miss relevant relations between predictors and target (large λ).

Variance: This error indicates sensitivity of training data to small fluctuations in it.

- **High variance (overfitting)**—model random noise and not the intended output (small λ).

Bias–variance trade-off: Bias–variance trade-off is required to get most generic model for prediction.

3.1 Ridge Regression

Ridge regression utilizes L2 regularization. Algorithm uses distance (Euclidean) as the penalty term. Given a vector with observations $y \in \mathbb{R}^n$ and a predictor matrix $X \in \mathbb{R}^{n \times p}$.

The ridge regression coefficients are defined by below expression. The expression minimizes the squared error and the size of the coefficients.[5]

$$\begin{aligned} \hat{\beta}^{\text{ridge}} &= \underset{\beta \in \mathbb{R}^p}{\operatorname{argmin}} \sum_{i=1}^{n} \left(y_i - x_1^T \beta \right)^2 + \lambda \sum_{j=1}^{p} \beta_j^2 \\ &= \underset{\beta \in \mathbb{R}^p}{\operatorname{argmin}} \underbrace{\|y - X\beta\|_2^2}_{\text{Loss}} + \lambda \underbrace{\|\beta\|_2^2}_{\text{Penalty}} \end{aligned} \tag{4}$$

Here, $\lambda \geq 0$ is a tuning parameter for controlling the strength of the penalty When $\lambda = 0$, it minimizes only loss—which is the case of overfitting. When $\lambda = \infty$ (very large value), it minimizes the penalty—which is the case of underfitting. When including an intercept term, we usually leave this coefficient unpenalized (Kong & Dietterich, 1995; Schmidt, 2005; Scholkopf & Smola, 2001).

$$\hat{\beta}_0, \hat{\beta}^{\text{ridge}} = \underset{\beta_0 \in \mathbb{R}, \beta_0 \in \mathbb{R}^p}{\operatorname{argmin}} \|y - \beta_0 1 - X\beta\|_2^2 + \lambda \|\beta\|_2^2 \tag{5}$$

The advantage of this optimization is it makes $\beta = \left(X^\mathrm{T} X + \alpha I \right)^{-1} X^T y$.. Adding $\alpha * I$ strengthens the main diagonal of $X^\mathrm{T} X$ makes it non-singular and full rank for inversion (Golub et al., 1979).

3.2 Lasso Regression

Lasso regression uses L1 regularization. In this approach, algorithm penalty term will be calculated by adding absolute values of all penalty term. The lasso coefficients are defined as:

$$\begin{aligned} \hat{\beta}^{\text{lasso}} &= \underset{\beta \in \mathbb{R}^p}{\operatorname{argmin}} \|y - X\beta\|_2^2 + \lambda \sum_{j=1}^{p} |\beta_j| \\ &= \underset{\beta \in \mathbb{R}^p}{\operatorname{argmin}} \underbrace{\|y - X\beta\|_2^2}_{\text{Loss}} + \lambda \underbrace{\|\beta\|_1}_{\text{Penalty}} \end{aligned} \tag{6}$$

The only difference between lasso and ridge regression is the penalty term ridge uses L2 penalty $\|\beta\|_2^2$ and lasso uses L1 penalty $\|\beta\|_1$.

Where $\lambda \geq 0$ is used as fine-tune parameter and used for controlling the strength of the penalty. The L1 penalty causes some coefficients to be shrunken to zero as λ increases (large value).

Larger the value of λ will set more coefficients to zero and leads to less numbers of predictors selection in turn make the function more regular in nature.

4 Regularization: Logistic Regression

The regularization parameter of logistic regression is same as ridge expression with some modification

$$\beta = \min \sum_{i=1}^{m} \left(\left(y_i - 1 / \left(1 + \mathrm{e}^{-\beta X^T} \right) \right) + \lambda \sum_{j=1}^{p} \beta_j^2 \right) \tag{7}$$

where first term is loss value and second is penalty value. $\lambda \geq 0$ is a used as fine-tune parameter and used for controlling the strength of the penalty. Penalty causes some coefficients to be shrunken to zero exactly as λ increases

---

[4]https://elitedatascience.com/overfitting-in-machine-learning.
[5]https://www.holehouse.org/mlclass/06_Logistic_Regression.html.

(large value). Parameter λ plays a role of parameter selection (Grandvalet et al., 1997; Kearns, 1988).

5 Impact of Regularization

Well, using L2 regularization as an example, if λ is set to be large, then it would incentivize the model to set the weights close to zero because the objective of SGD is to minimize the loss function. The original loss function is now being summed with the sum of the squared matrix norms, Fürnkranz (1997)

$$\sum_{j=1}^{n} \left\| w^j \right\|^2 \tag{8}$$

This is multiplied by $\lambda/2m$. If λ is large, then this term, $\lambda/2m$, will continue to stay relatively large, and multiplying that by the sum of the squared norms, then the product may large if weight parameters are large. This means that the model is incentivized to make the weights small so that the value of this entire function stays relatively small in order to minimize loss. Intuitively, this technique will set the weights so that it could basically zero-out or reduce the impact of some of our layers. If that's the case, then it would conceptually simplify the model, and making it less complex, which may in turn reduce variance and overfitting (Sun & Wohlberg, 2019; Zur et al., 2009).

5.1 Scope of the Study and Limitations

A least square-based model accuracy depends on the variance of training and testing data sets. Regularization significantly reduces the variance of training data sets without having the high increase in bias. The regularization parameter λ controls the balance between variance and bias. Rise in value of λ will reduce features coefficients and which further reduces the variance. But after the certain value of λ, the model start losing important properties which is due to rise in bias and model, therefore, underfitted.

6 Conclusion

Regularization does not discard any features, and regularization keeps all features and smoothen the prediction curve by reducing the magnitude of parameters β. The concept of regularization become very important when models have a lot of features and each feature plays some role (contributes) in prediction of unknown variable Y.

Repeat{

$$\beta_0 := \theta_0 - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta \left(x^{(i)} \right) - y^{(i)} \right) x_0^{(i)}$$

$$\beta_j := \theta_j - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta \left(x^{(i)} \right) - y^{(i)} \right) x_j^{(i)} \tag{10}$$

$$(j = 1, 2, 3, \ldots n)\}$$

Regularization is also required in updation of parameters as given below

$$\beta_j := \beta_j - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta \left(x^{(i)} \right) - y^{(i)} \right) x_j^{(i)} + \frac{\lambda}{m} * \beta_j \tag{11}$$

$$(j = 1, 2, 3, \ldots, n$$

$$\beta_j := \beta_j \left(1 - \alpha \frac{\lambda}{m} \right) - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta \left(x^{(i)} \right) - y^{(i)} \right) x_j^{(i)} \tag{12}$$

The first term $\left(1 - \alpha \frac{\lambda}{m} \right)$ is always less than 1. Generally, data science models take initial value of learning rate very small and if numbers of features (m value) are large, and the first term often comes around 0.95–0.99. Finally, the value of λ and m controls the next iteration of parameters value and this will leads the smoothen the hypothesis (regularization)

References

Bramer, M. (2002). Using J-pruning to reduce over fitting in classification trees. *Knowledge-Based Systems, 15*(5–6), 301–308.

Caruana, R., Lawrence, S., & Giles, C. L. (2001). Overfitting in neural nets: Backpropagation, conjugate gradient, and early stopping. In *Advances in neural information processing systems* (pp. 402–408).

Chiuso, A. (2016). Regularization and Bayesian learning in dynamical systems: Past, present and future. In *Annual Reviews in Control*. Elsevier.

Fürnkranz, J. (1997). Pruning algorithms for rule learning. *Machine Learning, 27*(2), 139–172.

Ghojogh, B., & Crowley, M. (1974). The theory behind overfitting, cross validation, regularization, bagging, and boosting: Tutorial 21 Barnett, Vick. In *Elements of sampling theory*. London: English Universities Press.

Golub, G. H, Heath, M., & Wahba, G. (1979). Generalized cross-validation as a method for choosing a good ridge parameter. *Technometrics, 21*(2), 215–223.

Grandvalet, Y., Canu, S., & Boucheron, S. (1997). The theory behind overfitting, cross validation, regularization, bagging, and boosting: Tutorial 22. Noise injection: Theoretical prospects. *Neural Computation, 9*(5), 1093–1108.

Karystinos, G. N., & Pados, D. A. (2000). On overfitting, generalization, and randomly expanded training sets. *IEEE Transactions on Neural Networks, 11*(5), 1050.

Kearns, M. (1988). Thoughts on hypothesis boosting. Technical Report, Machine Learning class project (pp. 1–9).

Kong, E. B., & Dietterich, T. G. (1995). Error-correcting output coding corrects bias and variance. In *Machine Learning Proceedings* (pp. 313–321). Elsevier.

Nasr, M., Shokri, R., Houmansadr, A. (2018). Machine learning with membership privacy using adversarial regularization. In *Proceedings of the 2018 ACM*.

Schmidt, M. (2005). Least squares optimization with 11-norm regularization. CS542B Project Report (Vol. 504, pp. 195–221).

Scholkopf, B., & Smola, A. J. (2001). *Learning with kernels: Support vector machines, regularization, optimization, and beyond*. MIT Press.

Srivastava, N., Hinton, G., Krizhevsky, A., et al. (2014). Dropout: A simple way to prevent neural networks from over fitting. *Journal of Machine Learning Research, 15*(1), 1929–1958.

Sun, Y., Wohlberg, B., & Kamilov, U. S. (2019). An online plug-and-play algorithm for regularized image reconstruction. In *IEEE Transanctions*. ieeexplore.ieee.org.

Tibshirani, R. (1996). Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society: Series B (Methodological), 58*(1), 267–288.

Wen, F., Chu, L., Liu, P., & Qiu, R. C. (2018). *A survey on nonconvex regularization-based sparse and low-rank recovery in signal processing, statistics, and machine learning*. IEEE Access. ieeexplore.ieee.org.

Wu, H., & Shapiro, J. L. (2006). Does over fitting affect performance in estimation of distribution algorithms. In *Conference on Genetic and Evolutionary Computation* (pp. 433–434). ACM.

Zur, R. M., Jiang, Y., Pesce, L. L., & Drukker, K. (2009). Noise injection for training artificial neural networks: A comparison with weight decay and early stopping. *Medical Physics, 36*(10), 4810–4818.

Optimized Reverse TCP Shell Using One-Time Persistent Connection

Anush Manglani, Tadrush Desai, Pooja Shah, and Vijay Ukani

Abstract

Reverse shell has now emerged as an effective tool used to penetrate systems and networks with speed and compromise them. The efficiency and robustness of reverse shell lie in its use of the victim's machine to generate the connection request to the attacker. Unfortunately, this connection request goes unchecked by the host's security systems as it originates from the host. To address this challenge, we present a typical reverse shell, its idea, its implementation including the model as well as how it works, how it infects the systems, and lastly, techniques with which we can prevent the reverse shell from infecting our systems and networks. It is coded in Python and implemented over Windows operating system, which gives this Shell an advantage because Python has various libraries which can control a significant number of aspects of any operating system. Exploiting this feature of the language, we have succeeded in building a reverse shell which gives the attacker complete control of the host the Shell has infected as well as the added functionality of uploading, downloading, and persistent backdoor creation. Furthermore, we present a technique which increases the robustness and functionality of our Shell and distinguishes it from other such similar programs.

Keywords

Reverse shell • Malware • Back connection

A. Manglani · T. Desai · P. Shah · V. Ukani (✉)
Institute of Technology, Nirma University, Ahmedabad, India
e-mail: vijay.ukani@nirmauni.ac.in

A. Manglani
e-mail: 15BCE009@nirmauni.ac.in

T. Desai
e-mail: 15BCE028@nirmauni.ac.in

P. Shah
e-mail: pooja.shah@nirmauni.ac.in

1 Introduction

Back connection is that connection request which originates from the client side in a server–client model. Because of its client-side origin, the anti-malware programs on the user's system do not try to hinder or block this request in any way, assuming it to be legitimate (Rothwell 2018; Rajasekhar Reddy and Aruna Sri 2020).

Except for the user on the client system deliberately making the connection request, there is another way for establishing back connection. Once the connection request is generated, it will be accepted by the server and a full-fledged connection is established. Any program which is able to establish such connection is known as a *reverse shell* (Atwell et al. 2016). Today, many malware exploit this concept to gain access of different systems and use them to their propaganda. According to the existing architecture, the connection established by the Shell is required to be terminated after a file is transferred. This is because as long as the connection is maintained, the file remains in the main memory and is written to disk only after the connection is closed which presents a detrimental scenario to the attacker. In this paper, we have improved this architecture such that it can send any number of files without closing the established connection, and they will be written to the disk. This method presents an inherent advantage to the attacker as there is no need to establish a new connection every time a file is to be sent which grants a greater degree of robustness to our Shell. This approach is later explained in the paper.

2 Shellcode

The term shellcode is given to a small fragment of code which when executed on the target's machine, starts a command shell aiming for the attacker to have control of the compromised machine. It is often used as a payload in various types of exploits. For robustness, the shellcode is
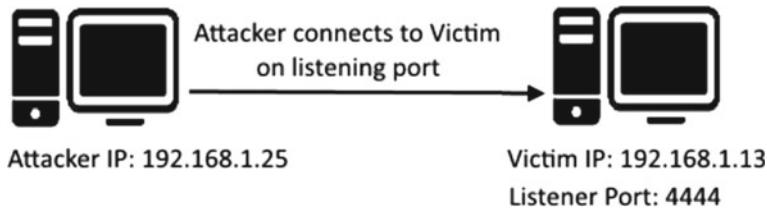
Fig. 1 Working of a bind shell
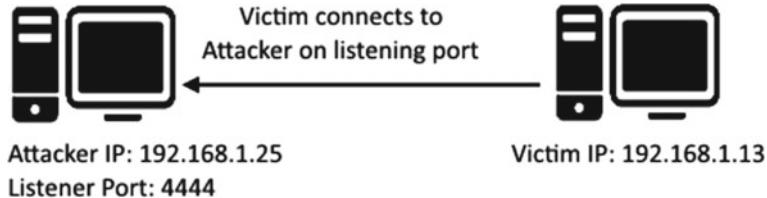
Fig. 2 Working of a reverse shell
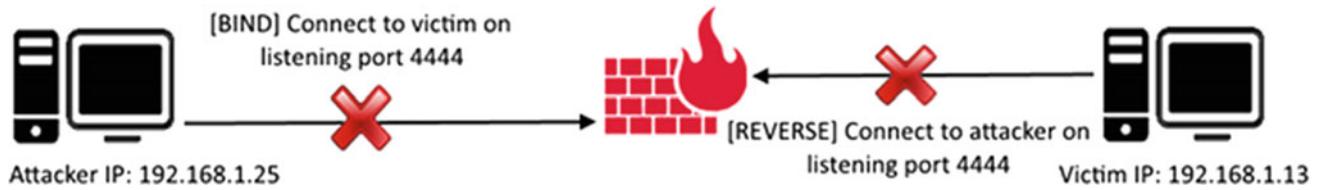
Fig. 3 Firewall blocking illegitimate TCP requests

typically written in machine code or assembly language. Shellcode classifies into two major categories, i.e., *local* and *remote*.

Local In case the attacker has very limited access to the target machine but can exploit a vulnerability, it is the local shellcode that the attacker uses. Upon successful execution, the shellcode will grant the attacker the same escalated privileges as the process which is targeted.

Remote When the attacker wants to gain access to a vulnerable machine across a network, local, or remote, the attacker uses remote shellcode (Bao et al. 2017). Mostly, the remote shellcode uses TCP/IP socket connections to establish a connection between the attacker and the targeted machine. The remote shellcode is further divided into two categories based on how the connection was established: If the attacker establishes the connection, it is called *bind shell* as it binds itself to a particular port on the victim's machine as shown in Fig. 1.

On the other hand, if the connection is originated from the targeted machine, the shellcode is called *reverse shell* (Atwell et al. 2016) because it is the targeted machine which connects back to the attacker machine upon the execution of the

shellcode as depicted in Fig. 2. Lastly, a third but rare type, known as *socket-reuse shellcode*, which does not create a new connection, but uses an already established connection created by a vulnerable process before closing on the target machine. Generally, this type is more complex as the shellcode has to first search for the particular vulnerable process.

One way to prohibit the attacker to gain access of the target machine using these types of shellcode is to have a firewall monitor (Heilig 2020) every outgoing and incoming connection request so as to block any illegitimate connections as outlined in Fig. 3. But when one uses *socket-reuse* shellcode, already established connections are exploited which makes the detection even more difficult.

3 Implementation

This section explains each and every aspect of our Shell in detail.

3.1 Model

The Shell is based on the simple *server–client* model, in which the client (victim) connects to the server (attacker).
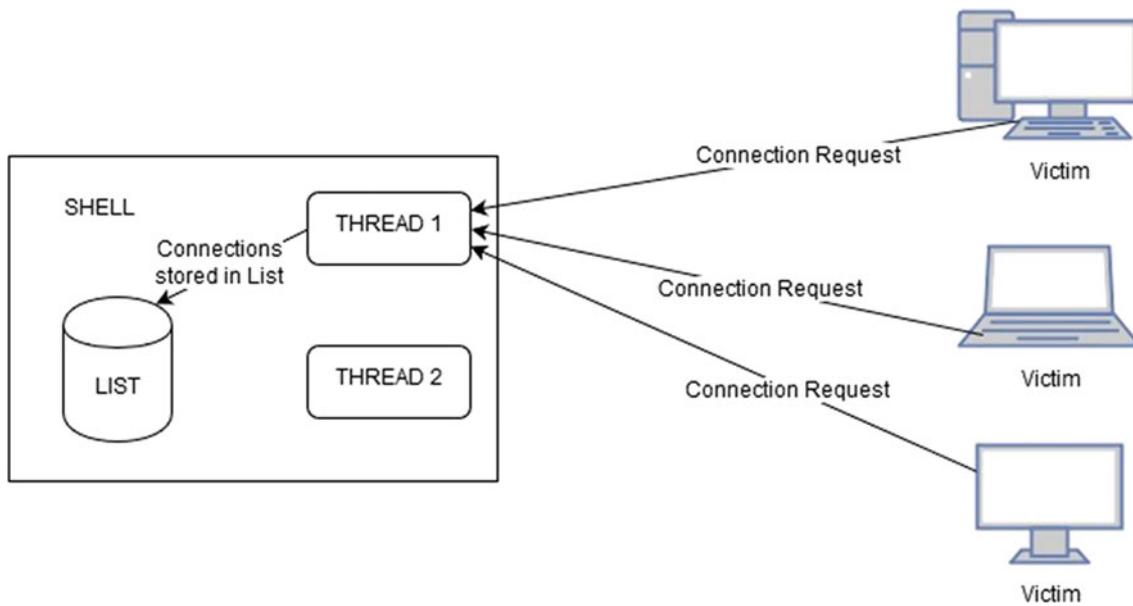
Fig. 4 First thread accepts connection requests and stores in a list

The communication between the two sides is via TCP/IP protocol. The Shell also supports multiple victims connecting to a single attacker, making it a true derivative of the server–client model. Another advantage of this approach is that it can cater to distributed computing (Glushan et al. 2015) should the traffic increases above a predefined threshold.

Every time a new victim generates a connection request, the attacker (server) stores that connection information in a table through which the attacker is able to manage every one of the connected victims.

3.2 Threading

The support for multiple victims (client) connecting to one attacker (server) is achieved through the process known as threading. An obvious advantage of using multiple threads in our Shell is increased in performance (Petriu et al. 1994). The Shell creates two threads. One thread is responsible for handling all the connections as shown in Fig. 4, storing them in a list, and also operating all the background processes. The other one will allow us to choose the machine with which we want to interact as depicted in Fig. 5. When a victim's machine sends a request to the attacker, it is the first thread which accepts the request via creating a connection object and storing it in the list.

If we want to interact with that machine, the second thread starts an inline[1] shell. This inline shell can show how many victims are connected to the attacker and also gives the functionality of interacting with one of the victims at a time. The two threads run in an infinite loop, one listening for any inbounds connection requests and the other for exchanging data with the victim's machine when it is chosen by the attacker. This all takes place on the attacker's side. On the victim's machine, the Shell only creates a socket object and uses it to connect to the attacker.

3.3 Socket Programming

The Shell uses socket programming to connect to the attacker. The first thread of the Shell is responsible for creating the socket interface via *socket()* method. After creating the socket, the Shell binds it to a particular host and port which are globally available and are parameters to the *bind()* method. Furthermore, the Shell allows for a few (usually five) unaccepted connections before refusing the new connections through *listen()* method which takes the number of backlog connection (unaccepted connections) as an argument.

On the victim's machine, the Shell tries to connect to the socket interface on the attacker's side using *connect()* method which takes *host* and *port number* as arguments. The *host* parameter holds the address of the attacker, and the *port number* holds the port on which the attacker's socket is listening. A feature of the IP protocol is that it assigns dynamic IPs to the users which creates a problem as the host

---

[1]An inline command-line is a command shell within a shell which has the capability to execute commands other than that of the parent command shell.
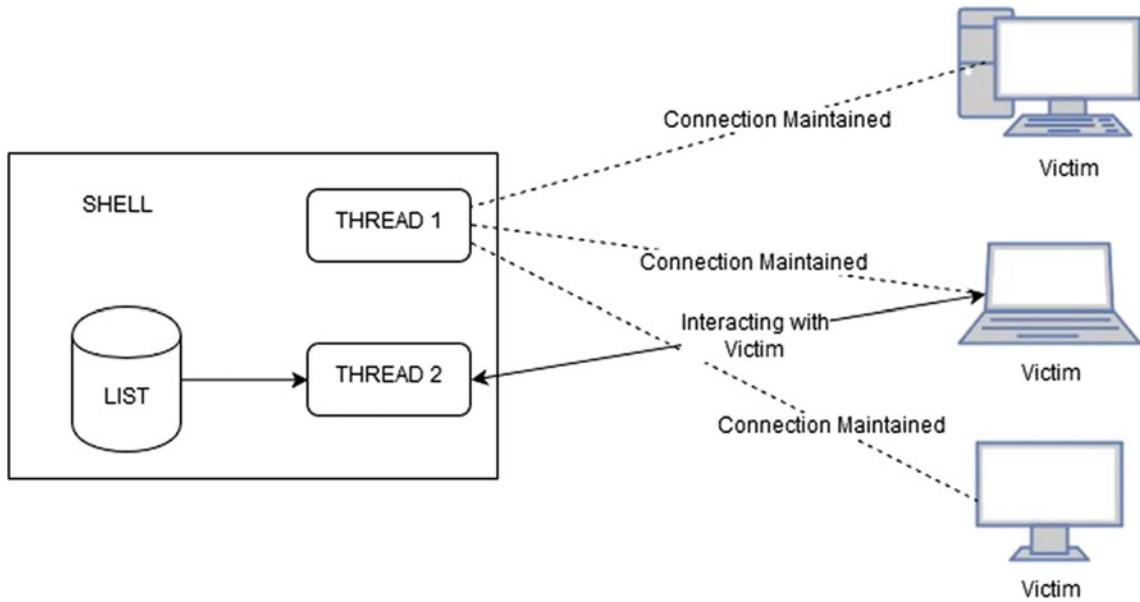
Fig. 5 Second thread interacts with a connected victim
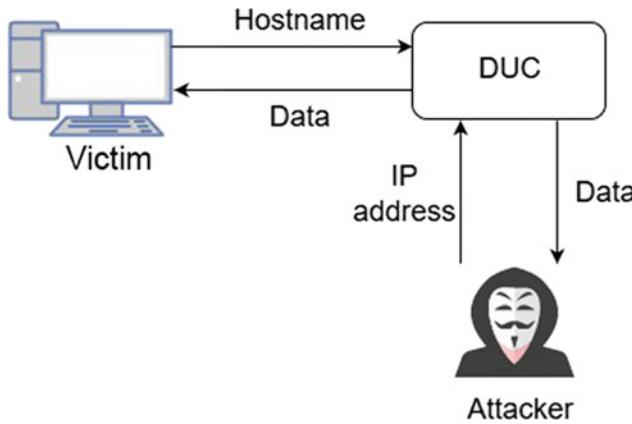

Fig. 6 DUC maps current IP address to the hostname

parameter's value cannot be changed once the Shell is deployed.

Three possible solutions to this problem can be observed. *First,* the attacker can contact their ISP to grant a *static* IP address which eliminates the need to change the value of *host* parameter. *Secondly,* we can configure the Shell to work with *mobile IP protocol* (Yun and Meng 2009), but it can be a tedious task. *Lastly,* we can take advantage of services like *dynamic DNS* provided by organizations such as *No-IP*. What they do is that they provide a domain name instead of an IP address. With a Dynamic DNS Update Client (DUC) provided by No-IP itself, it maps the current IP address of the attacker to that domain name as outlined in Fig. 6. Therefore, if the Shell on the victim's machine passes a domain name instead on an IP address, it does not need to

worry about the dynamic IP address of the attacker. An additional advantage of using this approach is that it will work irrespective of the attacker's location.

3.4 Shell Functionalities

Our Shell has its own *custom inline command line* with its own set of commands. It is possible to add additional commands as per the requirements. However, as of now, the Shell has only two commands at its disposal *as it was deemed necessary.* The first is the list command, and the other is select command.

The list command displays all the victims which are connected to the attacker. It fetches data from the list which was created by the Shell and was used to store information regarding every accepted request in the form of a connection object. Furthermore, the list command associates each victim with a serial number starting from zero. A unique feature of this command is that it only displays the *currently established connections;* that is, it may happen that by the time, the attacker executes the list command; some of the connections may cease to exist, which are not shown. When the list command is executed, the Shell checks the validity of each connection via sending a *blank string* and waits for the response. If the response arrives, the connection is valid. On the other hand, if an exception is raised while sending or receiving, that connection object is seen as invalid and, hence, deleted from the list.

The select command takes *sequence number* as the argument. The sequence number is assigned by the list

command. After executing the `select` command, the second thread of the Shell takes the sequence number specified in the command and fetches that corresponding connection object from the list of connection objects and prompts the attacker to interact with the victim whose connection object was fetched.

3.5 Execution

The main operation of the Shell takes place after a victim has been chosen by the attacker. Also, this whole operation is divided between attacker as well as the victim. After the attacker selects a victim, the Shell prompts the attacker to interact with it via commands. The commands are then encoded and sent by the Shell over to the victim's machine. The Shell running on the victim's side receives the encoded commands, decodes them, executes them, encodes the output received from the execution of commands, and finally, sends the encoded output back to the attacker. All this exchange of information takes place via the *socket interface.*

Aside from attacker executing commands on the victim's machine, one can also *upload* or *download* a file. The Shell is configured differently for executing either upload or download command.

Download The download command takes *file path* as an argument. This path should be a valid one on the victim's machine, or else the Shell will give an error. The download command executes in four phases which are as follows. *Phase 1* takes place on the attacker's machine when the attacker types the download command with a valid file path along with the name of the file as the argument. The Shell executes this command by first opening a file in *wb* (writing in binary) mode with same name as the one being downloaded, on attacker's machine. It then sends the command after encoding it to the Shell on the victim's machine. *Phase 2* begins when the Shell on the victim's machine receives the download command. It extracts the file path and name from the command and, with the help of Python's *OS* library, checks the validity of the path via os.path.exists() method. This method raises an error if the path is invalid terminating this phase then and there. Else, the Shell opens that file in *rb* (reading in binary) mode and starts to send packets of *predefined size* to the Shell running on the attacker's machine. *Phase 3* also begins on the victim's machine when *end of file* is encountered. When the Shell has completed sending the file in bytes, it closes the file and then sends a string of *predefined characters.* The Shell on the attacker's machine looks out for these elements and, upon receiving them, stops writing in the file. A problematic scenario is encountered when the same set of *predefined characters* appear in the byte stream being send. In that case, concept of byte stuffing

can be taken into consideration as in Cardoso (2007). As of now, the discussed Shell in the paper does not use byte stuffing. Lastly, *phase 4* marks the end of execution of the download command when, on the attacker's machine, the Shell removes the same set of *predefined characters* from the byte stream and closes the file after writing it for the last time. The file is now successfully saved in the attackers machine.

Upload The `upload` command is same as the `download`, except that processes happening on the victim's and attacker's machine are interchanged, however, with a few modifications. The `upload` command takes the file path with name as an argument which should exist on the attacker's machine and open a file in the *wb* mode. The attacker's Shell sends the command after encoding it to the victim's machine. On the victim's machine, the Shell distills the name of the file from the path entered by the attacker. It then creates and opens a file in *wb* mode with the same name and extension in the present working directory (as the Shell is a command line, it will have some present working directory). The Shell does this by obtaining the path of present working directory with the help of Python's *OS* library and calling os.getcwd() method. At this stage, the Shell on the attacker's machine starts sending packets of fixed size to the victim's Shell. Upon receiving the packets, the victim's Shell starts writing the file. End of file is indicated when a sequence of *predefined characters* is received in the byte stream. The Shell on victim's machine stops writing and closes the file.

The Shell has been programmed to handle special commands which do not generate output, for example, the change directory (cd) command or the make directory (mkdir) command. For all these types of commands, special *if* statements have been configured to manage them effectively. Again, the Shell uses Python's OS library for the execution of these commands. The os.chdir() and os.-makedirs() methods are used to change and make directory, respectively. Also, the Shell can be configured any time before deployment, should the need arise, to add any number of such commands. Python's *OS* and *subprocess* libraries are very powerful ones, providing support for many more commands.

4 Infection

The victim's machine must be infected with the Shell in the first place before the attacker can gain control over it. One must find a way to run the Shell on the victim's machine for the attacker to seize control. One of the most efficient ways to seize control is to use *social engineering* techniques such

Fig. 7 MAC and IP address of the victim's machine


```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Intel(R) Dual Band Wireless-AC 8265
   Physical Address. . . . . . . . . : 7C-76-35-A3-DA-13
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   Link-local IPv6 Address . . . . . : fe80::4467:20b1:88fb:ecf5%2(Preferred)
   IPv4 Address. . . . . . . . . . . : 192.168.0.105(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Lease Obtained. . . . . . . . . . : 29 July 2018 09:50:53 PM
   Lease Expires . . . . . . . . . . : 29 July 2018 11:50:52 PM
   Default Gateway . . . . . . . . . : 192.168.0.1
   DHCP Server . . . . . . . . . . . : 192.168.0.1
   DHCPv6 IAID . . . . . . . . . . . : 41711157
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-22-83-40-E8-00-E0-4E-68-02-85
   DNS Servers . . . . . . . . . . . : 192.168.0.1
   NetBIOS over Tcpip. . . . . . . . : Enabled
```

as *phishing* (Gupta et al. 2016). It involves obtaining sensitive information from a user by disguising as a trustworthy entity, or baiting the user to download seemingly harmless, but in fact malicious, files from the Internet. If a user downloads and runs a file infected with our Shell just once, the Shell will then obtain a persistent connection to the attacker by modifying the registry keys and copying itself into the Windows *%temp%* folder. After achieving this task, Windows will automatically run the Shell each time it boots up, without the knowledge of the user. But with the spreading awareness about such types of incidents, the users are wary of downloading anything from the Internet, and to make matters even worse, applications such as firewalls and anti-viruses alert the user immediately and quarantine a downloaded file if it seems malicious. This poses a serious hurdle in the propagation of our Shell. One way to counter this problem is to bind the Shell behind a completely harmless file, such as an image or a document. This is called *file binding*. Many hackers, nowadays, use this concept to bind malicious programs such as Trojan horse or malware in the harmless user content to make the detection even more difficult. A combination of file binding and phishing may result in a higher rate of infection.

Shown below are the screenshots of attacker's and victim's machine which clearly confirms to the reader that our Shell has indeed penetrated the victim. Three screenshots are used to convey the infection. First two show the MAC and IP addresses of the victim's machine and the attacker's machine obtained via the execution of *ipconfig/all* command in the Windows' command prompt as shown in Figs. 7 and 8. The third screenshot shows the MAC and IP address of the victim's machine which were obtained via the execution of *ipconfig/all* command in the Shell on attacker's machine which is same as the first screenshot as depicted in Fig. 9. The Shell sent our command to the victim's Shell, which executed it and sent the output back to the attacker's

machine. Finally, the Shell on the attacker's machine displayed the output to the attacker. As the MAC address is unique for a particular machine, these screenshots helps in conveying to the audience that our Shell is capable of penetrating a machine effectively.

Another common way of delivering payloads is by partitioning the entire payload into different functions and sending the different functions via different carriers and executing a Shell which uses those functions which were sent out earlier. This method is more extensive and more prone to errors as the victim may change the default file download location which may fail the execution of the Shell. On the other hand, this method is effective in bypassing anti-virus and firewalls which work on the basis of signatures.

5 Prevention

As the Shell relies on TCP/IP protocol to communicate, one way to prevent attacks caused by reverse shell is to monitor incoming and outgoing TCP packets. Doing so will reveal the information carried by such packets, and then, they can be classified as malicious or not. But if the Shell uses encryption to secure data, this method will not be of much help.

Another technique which can be utilized is to make use of *honeypots* (Mushtakov et al. 2018). They are isolated parts of networks which are constantly monitored but appear to be a legitimate to hackers. Hackers, unknowingly, try to penetrate the honeypots thinking that they are actually entering the networks but in fact, their attack patterns are being watched and analyzed. This gives a much greater insight about how hackers try to hack systems, and then, this information can help to make systems more secure. In our case, we can

Fig. 8 MAC and IP address of the attacker's machine

Fig. 9 MAC and IP address obtained via our Shell which are the same as the victim's MAC and IP address

monitor how Shell infects the honeypot and, then, can change our security protocols to avoid such infection.

Also, when configuring firewalls or edge routers, one do not tend to stress enough on their outbound rules which ultimately leads to a vulnerability through which the attackers conduct such attacks. Therefore, firewalls and edge routers should be configured while keeping this concept in mind (Elsawy et al. 2020; Okeke and Ibeonu). Furthermore, professional penetration testers should be given the task to find such kind of vulnerabilities (Boutnaru 2020).

Furthermore, intelligent anti-virus (Ding et al. 2020; Alazab et al. 2020; Darabian et al. 2020) systems which are adaptive in nature may help in prevention of the shells. Keeping a check on what processes are currently running on the system can certainly be helpful. Since the Shell can make changes to the registry, this event is bound to getting logged. If the victim has any log analysis software installed on the system, the execution of the shell may be detected as soon as it gets executed. Hence, the use of this Shell to victimize machines belonging to corporate networks is more likely to

fail due to the higher possibility of the presence of intelligent anti-virus software and log analysis tools. Lastly, when designing a system, designers should consider system security as an integral part of it and not merely as an add-on (Aslan and Samet 2020).

6 Conclusion

This paper shows that the proposed Shell was able to successfully seize the control of host's system which it infected. It is important to note that the executable file of the Shell is not classified as malicious by any anti-virus software which shows that we still are not secure enough. Analyzing our malware will give an insight regarding the firewall rules and network monitoring techniques that can be implemented so that the back connection will not establish in the first place. Apart from this, the primary challenges that were faced while developing this malware were figuring out the methods through which the victim side of the malware can communicate with the attacker side from one point in the Internet to another. In this regard, DUC was successfully able to bridge this huge gap. Also, it was taxing to find a way to bind the malware behind another file to provide another layer of obfuscation to the present anti-virus software. Because no computer can yet outsmart human intelligence and we, as humans, tend to make mistakes often, perhaps are the reasons such types of attacks still occur. In order to make sure that we have got the best chance of preventing attacks based on reverse shell, one should follow preventive measures mentioned in this paper as closely as possible. With more and more updates coming each and every day, the risk of zero-day exploit occurring in software is on the rise. If a hacker discovers such exploit before the authorities do, he/she can use that to infiltrate the system using any number of techniques, not limiting to reverse shell, and access sensitive information. The only prevention against such incidents is to consider security as integral part of system design and not a mere add-on.

References

Alazab, M., Alazab, M., Shalaginov, A., Mesleh, A., & Awajan, A. (2020). Intelligent mobile malware detection using permission requests and API calls. *Future Generation Computer Systems, 107,* 509–521.

Aslan, O. A., & Samet, R. (2020). A comprehensive review on malware detection approaches. *IEEE Access, 8,* 6249–6271.

Atwell, C., Blasi, T., & Hayajneh, T. (2016). Reverse tcp and social engineering attacks in the era of big data. In *2016 IEEE 2nd International Conference on Big Data Security on Cloud (BigDataSecurity), IEEE International Conference on High Performance and Smart Computing (HPSC), and IEEE International Conference on Intelligent Data and Security (IDS)*, April 2018, pp. 90–95.

Bao, T., Wang, R., Shoshitaishvili, Y., & Brumley, D. (2017). Your exploit is mine: Automatic shellcode transplant for remote exploits. In *2017 IEEE Symposium on Security and Privacy (SP)*, May 2017, pp. 824–839.

Boutnaru, S. (2020). *Enhanced security techniques for remote reverse shell prevention*. May 26, 2020, US Patent 10,666,618.

Cardoso, J. S. (2007). Bandwidth-efficient byte stuffing. In *2007 IEEE International Conference on Communications*, June 2007, pp. 6175–6180.

Darabian, H., Dehghantanha, A., Hashemi, S., Homayoun, S., & Choo, K.-K. R. (2020). An opcode-based technique for polymorphic internet of things malware detection. *Concurrency and Computation: Practice and Experience, 32*(6), e5173.

Ding, F., Li, H., Luo, F., Hu, H., Cheng, L., Xiao, H., & Ge, R. (2020). Deeppower: Nonintrusive and deep learning-based detection of iot malware using power side channels. In *Proceedings of the 15th ACM Asia Conference on Computer and Communications Security*, pp. 33–46.

Elsawy, H., Kishk, M. A., Alouini, M.-S. (2020). *Spatial firewalls: Quarantining malware epidemics in large scale massive wireless networks*. arXiv preprint arXiv:2006.05059.

Glushan, V. M., Lavrik, P. V., & Rybalchenko, M. V. (2015). Hypergraph model of hierarchical client-server architecture for distributed computing. In *2015 9th International Conference on Application of Information and Communication Technologies (AICT)*, October 2015, pp. 454–457.

Gupta, S., Singhal, A., & Kapoor, A. (2016). A literature survey on social engineering attacks: Phishing attack. In *2016 International Conference on Computing, Communication and Automation (ICCCA)*, April 2016, pp. 537–540.

Heilig, D. P. (2020). *Identifying malware-infected network devices through traffic monitoring*. August 27, 2020, US Patent App. 16/872,302.

Mushtakov, R. E., Silnov, D. S., Tarakanov, O. V., & Bukharov, V. A. (2018). Investigation of modern attacks using proxy honeypot. In *2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus)*, Jan 2018, pp. 86–89.

Okeke, O. C., & Ibeonu, O. C. (2020). *Design and implementation of an enhanced firewall system for network and internet security*.

Petriu, D. C., Majumdar, S., Lin, J., & Hrischuk, C. (1994). Analytic performance estimation of client-server systems with multi-threaded clients. In *Proceedings of International Workshop on Modeling, Analysis and Simulation of Computer and Telecommunication Systems*, January 1994, pp. 96–100.

Rajasekhar Reddy, S. P. J. A. M., & Aruna Sri, P. S. G. (2020). Backdoor implementation in android using open source tools. *International Journal of Innovative Technology and Exploring Engineering, 9*(3), 2870–2872.

Rothwell, W. G. (2018). *Computer protection against malware affection*. September 8, 2018, US Patent 9,129,111.

Yun, B., & Meng, K. Q. L. (2009). Mobile ip protocol simulation based on ns-2. In *2009 First International Conference on Information Science and Engineering*, December 2009, pp. 2649–2652.

Smart Contracts in Smart Cities: Application of Blockchain Technology

Rahul Johari, Kanika Gupta, and Anurag Singh Parihar

Abstract

Over the recent years, blockchain has emerged as an area of great interest with its applications in multiple domains like financial, technology, security, education, and many more. In addition to these, it also has a great potential to be used in many other areas and it is accompanied by other modern technologies like IoT, cloud computing, etc. In this time of global urbanization, a huge influx of people could be seen in the urban settings in pursuit of better career opportunities, health and education services and better standard of living. This has also tremendously increased the resource demands managing which could be a herculean task. A smart city could be considered as a modern digitized city which integrates the latest ICTs along with existing infrastructure to maximize the optimization of resource utilization to provide better quality of living with security and transparency. This paper aims to explore the potential and contribution of blockchain technology in smart cities along with IoT and provide a novel solution for easy and automated consumer utility payments based on smart contracts.

Keywords

Smart cities • Smart contracts • IoT • Blockchain • Utility payments

1 Introduction

In this era of emerging technologies, data has become a very important component for making decisions. This has encouraged various organizations to collect data from every possible source. Use of sensors in collecting various type of data, like logs, transactions, location information, etc., has resulted in exponential growth of collected data. Sensors are generally used to collect real-time data which can be processed, and information could be extracted. IoT is a collection of sensors connected in a network and being used to share the information with other devices for processing or storage.

This huge amount of structured and unstructured data can be categorized as big data. Managing such data flow and storage could be a very tedious task.

Big data could be considered as a huge amount of structured or unstructured data which could be difficult to process by traditional relational database management systems. Volume, variety, velocity, versatility, and variability are few characteristics of big data which make data difficult to process by using traditional techniques.

The rest of paper is organized as follows. Existing blockchain-related works and reviewed literature are placed under Related Work in Sects. 2, 3 describes the Methodology Adopted and Proposed Framework, Sect. 4 describes Algorithm Formulated, and Sect. 5 describes Experimental Results and Discussion followed by References.

R. Johari (✉) · A. S. Parihar
SWINGER (Security, Wireless IoT Network Group of Engineering and Research) Lab, USICT, GGSIP University, Sector-16C, Dwarka, Delhi, India
e-mail: rahul@ipu.ac.in

A. S. Parihar
e-mail: 1988.anurag@gmail.com

K. Gupta
ABES Engineering College, Ghaziabad, India
e-mail: kanika.gupta@abes.ac.in

2 Blockchain Architecture

Blockchain was first introduced in 2008 in a paper published by an anonymous entity, Satoshi Nakamoto and was implemented in 2009 in the form of cryptocurrency named bitcoin. It was the first decentralized digital currency system which used blockchain as public distributed ledger to record and verify all bitcoin transactions. In accounting, a ledger is used to record and store all transactions with respect to an entity. The same can be stored digitally using an excel sheet, database, or in a technology like blockchain. Decentralized feature of blockchain helped to remove the requirement of any intermediary third party for doing any transaction. Blockchain mainly functions as distributed database or ledger of transactions. This distributed structure allows to create a digital ledger containing transactions and then it is distributed among the nodes on the blockchain network.

As the ledger is distributed, it cannot be controlled or owned by any central authority and it is public hence can be viewed by the available users on the network. Whenever a transaction happens in the blockchain, they are written in a block and broadcasts to all nodes in blockchain network. Miner nodes will verify the transactions by spending come computing resources or by solving some puzzle, and then broadcast the block to other node to gain consensus. Once the block is validated by other nodes and consensus is achieved, it is added as next block in the chain. Only when the block is added to chain, all containing transactions become valid and legitimate. The decentralized consensus protocol controls the addition of new blocks in chain, secure verification of blockchain, data consistency in all the copies replicated to each node. This consensus part makes it possible to reduce the role of third parties in such processes, like bank or the notary (Watanabe et al. 2015).

Further going into details, each block is made up by two components namely: block header and block body. Block header consists of block version, parent block hash, Merkle tree root hash, time stamp, N-bits, and nonce. Each block contains transaction data, time stamp, the calculated hash value of the complete block which acts as cryptographic image and the hash value of its predecessor block, which serves as cryptographic linkage from the current block to previous block. This secured protocol where all nodes have the distributed copies of blocks makes blockchain tamper-proof as it is very difficult to alter any block once the block is created, and added to the chain after validation. The genesis block or the first block in the chain is not connected with any previous block; therefore, the hash value of previous block is stored as zero. In many applications, developers generally hard code the genesis block of the chain (Genesis Block. 2020). In bitcoin, blockchain implementation was supported by three important capabilities.

They were the hash chained storage, digital signature, and the commitment consensus to add new block. Hash pointer and Merkle tree were two fundamental building blocks of hash chained storage used in bitcoin. A Merkle tree is a kind of binary tree whose nodes are linked to each other by hash pointers. A hash pointer is a cryptographic image or calculated hash of the data which points the actual location of data. In blockchain, every block stores the hash pointer of the previous block and hence the hash pointer of the block indicates where the data of previous block is stored. This makes blockchain tamper-resilient, as to change any block, the attacker has to change hash pointers of every previous block and would end up reaching system generated genesis block which he will not be able to modify (Zhang et al. 2019). Blockchains can be public or private. The permissionless blockchain which we have discussed so far in this paper do not enforce any restrictions, allows users to read, verify, and validate the data by participation in accordance with consensus protocols. Such blockchains are also known as public or permissionless blockchains and are considered as fully decentralized.

Ethereum, which uses smart contracts, is a good example of such blockchains. It uses its own cryptocurrency called ether and resources consumed in doing transaction are charged in the form of entity known as gas. In contrast, private or permissioned blockchains are restricted to a limited set of participants authorized by administrators or current participants. The write access to the blockchain is limited; however, read access can be made public, if required. Information sharing and security are much better controlled in such blockchains (Mohan 2019; Natoli and Gramoli 2016). Every transaction in blockchain is marked valid only after it has gained required consensus of participating nodes in network by using any consensus algorithm. A consensus algorithm is a set of rules which defines the essential conditions for proper functioning of the distributed systems, and which are required to reach a consensus. A good consensus mechanism ensures the robust transaction ledger by not only maintaining persistence and liveliness but also needs to address Byzantine general problems to avoid rogue nodes from deliberately undermining the consensus process (Zhang et al. 2019; Lamport et al. 2019). We will discuss here about two important and commonly used algorithms, proof of work (PoW) and proof of stake (PoS). The blockchain consensus protocols can be mainly categorized into compute-intensive-based consensus protocols, capability-based consensus protocols, and voting-based consensus protocols. In PoW, which is one among compute-intensive-based consensus protocols, participating nodes which are called as miners performs some work like solving some kind of mathematical puzzle by spending their computing resources. A small amount of commission or

transaction fee is earned by the miner who solves the puzzle first and succeeds in adding the new block to blockchain. For example, calculating a valid double SHA 256 hash is considered as work. Bitcoin, ethereum works on PoW consensus protocol. Among capability-based consensus protocols PoS is popular in which miners are not selected based on their computing resources rather they are considered on the basis of their stake they hold. The miners in this consensus are known as forgers and the mining is known as forging. The forger is selected by the protocol based on the digital coins deposited by the forger in the beginning stage. The methods used by the protocol can be coinage-based selection method or randomized block selection on forger's private key hit value calculations (Ismail and Materwala 2019; Wu et al. 2020).

Blockchain 2.0 has been based majorly on the decentralized applications working over the prewritten conditions or contracts called smart contracts. Blockchain plays an important role in enabling financial transactions like digital payments and in smart contracts. Various algorithms have been designed and developed using state-of-the-art blockchain and cryptographic algorithms to secure digital payments using plastic cards (Johari and Parihar 2019). Smart contracts are the contracts which can be registered digitally by writing them directly into the code. These are the contracts which can be registered digitally having terms and conditions of the contract embedded in the code. They execute automatically when all the conditions mentioned in the contracts are met. Such contracts are signed by both the parties digitally and agreed upon before it is being recorded or written in the blockchain. The conditions remain same for everyone and once stored cannot be changed or deleted by anyone. Such contracts have applications which enable digital registrations like birth certificates, identity certificated, etc. Applications of smart contracts are not only limited to these but also have many other automated applications which can be programmed using code and have the potential of making process automated in both public as well as private sector and helps in reducing the cost, increasing transparency and making application more efficient (Tapscott and Tapscott 2016).

3 Smart Cities

Present time is the time of global urbanization and in the coming years there will be enormous growth in the numbers of people living in urban settings. This growth will also increase the unprecedented demand of resources and other challenges and managing them would certainly be a huge task. Cities provide better career opportunities, health and educational services, hence attracting more population to move in the urban territory at an unprecedented rate. Blockchain can come to the rescue in the form of preparing smart or digital cities. Smart cities enhance life quality by implementing modern technologies envisaging modern urbanization in a way that the resources can be utilized in a better way on one hand and, on the other hand, reducing cost, making urban distributions more livable. Smart city cannot be imagined with the contribution of only one technology, it requires integration of multiple latest technologies which come together in play and provides services in various domains like smart utility payments, transport management, smart energy grids, identity management, digital government services, and many more.

As per Salha et al. (2019), a smart city is a knowledge-based system which provides valuable real-time insights on the data collected through various digital means to the stakeholders and decisionmakers and help them in proactively managing the city's subsystem. It is a city which uses ICT infrastructure to collect the data and analyze it in real time or in batches using various analytical tools to gather usable information (Biswas and Muthukkumarasamy 2016) marks smart economy, smart people, smart governance, smart mobility, smart environment, and smart living as six major factors which makes up a smart city.

The ubiquitous Internet access and the location services which are accessible through our mobile devices can allow the digital network to handle the supply and demand of existing market in a very efficient way. Smart devices located throughout the city helps in measuring conditions, collecting data, and transmitting it over the network to other devices or database. Devices like smart traffic sensors can accurately measure the amount of traffic and existence of congestion and manage the traffic signals accordingly. They can also help in broadcasting the congestion to user devices and assist in suggesting appropriate alternate route. Smart phones with sensors can act as authentication and authorization devices and can help individual in getting access automatically without any requirement of additional identity document. Analyzing the sensor data will not only help in real-time decision making but can also help in predicting the future usage of any utility.

Our world is growing digital with each passing day and it is necessary to have a technology which provides trust, security, and ease of doing. Smart cities also work on the principle of integrated technologies like blockchain. Although it is in its emergent state, yet it has redefined the idea of trust in digital and local communities with respect to financial, logistics, and other important services. To add more value to blockchain, a greater number of technologies can be integrated with it like AI, IoT, etc. Sensors, drones, and devices can collect various data which can be stored and analyzed with help of AI/ML to gain insight, making decisions, etc.

Blockchain along with IoT, AI, ML, cloud computing, and interconnected networks can deliver more innovative

solutions and can contribute to a great level in developing a smart city. World has seen significant advancements in the field of IoT and wireless communication which has made deployment of interconnected network of devices very easy, but at the same time it has increased the chances of security attacks to gain the access of location, personal and financial data. Hence, the security framework of the smart city needs to be strong enough to defend against all such security attacks. As per Biswas and Muthukkumarasamy (2016), there could be five possible threats for smart cities namely: threats on availability, threats on integrity, threats on confidentiality, threats on authenticity, and threats on accountability. Blockchain should facilitate the governance in smart city without the intervention of any third party. The most important component of a smart city is the sensors which are interconnected with wireless network and collect all possible data required by the framework.

The data can be then completely transferred to the centralized database or can be computed at each edge and then can be transferred to other device or a decentralized ledger. Digital ledger for a city can also be managed where all property and utility-related information of every house can be stored which can be used by the administration and aid them to function in more efficient and proactive manner. The health of the network can be monitored, and the application can connect to the interface via API. The blockchain network not only gives the trust but also helps in enhancing security and providing transparency. Smart contracts can be used in formalizing business and commercial agreements in online version without any requirement of third party and can be executed automatically when certain conditions are met. This helps in automating a certain process securely to a great extent.

4 Smart Contracts in Utility Payments

Cities work on revenue, and the money flows from entity to entity or between individuals too. A large amount of money is paid to citizens, employees, suppliers, and authorities in the form of salary, taxes, business, service payments, etc. Digitizing the egress and ingress of money within the city results in significant resource savings and increases operational efficiency along with increasing transparency in the transaction. Authorities can encourage citizens to increase the use of digital money by providing benefits like rewards, etc. Blockchain transactions ensure that the money reached to the right person and does not disappears in between. Hence, building trust, it also removes the requirement of any third party or intermediary in the transaction. Smart contracts can play a vital role in automated digital transactions. Digitization can also be implemented in revenue collection and the charges collected for various services. On daily basis,

people generally use various kinds of services and pay by using different payment modes. The service charges are not uniform everywhere for the same service. A lot of digitization has already been done in the field of utility payments. People are generally preferring digital modes to make payments. In smart city where blockchain is implemented, this utility payment can also be done smartly by using smart contracts and cryptocurrencies. Utilities like electricity bills, house rent, gas bills, phone bills, parking charges, society taxes, road tax, maintenance charges, etc., can be automated by means of smart contract. Whenever a person is moving in the city/society, he can enter various smart contracts fixed by the authority.

When the contract is signed between the individual/entity and authority, whenever he uses any such kind of services, the required amount will be debited from his account after consensus is gained and credited to the concerned authority or office. This will not only save the time, resources but will keep the transactions secure and transparent, e.g., the energy grid further be divided into microgrids and can be connected to individual houses via smart meters. The individual can check his usage of certain utilities by accessing the Web interface of smart meter from any location after digitally authenticating himself. Smart meters can accurately measure water, gas, and electricity usage. Smart parking could also be a good example of utility payments.

The vehicle information is recorded once it enters the parking lot and when it leaves the time for the vehicle is parked is recorded and the individual is charged automatically as per the rates agreed in smart contract. This removes the requirement of any human intervention. The actors relevant to this system can be categorized as: service provider—who provides the service, this could be a government authority or a private one, consumer—who consumes the service, authorities—are responsible for ensuring that the complete system is legal and to resolve any dispute if arises. As the information contains sensitive personal details of provider and consumer, the system encrypts the data and a token is generated which can be stored in blockchain ledger. This token can be used to make the transaction while keeping the personal information hidden.

Blockchain is a trustless platform which allows a user to transfer funds and execute smart contract using decentralized applications. Blockchain-based transactions using smart contracts are not only secure but are efficient and reliable as well. Functioning of smart contract in case of smart meter for electricity can be explained as follows. In present scenario, the electricity bill usage is collected from the generic meter installed outside the house. The meter reading is collected by executive and entered into the service provider's system manually. There are chances of human error in this step. Further the consumption is calculated by the system based on previous data stored in database. The bill is

generated and sent to the user's address or online. The user pays the bill either by visiting the provider's office or by online payment module for which he pays some amount of commission to the bank. This process not only consumes time but also prone to human error. In smart city format, the smart IoT meter installed in the house will read the meter reading and send the data to blockchain ledger automatically on desired date. The consumption will be calculated automatically from the previous data stored in the ledger and the bill will be generated instantly and sent to the user on his device. Along with bill generation, the smart contract which was agreed by the consumer in the starting will automatically be executed and the amount will be deducted from his account and deposited in the service provider's account. This process will not only save the human effort but also time and resources. As the transaction is done automatically via blockchain, it will remove the scope of human intervention, hence reducing the chances of human error. As it is blockchain transaction as per the agreement, the data is tamper-proof and reliable. This also will save the consumer getting charged by the bank for doing the online payment of bill. Similar procedure can be followed with other utilities of smart city where a consumer has to pay the charges on availing the services.
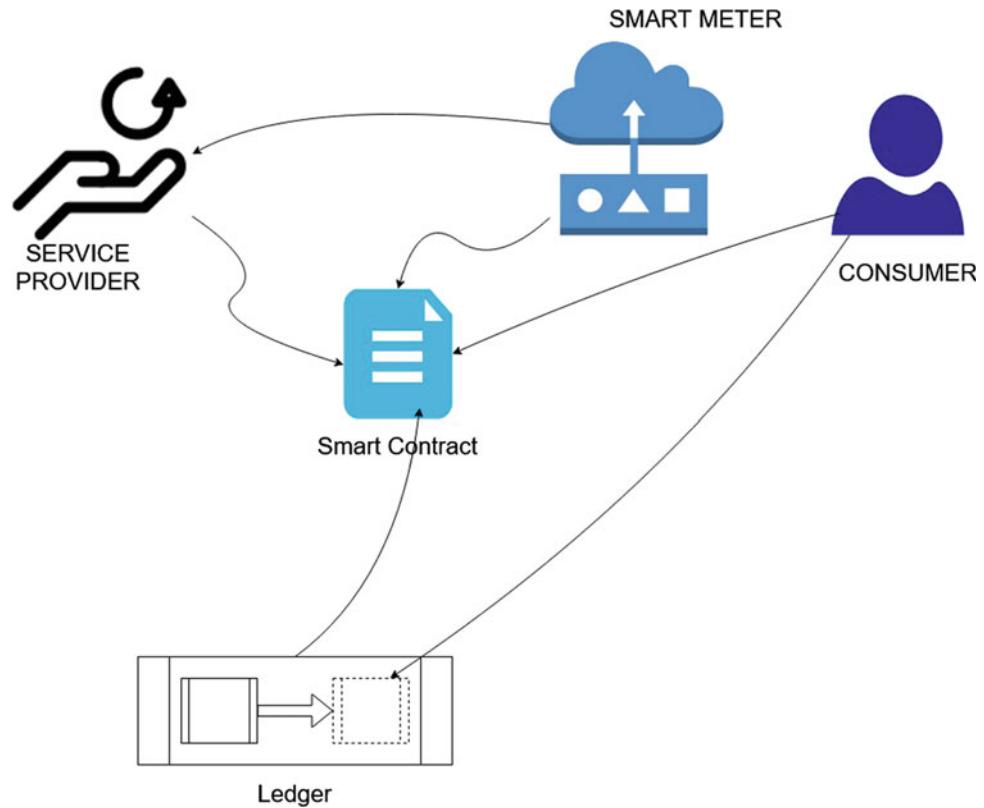
5 Methodology

The service model for this system consists of following below mentioned entities (as shown in Fig.1):

- Service provider—Government or private entity who provides services to the consumer, e.g., electricity department, parking authority, internet provider, etc.
- Consumer—Person/entity utilizing various services. Service meter–IoT device to monitor the usage of service by the consumer and sending the details to the service provider based on usage, e.g., smart meter for electricity, gas, water, parking, etc.
- Smart contract—Digital contract responsible for monitoring the bills and once it is generated by the service provider, the generated amount is automatically deducted from the consumers amount and deposited in the account of service provider.
- Public ledger—A blockchain ledger which holds non-repudiated token and records the transactions occurred.

The objective of carrying out the current research work was to design and develop state-of-the-art blockchain that

Fig. 1 Service model of the system

contains the consumer record and smart contract between him and service provider, secured using secure hash algorithm (SHA) 256 algorithm. The detailed working steps adopted are as follows:

- The provider deploys a smart contract and fixes the rate of charge of the service being provided.
- The consumer requests for the service and the provider installs the metering device for consumer.
- Provider and consumer mutually agree on the rate and other details as per the contract. Once the details are agreed, provider signs the details by his private key and encrypts them using consumer's public key. Once encrypted, he sends the details to the smart contract. The encrypted details can be seen by consumer using his private keys.
- If the length of consumer record less than 128 bits, dummy bits were padded to make the record as 128 bits so that it is 2n where n is even number so that the blocks are created without any issues. Each block contains following information:
  - Previous block hash value
  - Data
  - Time stamp
  - Current block hash value.

- Calculate the hash value of the current block by invoking the SHA 256 algorithm, as explained in Algorithm 3.
- The chain of the block is then stored in the array list.
- Consumer enjoys the uninterrupted service. IoT metering device monitors the consumption and send the details to the service provider. The bill is generated and the amount is deducted from consumer's account and credited to the service provider's account.
- The transaction is then added to the chain of blocks.

Notations

Consumer record	C_{rec}
Consumer name	C_{name}
Consumer ID	C_{id}
Consumer e-mail	$C_{emailid}$
Consumer mobile	C_{phno}
Consumer account detail	$C_{accDetails}$
Consumer address	$C_{address}$
Service meter	SM
Service provider	SP
Service disconnection	SD
Mutual service agreement	MSA
Database connection	D_c
Store the information into database	D_s

Algorithm 1: Algorithm 1: Creation of smart contract between consumer and service provider

---

1. Creates token for access of 128 bits by combining consumers' personal details.
   C_{rec}
   $\leftarrow C_{id} + C_{name} + C_{phno} + C_{emailid} + C_{accDetails} + C_{address} + C_{\text{Service Meter}}$
2. Validate: if access token is Non-Numeric String Record and length is 128 bit long
   $X \leftarrow Valid(Crec)$
   if $(Valid() = Fails || SizeOf(Crec) > 128$ **then**
   | Throw runtime exception
   else
   | goto step 3
   end
3. Procedure Utility Consumption
   Service provider deploys smart contract
   if *deployment successful* **then**
   | consumer requests for service
   | **if** *request successful* **then**
   | | SM installed at $C_{Address}$
   | | MSA between C_{id} and SP
   | | Stores encrypted details
   | | SP fetches data from SM at month end
   | | Generates bill and stores in block
   | | Automatic bill payment
   | | **if** *bill payment successful* **then**
   | | | send invoice $\leftarrow$ Store information in block
   | | | send notification to consumer to pay bill
   | | | **if** *bill not paid within due date* **then**
   | | | | SD $\leftarrow Store information in block$
   | | | **end**
   | | **end**
   | **end**
   end
   restart deployment if fails

Notations

PH	Previous hash value
CH	Current hash value
DoB	Data for block (Srec)
TS	Time stamp
LS	Length/size of student record

Algorithm 2: Block Creation Process

Trigger: Student Record is received and verified LS ← SizeOf(Crec)

if $(LS < 128)$ **then**

> print "Invalid String, block can't be created"
>
> print " Perform the Padding to create uniform block of 8 digits each"
>
> break

else

> Create : 16 Block each of 8 digits
>
> **if**
>
> *BCP(PH,DoB,TS,CH) is successful*
>
> *initiate the Hash Calculation Process;* **then**
>
> > print "Block Creation Failed"
> >
> > raise an exception
> >
> > break
>
> **else**

end

Notations

DoB   Data for block (Crec)

PH   Previous hash value

CH   Current hash value

Algorithm 3: Hash Calculation using Secure Hash (SHA 256) Algorithm

---

Trigger: Block Containing the Consumer Record Information is received

1. Generate Hash Value by Applying SHA 256 Algorithm
2. HC ← [HC(SHA256(PH,DoB,TS)] // PH for First Block is Zero,called as Genesis Block and Next Block contains Hash of Previous Block
3. BLOCK ← [PH,DoB,TS,HC]

---

6 Conclusion

The primary objective of the current research, viz. to design, develop, and deploy a blockchain framework for smart cities and showcase the potential of integrating blockchain with other modern technologies (Johari et al. 2019). Blockchain and IoT is combined to develop a smart utility payment solution for smart cities using smart contracts which executes automatically once the predefined condition is fulfilled. The consumer requests for a service and after successful request the service provider deploys the smart meter at the address provided by the consumer and integrates it with a smart contract for automated billing and payments. Therefore, it could be said that integrating blockchain with other technologies can be a promising approach to make the smart cities more smarter and to mitigate the optimized resource utilization-related challenges.

References

Biswas, K, & Muthukkumarasamy, V. (2016). Securing smart cities using blockchain technology. In *2016 IEEE 18th international conference on high performance computing and communications; IEEE 14th international conference on smart city; IEEE 2nd international conference on data science and systems (HPCC/SmartCity/DSS)*, pp. 1392–1393. IEEE, 2016.

Genesis Block. (2020). Accessed May 27, 2020. https://en.bitcoin.it/wiki/Genesisblock.

Ismail, L., & Materwala, H. (2019). *A review of blockchain architecture and consensus protocols: Use cases, challenges, and solutions.* https://doi.org/10.20944/preprints201908.0311.v1.

Johari, R., Gupta, K., Jha, S. K., & Kumar, V. (2019). CBCT: CryptoCurrency based blockchain technology. In *International Conference on Recent Developments in Science, Engineering and Technology*, pp. 90–99. Springer, Singapore

Johari, R., & Parihar, A. S. (2019). BLAST: Blockchain algorithm for secure transaction. *International Journal of Security and Its Applications, 13*(4), 59–66. https://doi.org/10.33832/ijsia.2019.13.4.06.

Lamport, L., Shostak, R., & Pease, M. (2019). *The Byzantine generals problem. Concurrency: The Works of Leslie Lamport*. https://doi.org/10.1145/3335772.3335936.

Mohan, C. (2019). State of public and private blockchains: Myths and reality. In *Proceedings of the 2019 International Conference on Management of Data*, pp. 404–411.

Natoli, C., & Gramoli, V. (2016). The blockchain anomaly. In: *2016 IEEE 15th International Symposium on Network Computing and Applications (NCA)*. https://doi.org/10.1109/nca.2016.7778635.

Salha, R. A., El-Hallaq, M. A., & Alastal, A. I. (2019). Blockchain in smart cities: Exploring possibilities in terms of opportunities and challenges. *Journal of Data Analysis and Information Processing, 7* (3), 118–139.

Sogeti Labs. (2014). I*BM's smarter cities challenge: A 5-year evaluation*. https://labs.sogeti.com/ibms-smarter-cities-challenge-5-year-evaluation.

Tapscott, D., Tapscott, A. (2016). *Blockchain revolution: How the technology behind bitcoin is changing money, business, and the world*. Penguin.

Watanabe, H, Fujimura, S., Nakadaira, A., Miyazaki, Y., Akutsu, A. h., & Kishigami, J. J. (2015). Blockchain contract: a complete consensus using blockchain. In *2015 IEEE 4th Global Conference on Consumer Electronics (GCCE)*. https://doi.org/10.1109/gcce.2015.7398721.

Wu, Y., Song, P., & Wang, F. (2020). Hybrid consensus algorithm optimization: A mathematical method based on POS and PBFT and its application in block-chain. *Mathematical Problems in Engineering, 2020,* 1–13. https://doi.org/10.1155/2020/7270624.

Zhang, R., Xue, R., & Liu, L. (2019). Security and privacy on blockchain. *ACM Computing Surveys, 52*(3), 1–34. https://doi.org/10.1145/3316481.

On Selection and Extraction of Biometric Features of Human Motor Activity from Data Obtained from Inertial Measurement Units

G. A. Fofanov

Abstract

The article describes a part of implementation of the project, the purpose of which is to create a universal system for the recognition and analysis of human motor activity, based on inertial measurement units. Analysis of biometric features was conducted, and most informative and universal features that uniquely describe movements performed by a person in the course of everyday activity were identified. A method for identifying features using micro-electromechanical inertial measuring units was proposed. A method for the formation of training examples for hybrid artificial neural networks was proposed. The classification of features depending on the dynamics and cyclicity was proposed. A method for automated feature extraction based on data threshold separation was proposed.

1 Introduction

In recent decades, the range of applications of inertial measuring units (IMU) has been actively expanding (Barbour and Schmidt 2001; Perlmutter and Robin 2012; Hol 2011). Thanks to the miniaturization of microcircuits and the improvement of sensor architectures, the determination of the orientation and position of objects in space has become possible not only for expensive industrial tasks (marine and aerospace navigation), but also for personalized localized problems. As of 2015, the use of inertial modules in local navigation tasks (indoors, tracking the movements of objects within one room) was 28% according to Adler et al. (2015). Wide commercial availability of sensors has made it possible to apply them in the fields of robotics, biomechanical analysis and motion capture for movies and games. In fact, the use of inertial sensors to estimate the orientation of objects has become common practice (Yuan et al. 2019; Melendez-Calderon et al. 2020; Falbriard et al. 2020). However, since the task of determining the position and orientation of body parts in space, as well as the dynamics of movements, is nonlinear, there are a large number of publications and approaches to isolation and processing of features of motor activity. Approximate models and relatively simple algorithms for assessing position and orientation work quite well in practice: Crema et al. (2017)—92%, Parate et al. (2014)—95.74%, Bao et al. (2017)—97.1%, Jiang et al. (2017)—92.6%, Kim et al. (2019)—98.6%. These algorithms are based on artificial neural networks. The most promising of them are approaches based on a combination of independent features and on a set of wide neural networks capable of recognizing one specific action.

However, it must be understood that the use of neural networks in itself is not a universal solution, and although networks have great potential for classifying data, the information used for training obeys certain patterns. Also, the algorithms used can be effective only for a certain range of movements, and the features used in different approaches have different information content and different forms. Therefore, to implement a system capable of recognizing the entire spectrum of human movements, it is necessary, first of all, to identify the most stable and most informative features. In other words, it is necessary to select the signs of human motor activity, which:

- firstly, universal; can be obtained from any person;
- secondly, unique; the data received about a certain movement should differ from the data about other movements to a sufficient extent for recognition;

G. A. Fofanov (✉)
FGBOU VO, Omsk State Technical University, Omsk, Russia
e-mail: saret_01@mail.ru

- thirdly, constant; should not change significantly over time;
- fourthly, representative; correlate with changes in the physical world uniformly and consistently.

It is also necessary to choose hardware, determine a method for identifying and processing features, develop a method for dividing images into separate classes and determine a method for recognizing classes (choice of neural network architecture, choice of functional).

The purpose of the article is to consider methods for identifying features using inertial measuring modules (IMM) of the lowest price category, choosing the most reliable and computationally simple algorithms for identifying features, identify most informative features of a human motor activity from data obtained from inertial measuring units. Parameters such as the correlation of features belonging to one class of movements, correlation of features belonging to different classes of movements, and the average deviation of the feature from the reference class value are evaluated.

2 Background

The problem of finding the optimal orientation estimate taking into account multiple support vectors was formulated in 1965 (Wahba 1965). Many algorithms have been proposed in the literature to solve this problem, most of which provide a relatively optimal solution with a relatively low computational complexity (Yun and Bachmann 2006; Gebre-Egziabher et al. 2004; Valenti et al. 2015).

In general, the work of the existing algorithms (filters) can be summed up to processing the readings of IMU sensors and creating an approximation of the orientation and position of objects in space. The raw data is a temporary function and commonly denoted as:

- Function of changing the linear acceleration along the x-axis, $Ax(t)$;
- Function of changing the linear acceleration along the y-axis, $Ay(t)$;
- Function of changing the linear acceleration along the z-axis, $Az(t)$;
- Function of changing the angular velocity along the x-axis, $Gx(t)$;
- Function of changing the angular velocity along the y-axis, $Gy(t)$;
- Function of changing the angular velocity along the z-axis, $Gz(t)$;
- Function of changing the magnetic field induction in the plane of the x-axis, $Mx(t)$;
- Function of changing the magnetic field induction in the plane of the y-axis, $My(t)$;
- Function of changing the magnetic field induction in the plane of the z-axis, $Mz(t)$;

A graphical representation of the raw data is shown in Figs. 1, 2 and 3.

Most commonly used filters are the extended Kalman filter (EKF) and various complementary filters. Einike (2019) Kalman filtering methods use probabilistic determination of the state, modeled using a Gaussian distribution. This approach gives good results, but it is computationally demanding. Complementary filters are a common alternative to EKF due to their simplicity and effectiveness. These filters use combinations of different sensor readings and frequency

Fig. 1 Changes in the linear acceleration graph $Ax(t)$, $Ay(t)$, $Az(t)$ when the sensor is rotated by 90° along three axes (m/s²)
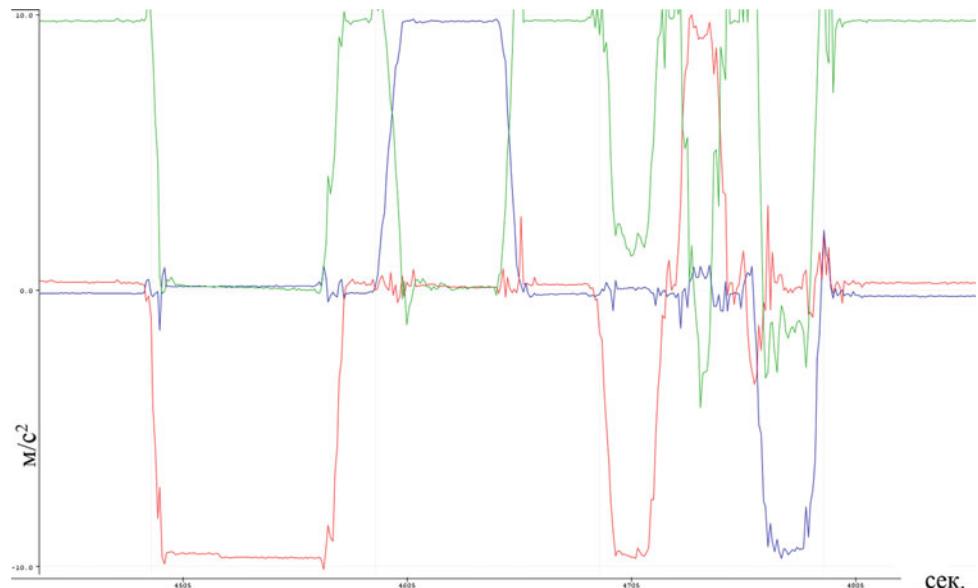
Fig. 2 Changes in the graph of the angular velocity $Gx(t)$, $Gy(t)$, $Gz(t)$ when the sensor is rotated by 90° along three axes (deg/s)
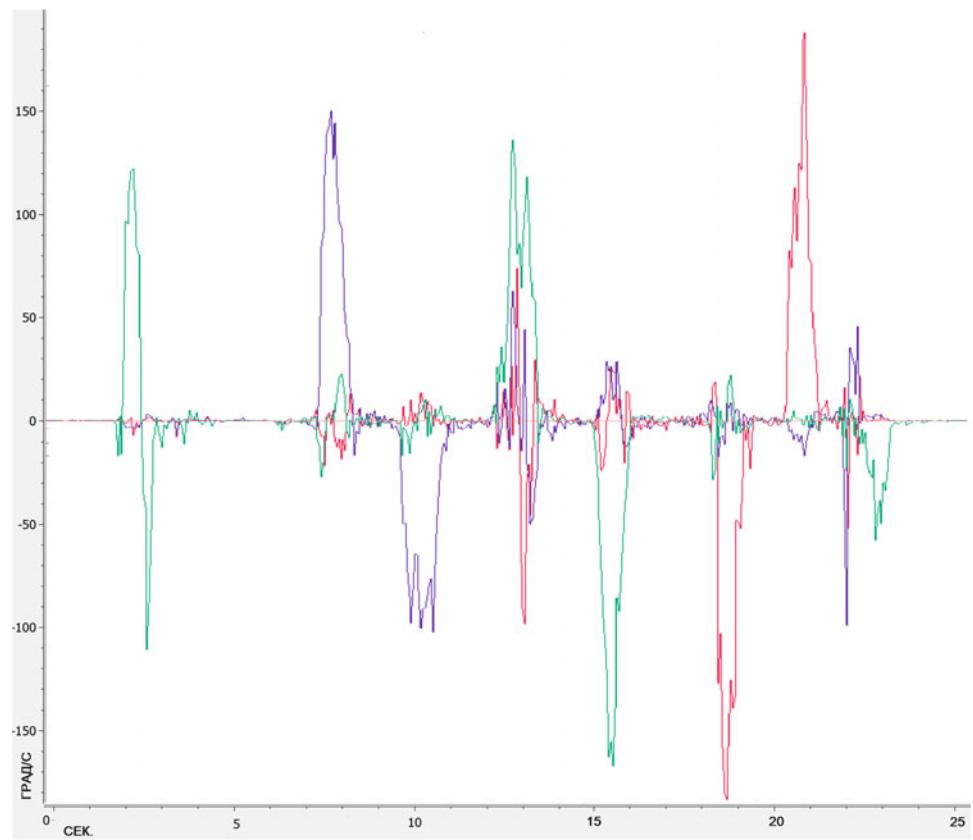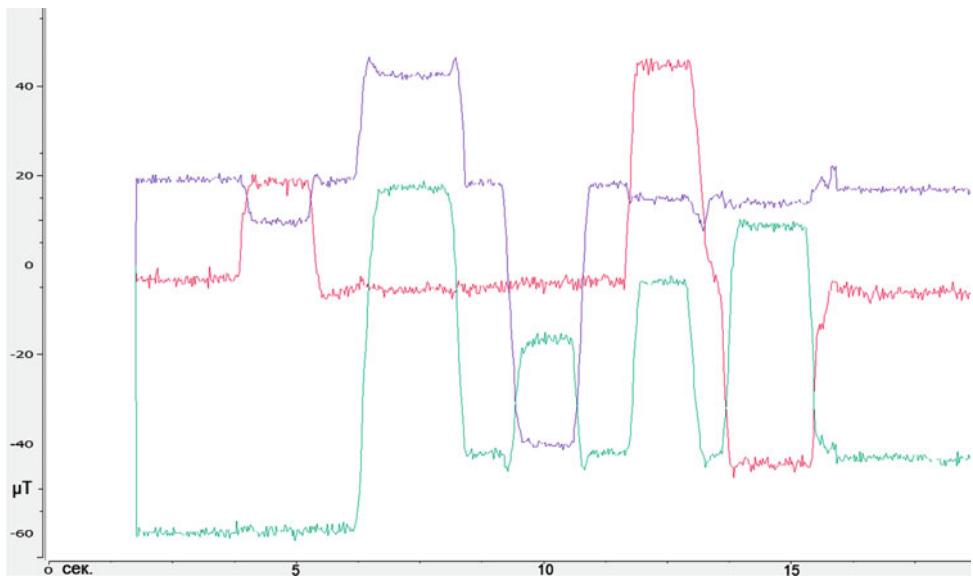

Fig. 3 Changes in the graph of magnetic field induction $Mx(t)$, $My(t)$, $Mz(t)$ when the sensor is rotated by 90° along three axes (µT)

analysis to provide an estimate of orientation. Among this group of filters stands out the Madgwick filter, which uses a quaternion to estimate the orientation.

Quaternions are part of a powerful mathematical apparatus that makes it possible to simplify calculations when determining the orientation (Tanveer et al. 2011), as well as to avoid conflicts that occur when using the orientation of Euler angles as a representation.

Formally, a quaternion is defined using a scalar qs and a three-dimensional vector (q_x, q_y, q_z) and can be expressed by the following equation:

$$q = qs + q_x i + q_y j + q_z k \qquad (1)$$

where i, j, k are imaginary basic variables whose square is equal to -1, q_x, q_y, q_z, are vector components, qs is a scalar. In practice, the orientation of an object in three-dimensional space (x, y, z) is represented by a unit quaternion, where θ represents the angle of rotation about a given axis:

$$q = \cos\frac{\theta}{2} + x * \sin\frac{\theta}{2} i + y * \sin\frac{\theta}{2} j + z * \sin\frac{\theta}{2} k \qquad (2)$$

The object is rotated by a given vector with coordinates (p_x, p_y, p_z) according to the formula:

$$p' = q \cdot p \cdot q^{-1} \qquad (3)$$

where $p = p_x i + p_y j + p_z k$ is the representation of the vector in the form of a quaternion, q^{-1} is the conjugate q quaternion. It should be noted that q^{-1} conjugate quaternion appears due to the fact that operations on quaternions are not communicative.

To determine the orientation, the Madgwick filter evaluates quaternion by integrating gyroscope output and then corrects the data using the accelerometer and magnetometer deviations calculated by gradient descent algorithm. In addition to the Madgwick filter, there is the Mahoney filter, which is essentially an alternative approach. The literature contains many comparisons of the performance of these filters and their modifications (Wu et al. 2016; Ludwig et al. 2018; Ludwig and Burnham 2018). The choice of a specific filter depends on the specific task and is made based on the requirements for the system being developed.

Since the developed system must be able to process sufficiently large amounts of data, the Madgwick filter was chosen as the basis for feature extraction.

In addition, to compare and highlight general patterns in the work, we used the data of motor activity obtained using the methods of visual analysis. The data were taken from Kuehne et al. (2011), Laptev et al. (2008) and Maurice et al. (2019).

To determine the position in space, IMU is usually not used on its own, or is used as an additional source of information in combination with high-precision GPS or stationary sensors. This is primarily due to the fact that for continuous position determination, it is necessary to integrate the accelerometer readings twice, which in turn quadruples the error of each measurement, as a result of which the data is shifted in an unpredictable manner. In practice, this approach is not viable, since the readings of the accelerometer mostly consist of data of direction of the gravitational vector and, as a consequence, will shift data about the real change in position in direction of this vector.

In ground navigation to determine the position in space used an approach based on subtracting the gravity vector from the readings of the accelerometer and then integrating the readings. This approach is a fairly good solution for problems where movement is limited to two directions of movement (navigation on a plane, in this case, the change in the height of the object is ignored X, Y).

Over the past decade, many algorithms have emerged that offer various solutions to this problem. In the article, a combination of approaches (He et al. 2020; Berkane and Tayebi 2019; Yang et al. 2020; Kok et al. 2017; Yan et al. 2018) with the modifications proposed below was used to highlight the position in space.

3   Feature Extraction

To analyze the informativeness and correlation of features, the following potential features were identified:

- Change in orientation of body parts in space
- Change in position of body parts in space
- Change in acceleration of body parts
- Change in the angular velocity of body parts
- Change in speed of body parts
- Change in the strength of the magnetic field around body parts.

Changes in the acceleration of body parts, changes in the angular velocity of body parts, changes in the strength of the magnetic field around body parts do not require a special procedure for isolation, since they are raw data received from sensors. Before feature extraction, the sensors were calibrated to reduce the amount of noise.

The extraction of changes in the speed of body parts was made by integrating the readings of the raw accelerometer data. Based on the information obtained during the analysis of the subject area, the Madgwick filter in the form of a

quaternion was used to highlight the change in the orientation of body parts in space.

Extraction of changes in the position of body parts done by orienting the sensor relative to the earth's coordinate system and using complementary filters.

To determine the arbitrary orientation of the sensor relative to the Earth reporting system, the data received from the gyroscope readings were normalized and converted in accordance with the equation:

$$w = [0, Gx, Gy, Gz] \tag{4}$$

The transformed data was substituted into the equation:

$$esq_{w,t} = 0.5 * \widehat{esq_{est-1}} \otimes w_t \tag{5}$$

$$esq_{w,t} = \widehat{esq_{est-1}} + esq_{w,t} * \Delta t$$

where w_t is the angular velocity at the current time, $\widehat{esq_{est-1}}$ is the orientation estimate at the previous time, and $esq_{w,t}$ is the current orientation estimate (Parate et al. 2014). The essence of the approach boils down to transforming the gravity vector and the earth's magnetic field vector obtained from various sensors for their subsequent combination with the gyroscope readings and the selection of the orthogonal plane of the navigation reference system (coordinate system associated with the uniquely determined directions Up-North-West).

To isolate changes in position in space using IMM, a combination of existing methods, multistage threshold and complementary filtering was used. Orientation data obtained from the definition of the navigation coordinate system were used to determine the tilt of the sensor relative to the direction of the gravity vector. Compensation for the influence of the gravity vector was carried out by normalizing the data received from the accelerometer as follows:

$$n = \sqrt{Ax_t^2 + Ay_t^2 + Az_t^2}$$
$$Axn_t = \frac{Ax_t}{n}$$
$$Ayn_t = \frac{Ay_t}{n} \tag{6}$$
$$Azn_t = \frac{Az_t}{n}$$
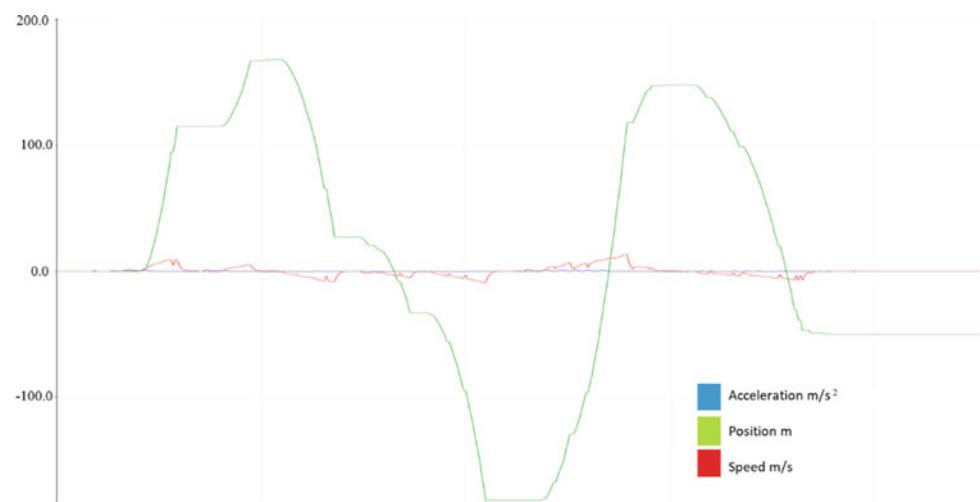
where n is the norm, An_t normalized readings of the accelerometer per unit of time. Then, using the previously obtained orientation relative to the navigation coordinate system, the gravity vector is selected, which is proportional to each axis of the accelerometer.

$$A_xG = 2 * (q_{xt} * q_{zt} + qs_t * q_{yt})$$
$$A_yG = 2 * (qs_t * q_{xt} + q_{yt} * q_{zt}) \tag{7}$$
$$A_zG = (qs_t^2 - q_{xt}^2 - q_{yt}^2 + q_{zt}^2)$$

The resulting vector was subtracted from the normalized vector of the accelerometer readings. The resulting data was filtered with a high pass filter. The data obtained represent an approximate estimate of the position of the IMM in linear motion.

Due to the peculiarities of human physiology, the limbs during the performance of actions move along a trajectory similar to the segments of circles. An example is the movement of the elbow when raising the arms above the head or rotating the hands. Since an accelerometer is a combination of physical objects that have a specific mass,

Fig. 4 Graph of the dynamics of changes in acceleration, speed, and position of the sensor along the X-axis when rotating around the remote axis
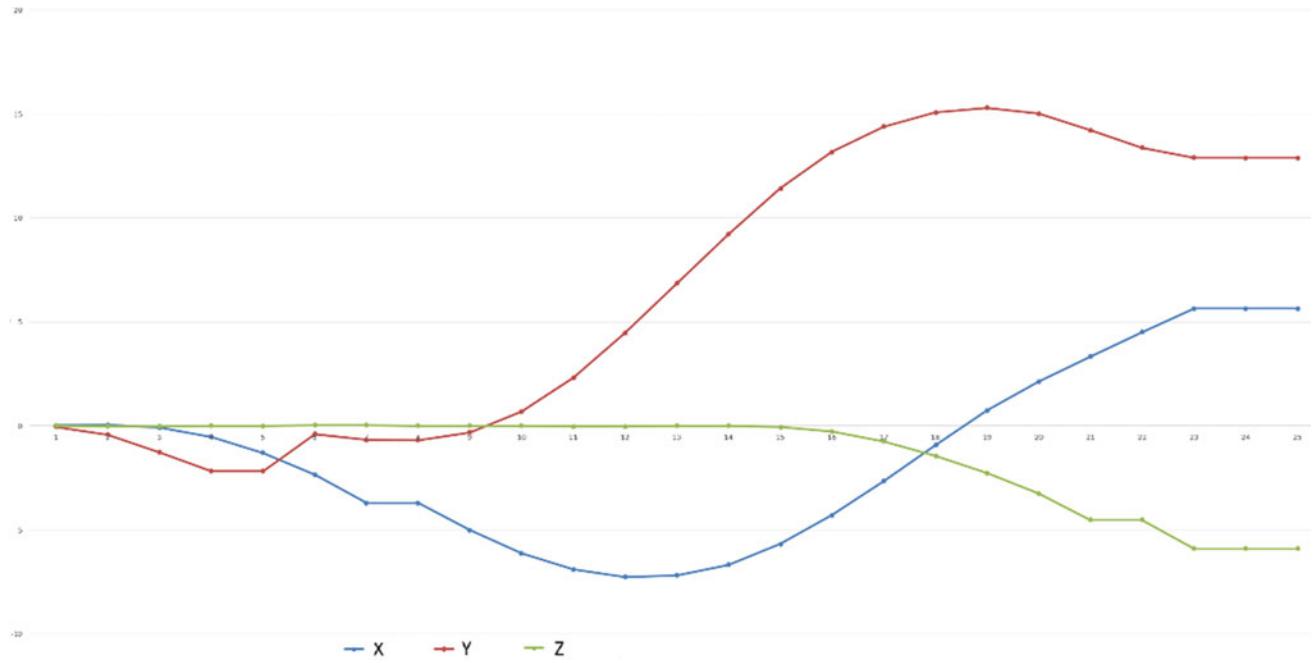
Fig. 5 Graph of the dynamics of changes in position by coordinates during circular motion

the circular motion causes it to register linear motion, which is essentially centrifugal force. This leads to false readings. Figure 4 shows a graph of the change in the position of the sensor in space when rotating around the axis.

It can be observed that when the sensor is rotated around a certain point, the speed and distance traveled in the direction of the centrifugal force vector increase regardless of the direction of rotation. In other words, as the sensor rotates around a distant point, the resulting position estimate is shifted along the axis of the centrifugal force. This problem can be solved by using a complementary filter. For filtering, it is proposed to evaluate the gyroscope readings at a time and compare them with the accelerometer readings. Whenever the gyroscope readings become more than a certain value, it is suggested to filter the accelerometer readings. Filtration can be performed both by simple cutoff and proportionally depending on the size of the angular velocity.

Since long-term (hours, days) tracking the position of body parts in space is not necessary for the implementation of the motion recognition system, it is proposed to divide the sequential data stream into fragments to form training examples. The separation will occur every time the accelerometer readings reach near-zero values, for a period of time equal to 1/5 of a second. Also, to create training examples, it is proposed to set to zero position readings in space after data separation. And also to divide the data into classes of samples. In addition, for the automated distribution of the resulting images, it is proposed to calculate the correlation coefficients of the new sample relative to the reference representatives of all classes of samples. If the correlation reaches values greater than 0.85, the image will be added to the existing ones and the corresponding network will undergo additional training. Otherwise, the sample will be defined as a new class. An example of the resulting change in position during movement describing an arbitrary circle with a hand is shown in Fig. 5.

4 Correlation and Informativeness Analysis

To collect and analyze features, a prototype of a data collection system was developed and tested using the most reliable IMU presented in the lowest price category (Fofanov 2020). The analysis also used data obtained from an open database of human movements (Maurice et al. 2019). Experimental data were movements that describe various simple geometric shapes (circle, triangle, square), as well as more complex movements that combine rotation, movement of the arms in space (raising the arms above the head) and simple cyclical movements (walking). In total, more than a thousand images of various movements were collected. Following features where extracted from collected images:

- Change in orientation of body parts in space
- Change in position of body parts in space
- Change in acceleration of body parts
- Change in the angular velocity of body parts

- Change in speed of body parts
- Change in the strength of the magnetic field around body parts.

Data obtained from open sources were collected using both inertial sensors and systems using a set of cameras and infrared markers. All datasets were divided into two classes of images: static and dynamic. Static images included data obtained in a stationary position of the body (movement of the limbs in a sitting position, standing still); dynamic images included data obtained during movement (walking, turning in place). Also, the data was transformed into vector form and scaled to obtain a uniform dimension. The scaling was done by adding intermediate averages between the existing data points. The frequency of obtaining experimental data was 20 Hz.

To determine the most suitable features, correlation analysis was carried out and the informativeness of features was determined (Загоруйко 1999). Informativeness was determined as the average value of the Euclidean distance between the mathematical expectations of images for individual characteristics. The analysis results are presented in Table 1.

Average correlation between realizations of one movement is a metric that describes how "far" features of one image of a specific movement from another image of the same movement. Likewise, average correlation between realizations of different movements describes same metric for different movements. In other words, these are measurements of likeness of any two features extracted from images. Basically, it says how similar features are in terms of dynamical changes within the features. Informative value of experimental data and informative value of open data is a similar metric used to measure Euclidean distances between

the aggregate feature (most common feature realization) and all other realizations of one specific movement. Typically, the closer informativeness to 1 the more reliable feature is in terms of consistency.

Based on the data obtained, it can be concluded that the most informative features are changes in position of body parts in space relative to time and a change in orientation of body parts in space relative to time.

5   Conclusion

In the course of the analysis of existing approaches to the recognition of motor activity, the following regularities were identified: The most frequently used features, without reference to a specific data collection system (both system types based on wearable electronics and methods of visual analysis, cameras, infrared sensors) are determination of position of body parts in space and determination of orientation of body parts in space, approaches showing a high degree of recognition and a low percentage of erroneous decisions (in the case of systems using IMU), the overwhelming majority use data filtering algorithms to create extract features.

The analysis of features extracted from human motor activity was carried out. The most informative and stable features that can be used to recognize both stationary and cyclic movements were identified. A method for extracting changes in position of body parts in space is proposed. A criterion for dividing the data flow into separate classes of features is proposed, allowing automating and simplifying the creation of training examples. The selected features are suitable for training hybrid artificial neural networks based on neurons with different functionalities. The most suitable functionals are those based on the dynamic transformation of

Table 1 Correlation and informativeness of features

Feature	Average correlation between realizations of one movement		Average correlation between realizations of different movements		Informative value of experimental data	Informative value of open data
	Experimental data	Open data	Experimental data	Open data		
Orientation of body parts in space	0.95122	0.883685	0.000381	0.087768	0.914324	0.889016
Position of body parts in space	0.776687	0.67952	-0.00946	0.0144	0.71902	0.76949
Acceleration of body parts	0.404175	0.385833	-0.00634	0.003171	0.41013	0.40207
Angular velocity of body Parts	0.46044	0.42975	0.0224	-0.01175	0.58124	0.52591
Body parts speed	0.469676	0.423991	0.0247929	-0.01428	0.70314	0.51029
Magnetic field strength around body parts	0.34579	0.36894	0.051429	-0.12246	0.26106	0.23917

time scale, threshold activation function (Frank et al. 2010; Yasuoka et al. 2016) and Bayesian functionals (Ivanov et al. 2017).

A comparative analysis of the extracted features and features obtained from open sources was carried out. The regularities that exist in the experimental data correspond to those obtained from open data, which indicates accuracy of proposed algorithm for feature extraction and appropriateness of use for training neural networks. During the next stage of the development of the motor activity recognition system, a comparison of the performance of various neural network architectures will be carried out. Developed feature extraction method can be used for tracking limbs position and orientation in sports and medical rehabilitation applications, for non-intrusive tracking and data acquisition with IMU.

References

Adler, S., Schmitt, S., Wolter, K., & Kyas, M. (2015). A survey of experimental evaluation in indoor localization research. In *Proceedings of the IEEE International Conference on Indoor Positioning and Indoor Navigation (IPIN)*, pp. 1–10, Banff, Alberta, Canada, October 2015.

Bao, P., Maqueda, A., Del-Blanco, C., & García, N. (2017). Tiny hand gesture recognition without localization via a deep convolutional network. *IEEE Transactions on Consumer Electronics, 63,* 251–257. https://doi.org/10.1109/TCE.2017.014971.

Barbour, N., & Schmidt, G. (2001). Inertial sensor technology trends. *IEEE Sensors Journal, 1*(4), 332–339.

Berkane, S., & Tayebi, A. (2019). *Position, velocity, attitude and gyro-bias estimation from IMU and position information*, pp. 4028–4033. https://doi.org/10.23919/ecc.2019.8795892.

Crema, C., Depari, A., Flammini, A., Sisinni, E., Haslwanter, T., & Salzmann, S. (2017). IMU-based solution for automatic detection and classification of exercises in the fitness scenario. *IEEE Sensors Applications Symposium (SAS), Glassboro, NJ, 2017,* 1–6. https://doi.org/10.1109/SAS.2017.7894068.

Einike, G. A. (2019). *Smoothing, filtering and prediction: Assessing the past, present, and future* (2nd ed.). Amazon Prime Publishing. ISBN 978-0-6485115-0-2.

Falbriard, M., Meyer, F., Mariani, B., Millet, G., & Aminian, K. (2020). Drift-free foot orientation estimation in running using wearable IMU. *Frontiers in Bioengineering and Biotechnology., 8,* 65. https://doi.org/10.3389/fbioe.2020.00065.

Fofanov, G.. (2020). Comparative analysis of microelectromechanical inertial measurement units of various manufacturers for human motor activity monitoring. *Omsk Scientific Bulletin* 121–127. https://doi.org/10.25206/1813-8225-2020-171-121-127.

Frank, J., Mannor, S., & Precup, D. (2010). Activity and gait recognition with time-delay embeddings. In *Proceedings of the AAAI*, Atlanta, GA, USA, 11–15 July 2010.

Gebre-Egziabher, D., Hayward, R., & Powell, J. D. (2004). Design of multi-sensor attitude determination systems. *IEEE Transactions on Aerospace and Electronic Systems, 40*(2), 627–649.

Загоруйко, Н. Г. Прикладные методы анализа данных и знаний. — Новосибирск: ИМ СО РАН, 1999.— 270c. ISBN 5-86134-060-9.

He, B., Wang, H., Li, M., Yury, K., & Shi, X. (2020). *A novel indoor positioning algorithm based on IMU*. https://doi.org/10.1007/978-3-030-41117-6_14.

Hol, J. D. (2011). *Sensor fusion and calibration of inertial sensors, vision, ultra-wideband and GPS*. Dissertation no. 1368, Linköping University, Linköping, Sweden, June 2011.

Ivanov, A. I., Lozhnikov, P. S., & Vyatchanin, S. E. (2017). Comparable estimation of network power for Chisquared Pearson functional networks and Bayes hyperbolic functional networks while processing biometric data/control and communications (SIBCON), 29–30 June 2017, Astana, Kazakhstan, pp. 1–3. https://doi.org/10.1109/sibcon.2017.7998435.

Jiang, S., Lv, B., Guo, W., Zhang, C., Wang, H., & Sheng, X. (2017). Feasibility of wrist-worn, real-time hand and surface gesture recognition via sEMG and IMU sensing. *IEEE Transactions on Industrial Informatics, 14,* 3376–3385. https://doi.org/10.1109/TII.2017.2779814.

Kim, M., Cho, J., Lee, S., & Jung, Y. (2019). IMU sensor-based hand gesture recognition for human-machine interfaces. *Sensors, 19,* 3827. https://doi.org/10.3390/s19183827.

Kok, M., Hol, J. D., & Schön, T. B. (2017). Using inertial sensors for position and orientation estimation. *Foundations and Trends® in Signal Processing, 11*(1–2), 1–153. http://dx.doi.org/10.1561/2000000094.

Kuehne, H., Jhuang, H., Garrote, E., Poggio, T., & Serre, T. (2011). *HMDB: A large video database for human motion recognition*. ICCV, PDF Bibtex.

Laptev, I., Marszalek, M., Schmid, C., & Rozenfeld, B. (2008). *Learning realistic human actions from movies*. CVPR, 2008; Jhuang, H., Serre, T., Wolf, L., Poggio, T. (2007). *A biologically inspired system for action recognition*. ICCV, 2007.

LNCS Homepage. (2016). http://www.springer.com/lncs. Last accessed November 21, 2016.

Ludwig, S. A., & Burnham, K. D. (2018). Comparison of euler estimate using extended Kalman filter, Madgwick and Mahony on Quadcopter flight data. In *2018 International Conference on Unmanned Aircraft Systems (ICUAS)*, Dallas, TX, 2018, pp. 1236–1241, https://doi.org/10.1109/icuas.2018.8453465.

Ludwig, S., Burnham, K., Jiménez, A., & Touma, P. (2018). Comparison of attitude and heading reference systems using foot mounted MIMU sensor data: basic. *Madgwick, and Mahony*. https://doi.org/10.1117/12.2296568.

Maurice, P., Malaisé, A., Amiot, C., Paris, N., Richard, G., Rochel, O., et al. (2019a). Human movement and ergonomics: An industry-oriented dataset for collaborative robotics. *The International Journal of Robotics Research*. https://doi.org/10.1177/0278364919882089.

Maurice, P., Malaisé, A., Amiot, C., Paris, N., Richard, G., Rochel, O., et al. (2019b). Human movement and ergonomics: An industry-oriented dataset for collaborative robotics. *The International Journal of Robotics Research*. https://doi.org/10.1177/0278364919882089.

Melendez-Calderon, A., Shirota, C., & Balasubramanian, S. (2020). *Estimating movement smoothness from inertial measurement units*. https://doi.org/10.1101/2020.04.30.069930.

Parate, A., Chiu, M.-C., Chadowitz, C., Ganesan, D., & Kalogerakis, E. (2014). RisQ: recognizing smoking gestures with inertial sensors on a wristband. In *Proceedings of the 12th Annual International Conference on Mobile Systems, Applications, and Services (MobiSys '14)*. Association for Computing Machinery, New York, NY, USA, pp. 149–161. doi: https://doi.org/10.1145/2594368.2594379.

Perlmutter, M., & Robin, L. (2012). High-performance, low cost inertial MEMS: A market in motion! In *Proceedings of the IEEE/ION Position Location and Navigation Symposium (PLANS)*, pp. 225–229, Myrtle Beach, South Carolina, USA.

Tanveer, F., Waheed, O. T., & Rehman, A. (2011). Design and development of a sensor fusion based low cost attitude estimator. *Journal of Space Technology, 1*(1).; Kuipers, J. B. (1999). *Quaternions and rotation sequences: A primer with applications to orbits, aerospace and virtual reality*. Princeton, NJ, USA: Princeton University Press.

Valenti, R. G., Dryanovski, I., & Xiao, J. (2015). Keeping a good attitude: A quaternion-based orientation filter for IMUs and MARGs. *Sensors (Switzerland), 15*(8), 19302–19330.

Wahba, G. (1965). A least square estimate of spacecraft attitude. *Society for Industrial and Applied Mathematics (SIAM) Rev, 7*, 409–1965.

Wu, J., Zhou, Z., Chen, J., Fourati, H., & Li, R. (2016). Fast complementary filter for attitude estimation using low-cost MARG sensors. *IEEE Sensors Journal, 16,* 1–1. https://doi.org/10.1109/JSEN.2016.2589660.

Yan, H., Shan, Q., & Furukawa, Y. (2018). RIDI: Robust IMU Double Integration. In: V. Ferrari, M. Hebert, C. Sminchisescu, & Y. Weiss (Eds.) Computer Vision—ECCV 2018. ECCV 2018. Lecture Notes in Computer Science, Vol. 11217. Cham: Springer. https://doi.org/10.1007/978-3-030-01261-8_38.

Yang, C., Chen, J., Guo, X., Liu, D., & Shi, Y. (2020). *Study on indoor combined positioning method based on TDOA and IMU*. https://doi.org/10.1007/978-981-13-6504-1_149.

Yasuoka, Y., Shinomiya, Y., & Hoshino, Y. (2016). Evaluation of optimization methods for neural network. In *Soft Computing and Intelligent Systems (SCIS) and 17th International Symposium on Advanced Intelligent Systems*. https://doi.org/10.1109/scis-isis.2016.0032.

Yuan, Q., Asadi, E., Lu, Q., Yang, G., & Chen, I.-M. (2019). Uncertainty based IMU orientation tracking algorithm for dynamic motions. *IEEE/ASME Transactions on Mechatronics*, 1–1. https://doi.org/10.1109/tmech.2019.2892069.

Yun, X., & Bachmann, E. (2006). Implementation and experimental results of a quaternion-based Kalman filter for human body motion tracking. In *Proceedings of the 2005 IEEE International Conference on Robotics and Automation*, vol. 22, pp. 317–322.

Secure and Efficient Bandwidth Management for Local and Personal Area Networks Using Customized Open Source Application on a Commodity Hardware: RadSense—An Integration of pfSense Over Radius and MySQL

Shamneesh Sharma, Manoj Manuja, Digvijay Puri, and Ajay Kumar

Abstract

The bandwidth allocation and management which converges on efficient network performance is one of the important issues today in most of the organizations. The commercial service providers in this field are costly in terms of finance as well as time. This paper focuses on the development and customization of an open source application product "RadSense" over a network of two thousand nodes for a better network performance. The performance of the network is measured over a customized application which is further an integrated platform of open source applications pfSense and Radius. The development of this product has been done to reduce the cost of the commercial applications and high-end servers in the organizations. This paper also presents a study of network performance with properly managed data over an open source data base application "MySQL" on a low-end commodity server. Also, the integration of the different technologies over a newly developed application has come up with new dimensions in the field of open source firewall systems.

Index Terms

Access control • Bandwidth shaping • Commodity hardware • Open source applications • Network performance

S. Sharma (✉)
Poornima University, IS-2027-2031, Ramchandrapura,
P.O. Vidhani Vatika, Sitapura Extension, Jaipur, Rajasthan, India
e-mail: shamneesh.sharma@gmail.com

M. Manuja
Chitkara University, Chandigarh, Punjab, India
e-mail: manoj_manuja@yahoo.in

D. Puri
Chandigarh University, Ajitgarh, Punjab, India
e-mail: digvijaypuri@gmail.com

A. Kumar
Alakh Prakash Goyal (APG) Shimla University, Shimla, HP, India
e-mail: darkverma@gmail.com

1 Introduction

Most of the organizations are shifting toward the open source community. pfSense is the open source firewall solution which is as capable as other commercial firewall solutions with many additional features (Patel Krupa and Sharma 2017).

Every invention has its own benefits and drawbacks. The existing architecture can be used in the small organizations for pfSense firewall implementations. The pfSense server in the explained architecture can be used for automatic IP address allocation as Dynamic Host Control Protocol (DHCP), threat management as Unified Threat Management and security system as Intrusion Prevention and Detection System (IPS and IDS) (Fig. 1).

This architecture is good in terms of security, IP address management and UTM, whereas there are two drawbacks of this systems architecture:

- The authentication and authorization mechanisms are available in this solution, but the user-based accounting system cannot be managed effectively with the explained architecture if the size of database increases.
- The efficiency of the system gets with the increase of users as it stores the user data in a single text file. The primary task of pfSense is to handle the traffic and prevent its local area networks from outside attacks using Intrusion Prevention and Detection System. The increase in the user database may slow down the authentication process and protection system.

The above-mentioned points have become the motivation to carry out this research. A Web-based application is further modified to solve the problem of better authorization and authentication mechanisms, and the researchers have integrated the pfSense with the Radius application. Radius is an open source platform which has AAA mechanism in it. AAA mechanism is responsible for authentication,
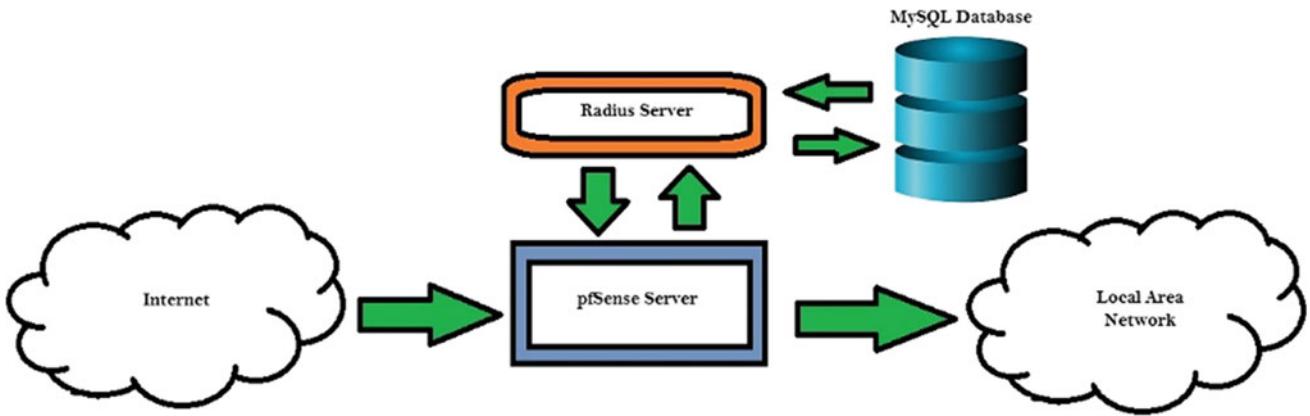
Fig. 1 Proposed integrated architecture of RadSense

authorization and accounting. To handle the large databases, the easiest way is to manage it through the SQL servers.

2 Related Work

Network security is an important aspect in the field of information technology, and firewalls are playing an important role to manage it. The authors of Patel Krupa and Sharma (2017) have done the comparison of three different open source firewall solutions. The preventive measures cannot assure the full protection of network, but it makes the user ready for the disaster management techniques (Kishore and Sharma 2013). The organizations need the efficient and secure management of its resources. To deal with the attacks, the organizations must understand the psychology of the attackers (Sharma et al. 2011). The firewall solutions can manage the security of the network, but commercial firewall solutions are very costly. The combination of pfSense and Radius will provide an Internet Authentication Service (IAS) (Tittel 2012). Unanticipated scalability and recital tribulations may appear with the increases in the number of network's users. The commercial firewall systems might be an overkilling for these SMEs both financially and functionally (Mamat and Ruzana 2013). pfSense is the most trusted open source firewall system till now, but there are certain disadvantages of this system which researcher must take care while implementing it. The integration of Radius with pfSense is done earlier by many researchers but operability in totality is based on the Command Line Interface which is not a simple task for beginners (Donoghue 2019). The pfSense comes up with many features, but limited support and no update schedule are the problems of this firewall system (Campbell 2019). As the pfSense is the open source solution, so many organizations had integrated with different platforms like Radius using active directory accounts (Vorkbaard 2019), VPN using Active Directory Authentication (User Management and Authentication,

Authentication Servers) and many more. The pfSense and Radius store files in the .txt format only, so the user management is a little complicated; moreover, this will make the system busier with this structure (Kumar and Gupta 2018). There is a need of lightweight application which can run on the normal hardware and can be helpful for the users. The authors of Nahid Kausar et al. (2018) have implemented and recommended the pfSense for small and medium-scale enterprises. The recommendation is based upon its cost-effectiveness and provision of broad list of services. In a survey on network firewall solutions (Aryeh et al. 2016), the researchers compared pfSense and Endian firewall solutions and concluded that open firewall solutions are becoming more popular. The researcher also stated that the pfSense can be implemented in the organizations with complex networks in them. The researchers from Ghana, in research (Sharma and Parekh 2017), show that it will be difficult for large organizations with over 2000 user login credentials to manage the network using pfSense alone. The main objectives of this research are as follows:

- To integrate pfSense with Radius (RadSense) for the improvement of the authentication, authorization and accounting (AAA) mechanism in case of large databases on commodity hardware infrastructure.
- To connect the integrated RadSense with the MySQL server to manage a large database.
- To design a user-friendly interface for the proposed solution so that it can handle the data with efficiency.

3 Experimental Setup and Methodology

To integrate the environment of RadSense, we have installed the pfSense application (3.3) on a machine which comes under the commodity hardware. This machine is then

connected to a network of 2500 nodes. On the same network, we have installed and configured the Free Radius Application (3) on the pfSanse machine. After enabling the captive portal, instead of using the data of users on a locally stored file, we have connected the Radius application with the Maria DB MySQL Application. pfSense and Radius do not provide any interface for the help of Network Administrator to manage the users and services on external databases. So, our developed application will act like a bridge between the Radius and External Database for Network Administration. In simple terms, to manage the external Radius database, we have configured the MySQL database server on commodity hardware of same configuration with the developed integrated application "RadSense".

There are certain features of pfSense which makes it so popular in the firewall networking solutions. These features (Binti 2017) include the compatibility, DHCP and DNS services, traffic shaping and real-time network information and inbound and outbound load balancing. The implementations of pfSense and Radius have also been provided in a research project (Naik et al. 2018) of a student of University of Sultan Zainal Abidin. The optimization of the applications may lead to get good results on the commodity hardware platforms. P. Naik et al. presented a paper on Virtualization of Network Functions (Sylvester et al. 2016) and concluded the optimization of applications to run on commodity hardware platforms.

Algorithms used in integration and Functioning

In the present research, there are multiple algorithms used for the integration of the different technologies. Some of them are given below:

Algorithm for setting up the RadSense:

To set up the developed application "RadSense" on the hardware described in Table 1, the following algorithm and flowchart are used:

A. START
B. Request from user on the browser for accessing RadSense which is already stored on the Apache Web server directory.
C. RadSense will check whether user session exists or not. (Checking if the user is logged in)

    a. If session is instantiated, user will be redirected to dashboard.
    b. If not, redirected to login page.
D. Login page will check whether the RadSense is already installed or not.
    a. If yes, ask for admin credentials and script for credential match will be commenced from the database.
      • If matched, user will be redirected to the dashboard.
      • If not, redirected to the login page with an error message.
    b. If no, it will run the installation script (Install.php).
E. END

Algorithm for user management

The pfSense can manage the users on the text file; therefore, management of more and more users is not possible. To solve the problem of administrators, the RadSense is best application which can manage the users on the MySQL application with a user-friendly interface. The following algorithm has been used for user management:

A. START
B. Admin will login into the system.
C. System will ask for the input.
    a. If input is "a"
      1. Admin will enter the credentials of the user.
      2. Script will check that if the user already exists in the database.
        • If yes, reflect the message "User already exist".
        • If no, user will be added to the database along with the message "User added" and will be allocated to the respective service.
    a. If input is "b"

Admin will enter the credentials of the user.

1. Script will check that if the user already exists in the database.
    • If yes, admin will be shown a modifying page where he can modify user details like user password, user service or delete the user.

Table 1 Commodity hardware, software and network specifications used in the experiment	Machine information	
	RAM	4 GB
	HDD	250 GB
	Processor	Intel® Core TM i3-3210 CPU @ 3.20 GHz
	pfSense	3.3
	Network	40 Mbps, mesh with 2500 nodes

- User will be shown error "User does not exist".
2. Update
   - If password field is "Empty", user password will remain unchanged but selected service will be updated.
   - If password field is "Not Empty", user password will be updated with respective password and service.
c. If input is "c"
   1. Delete button is clicked. User will be deleted from the database along with its service relation.
D. END

Algorithm for Service Management

The service management mechanism deals with the creation and deletion of the services in the existing system. There can be different services which can be created in this system. Different user groups of unique and same accessing rights can be created with different services. The following algorithm has been used for the service management:

A. START
B. Admin will login into the system.
C. System will ask for the input.
   a. If input is "a"
      1. Admin will enter the credentials for the creation of service. These credentials may be upload bandwidth limit, download bandwidth limit and service name.
      2. RadSense script will check that if the service already exists in the database.
         - If yes, reflect the message "Service already exists".
         - If no, service will be added to the database along with it all the attributes and pop up a message "Service added".
   b. If input is "b"
      - List service page will load, and all the services in the system will be loaded along with the delete button.
      - If admin will click on delete button, admin will be asked to move the users of selected service to different services or delete all the users along with the selected service.
      - "Move Users" button is pressed. Users will be moved to selected service, and service will be deleted.
      - If "Delete Users with Service Button" is pressed, users will be deleted along with service.
D. END

Algorithm for Logout Function

To logout from the system, we have implemented the logout mechanism in pfSense. The "*user/local/captiveportal/index.php*" file was edited to make that possible. A logout logic code is placed in "*if block*" of an *index.php* file which validates that the user is accessing the captive portal login page or not. After successful login, user is redirected to a user page where he can change the password and logout from the pfSense. pfSense with its default setup does not have the functionality of providing a logout page, so researchers made the mentioned tweak to the system and successfully created a logout mechanism. A pre-authentication and post-authentication mechanism have been implemented in the system which is explained in the following algorithm:

A. START
B. User will enter the credentials on the login page and login into the system.
   a. If captive portal page is accessed for the first time and user is not logged in, then a login form will be shown to the user.
   b. If captive portal page is accessed, but user is already logged in the system. User will be logged out upon accessing the captive portal page again.
C. END

Algorithm for Network Access

The network access control mechanism is an important factor which can prevent the non-competent or unauthorized users to take access over the network. This mechanism can also give restricted access to computing resources by keeping the insecure nodes away from the network. The following algorithm has been used in RadSense:

1. START
2. User will connect to the network and try to access the resources through a browser application.
3. An HTTP request will go to the pfSense server.
4. pfSense server will check the request validity and redirect the request to the captive authentication portal on port 8002.
5. User will have to put the credentials through sign-in or sign-up process.
6. The entered credentials will be sent to the Radius application with a Network Access Request.
7. The credentials of the users are checked in the MySQL database.

a. If credentials match, Radius application responds with the access-accept and grants the access according to the authorization capacity of the user through its AAA mechanism.

b. If credentials do not match, the Radius application will respond with access-reject response.

8. After the acceptance, user can access the network resources. Any HTTP request beyond the authorization of user will be rejected by pfSense itself; it will not reroute to the database server.

9. END

4 Implementation and Working of RadSense

RadSense is developed to help the Network Administrators for the management of users and services. This application acts as the user interface and frees the administrators from typing big commands on the command line interfaces. Figure 4 shows demonstrating the front panel access page of the administrators. This shows how the developed application has made it easy for administrators to manage the users, services and NAS clients. There are many things included in the developed application which makes it unique from the existing systems. The integration of the existing technologies on a single platform made it easy for the system and network administrators to manage the large node networks. The RadSense can do the following things:

Service Management
The RadSense can manage multiple services in a single network. These services can be in terms of creation, deletion and listing. A service can provide a user with resource access, network speed (capping), Internet resource accesses and restrictions. There are many more services which can be managed by the RadSense.

User Management
The RadSense can manage the users on the user interface. This management can be in terms of user creations, user deletion, user service updates and tracking all activities of users.

Network Access System
RadSense can create a Network Access System to manage different networks from a single server. Different networks in any organization are a common thing nowadays. It helps the organizations to keep privacy among the different users, and moreover in case of security breach, there is a possibility that some of the networks will be kept safe with recommended security measures. The researcher from Ghana (Bahram and Godwin Ponsam 2020) also concluded the

network access controls must comply with local area network (LAN), firewall types, LAN standards, LAN security, network access control (NAC) and access control models. The developed application has all the features to make the access control mechanism more convenient for the network administrators. We can create new networks and delete existing ones in the RadSense application.

5 Results and Discussion

The research carried out in this paper has demonstrated the method to configure the pfSense captive portal and a local Radius server for authenticated users on a wired and wireless network. The developed application has been integrated on the network to help the network administrators using UI design. The implementation of the current system will secure the user credentials using the AAA mechanism along with a cost-cutting solution over a commodity hardware solution (Fig. 2).

A user connected to the network is assigned an IP address by the Dynamic Host Configuration Protocol in the pfSense, and any Web request from the user is redirected to the captive portal page. Only legitimate users with the correct login credentials can gain access to the Internet. Once the user is provided with authentication, the captive portal stops the redirection of further requests of the user. The current system is working fine on a machine with normal configuration. For the validation of the proposed solution, it has been successfully tested at Alakh Prakash Goyal Shimla University, Shimla, Himachal Pradesh, India, over a network of 2500 users. Once the user will logon to the system, it will be able to access the network resources. The uniqueness of the designed system is that it has the logout parameter for the users which are not present in the earlier designed systems. After the implementation of the proposed solution, the following results have been achieved:

- The whole solution is implanted on a commodity hardware platform which is unique in case of existing systems as they have been implemented only on the commercial servers and applications.
- The Web UI design makes the solution different from available solutions. The existing systems are still using the pfSense interface to manage the users which is not a very efficient way to manage the users.
- The database integration has been done with the Maria DB server which is a lightweight application of database management servers.
- The effective session management especially session termination for the users was not available in the earlier applications developed in this field. This paper has come up with this solution to the users and administrators.
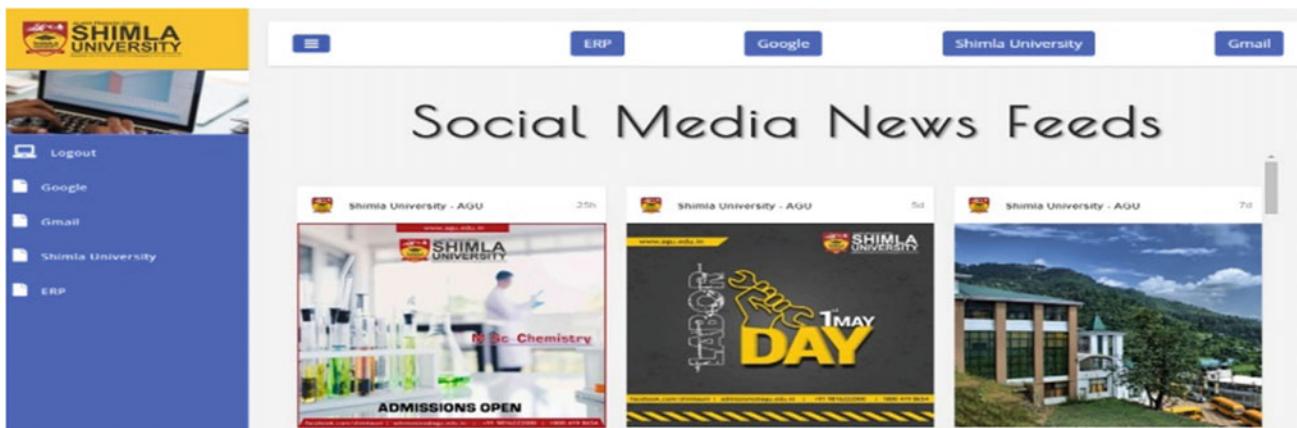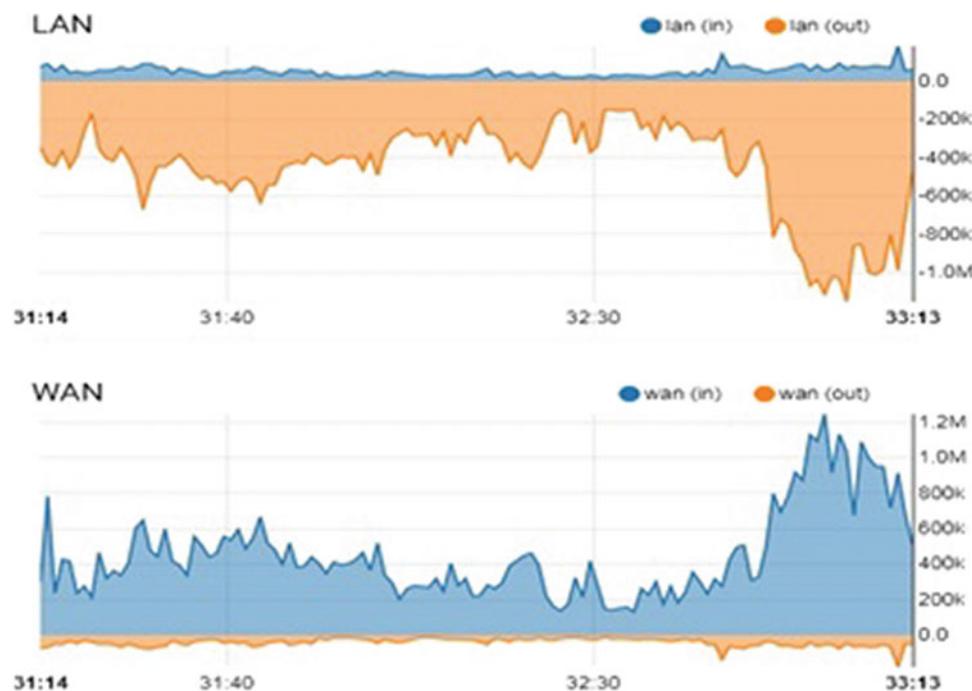
Fig. 2 User front end page on RadSense

Fig. 3 LAN traffic graph over 100 Mbps speed of network

The developed application is optimized in a way that it can run on normal personal computers. The performance of the users on the network can be analyzed from the traffic graphs. The Traffic graphs keep the track of various bits of data about how the system performs and then stores this data in the database in a round-robin fashion. The traffic graph shows all the real-time information of all traffic flow on a scrupulous interface. It shows how much bandwidth is used by an interface. Traffic graph helps in monitoring incoming and outgoing traffic. The traffic graph or RRD graphs are given below (Fig. 3):

The user control over the network in the organizations is an important aspect these days. The user-based network policies will help the organizations with the management of current resources as well as their future network plans. With the help of AAA mechanism of pfSense, the developed application can help the network administrators to keep an eye on the resources used by the current users (Fig. 4).

Challenges faced during the Implementation: The work was implemented on a commodity machine, so the optimization of the firewall was a little challenging, but it was done with the optimized algorithms. Another challenge was to test it on real test beds. It took around 6 months to test it and get the results.

Measuring for 1 min, 10 secs, **since** 2019-06-03 11:12:34 IST+0530.
Seen 33,622,124 **bytes, in** 48,703 **packets.** (49,905 **captured,** 0 **dropped)**

in ■ min: 10.5 KB/s, avg: 424.1 KB/s, max: 1575.1 KB/s
out ■ min: 7.9 KB/s, avg: 28.0 KB/s, max: 65.8 KB/s
last 60 seconds

in ■ min: 202.3 KB/s, avg: 8.4 KB/s, max: 301.0 KB/s
out ■ min: 11.8 KB/s, avg: 0.5 KB/s, max: 21.1 KB/s
last 60 minutes

in ■ min: 8.4 KB/s, avg: 0.3 KB/s, max: 8.4 KB/s
out ■ min: 0.5 KB/s, avg: 0.0 KB/s, max: 0.5 KB/s
last 24 hours

in ■ min: 0.3 KB/s, avg: 0.0 KB/s, max: 0.3 KB/s
out ■ min: 0.0 KB/s, avg: 0.0 KB/s, max: 0.0 KB/s
last 31 days
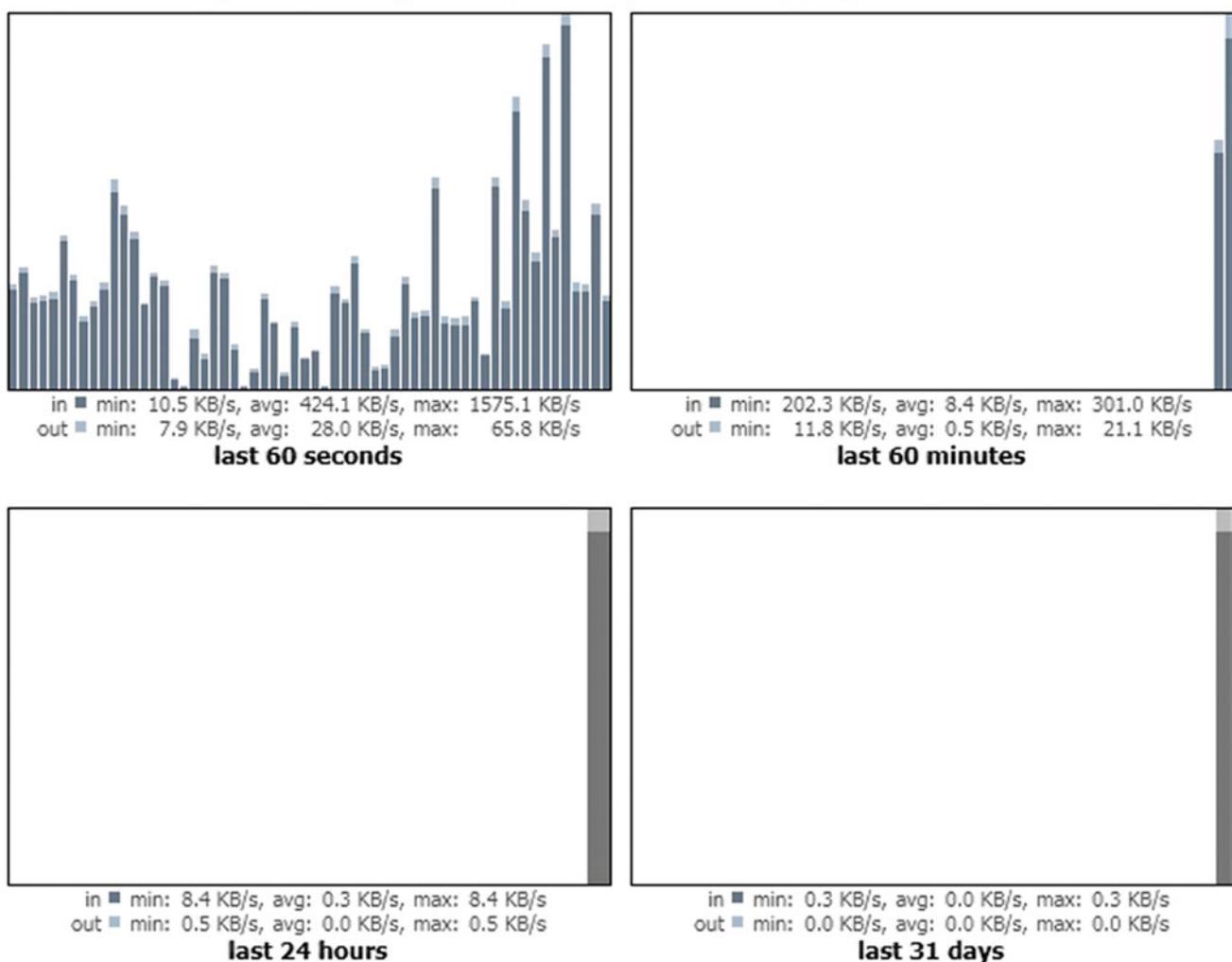
Fig. 4 User-based graphs generated by the developed application

6 Conclusion

The security and compatibility over the cost-effective hardware platforms are two main aspects of today's computing. The use of open source applications over the commodity hardware platforms is becoming a popular trend in today's computing industry. As per the objectives of this research, the researchers have successfully integrated the pfSense, MySQL and Radius on a single platform, where all can be managed from an application "RadSense" with its own feature. Moreover, all the system is working on commodity hardware resources which can reduce the extra cost on the organizations. The captive portal interfaces the firewall services with the user and services database stored in the MySQL server with the accounting system of Radius. The accounting system will track the unusual activities of the users on the network and keep the track in the database. All the three objectives of this research have been accomplished, and the user-friendly application has been tested on the network of 2500 users in the promises of Alakh Prakash Goyal Shimla University over the 40 mbps network of speed with three different user groups. The system has the capability to manage all the resources available on the network so in the future scope of this research project, researchers can enhance the application in a way from where all the available resources can be managed from a single window. In the future, the work can be done on managing the network devices with the central server in case of device failures.

References

Aryeh, F. L., Asante, M., & Danso, A. E. Y. (2016). Securing wireless network using pfSense captive portal with RADIUS authentication. *Ghana Journal of Technology, 1*(1), 40–45.

Bahram, F., & Godwin Ponsam, J. (2020) Securing network using PfSense technology. *International Journal of Advanced Science and Technology, 29*(05), 9667–9675. Retrieved from http://sersc.org/journals/index.php/IJAST/article/view/19431

Binti, O. R. (2017). *Network monitoring using captive portal in pfSense*. Abidin: Faculty of Informatics and Computing, University of Sultan Zainal.

Campbell, R. (2019). *How to: pfSense admin logins via RADIUS using Active Directory Accounts*. https://community.spiceworks.com/how_to/128944-pfsense-admin-logins-via-radius-using-active-directory-accounts.

Donoghue, J. (2019). *Firewalls with pfSense Software: What are they and why should i use one*. https://www.logicsupply.com/company/io-hub/pfsense-firewalls-what-are-they-and-why-should-i-use-one/.

Kishore, K., & Sharma, S. (2013). Information security & privacy in real life—threats & mitigations: A review. *International Journal of Computer Science and Technology, 4*(3).

Kumar, D., & Gupta, M. (2018). Implementation of firewall & intrusion detection system using pfSense to enhance network security. *International Journal of Electrical Electronics & Computer Science Engineering, 1*(Special Issue 2018), P-ISSN: 2454-1222.

Mamat, K., & Ruzana, M. (2013). Home wireless network security using pfSense captive portal. In: *Proceedings of 8th International Conference on IT*, Asia.

Nahid Kausar S, Poonam D and Shruti A (2018) A Survey on Network Firewall Solutions. Journal of Engineering practices and Futuristic Technologies, 2018; Volume 1, Issue 1, ISSN 2581-6594.

Naik, P., Kanase, A., Patel, A., & Vutukuru, M. (2018). libVNF: Building virtual network functions made easy. In *Proceedings of ACM Symposium on Cloud Computing*, Carlsbad, CA, USA.

Patel Krupa, C., & Sharma, P. A. (2017). Review paper on pfsense—an Open source firewall introducing with different capabilities & customization. *International Journal of Advance Research and Innovative Ideas in Education, 3*(2), 635–641.

Sharma, R., & Parekh, C. (2017). Firewalls: A study and its classification. *International Journal of Advanced Research in Computer Science, 8*(4), ISSN 0976-5697.

Sharma, G., Sharma, S., & Singh, S. (2011). Secure efficient management of Resources in Local and Wide Area Networks. In: *Proceedings of National Conference on Challenges in Information Systems and Technology*, Delhi, India.

Sylvester, A., Asante, M., & Twum, F. (2016) *An improved computer network access control using Free BSD PFSENSE: A case study of UMaT Local Area Network* (Vol. 6, No. 1). New York: Foundation of Computer Science FCS.

Tittel, E. (2012). *Unified threat management for dummies*. Hoboken, New Jersey: Wiley, p. 153.

User Management and Authentication, Authentication Servers. https://docs.netgate.com/pfsense/en/latest/book/usermanager/usermanagement.html.

Vorkbaard, K. (2019). *Set up OpenVPN on PfSense with user certificates and active directory authentication*. https://vorkbaard.nl/set-up-openvpn-on-pfsense-with-user-certificates-and-active-directory-authentication/.

Hybridization of Energy-Efficient Clustering and Multi-heuristic Strategies to Increase Lifetime of Network—A Review

Deepak Sharma and Bhavna Arora

Abstract

Wireless sensor network has significant applications but few flaws also exist. The flaw of sensor energy consumption requires to be tackled. The sensor is an integrated component of WSN that is used to collect data and then store within the data store. Sensors have limited energy associated with them. Conserving energy so that data collection can be prolonged is discussed through this paper. There are many mechanisms including LEACH, DEEC, MDEEC, EDEEC, etc., and all these mechanisms conserve energy but optimization in each protocol is missing. Problems associated with listed protocols are discussed, and mechanisms used to overcome the problems are also briefed. Nodes collaborating form clusters. Data transmission takes place from distinct clusters toward the base station. The energy of sensors needs to be preserved to enhance the lifetime of the network. This paper presents an overview of various existing meta-heuristic techniques used to enhance the lifetime of the network. The multi-heuristic algorithms are chosen because it optimized energy of sensors or prevented from deterioration. The degradation is indicated in terms of packet drop ratio for determining network bandwidth. The analysis of some popular protocols has been done in this paper which can be used for future enhancements. DEEC protocol is best of all and can be used for optimization purposes. Energy efficiency predictions will be better in case sensors and can consume less energy.

1 Introduction

WSN provides mechanisms to transmit the packets from the source to the sink node (Kumar 2014). Combining multiple techniques gives rise to fog computing. In today's world, the user uses sensor services to store data of nodes and assign them with unique ids. This means data of nodes can be accessed anytime anywhere. As more and more data collected together to form a large dataset, certain filtering mechanisms are required to fetch data incorrectly way. Data mining subsequently comes into casing and structures the basic piece of data getting an instrument. To get to administrations from WSN clients must have an account with a sensor specialist organization, and the client requires to pay as indicated by administrations they get to Tiwari and Roy (2015). The building block of this structure is sensors. Sensors are used to sense abnormal data from the client. These sensors can be attached through electronic equipment's, etc. Sensors consume energy as data is transmitted from the source station toward the destination station (Kumar 2014; Cheikh et al. 2014). Energy conservation is critical as loss of energy causes loss of data packets. Also, the lifetime of the network decreases considerably due to energy loss. In a wireless sensor network, throughput is the main parameter that is to be enhanced using LEACH, DEEC, EDEEC, etc., mechanism. In addition to these mechanisms, there is also an asleep and wake protocol that causes sensors to shut off if it is not used for a long period of time. As soon as sensor services are required, the wake-up mechanism puts the sensor to work leading to the conservation of energy. All of these mechanisms are discussed in Sect. 2.

D. Sharma (✉) · B. Arora
Department of Computer Science and Information Technology,
Central University of Jammu, Jammu and Kashmir, India
e-mail: dsdeepaksharma739@gmail.com

B. Arora
e-mail: bhavna.aroramakin@gmail.com

Another critical component is the sensor in which data storage is performed. Information about sensors corresponding to nodes is stored at a centralized location within the sensor. To access sensor services, the client must have direct access to resources. To this end, a sensor service subscription is required. Once the subscription is performed, the service level agreement (SLA) is established. Service level agreements cannot be violated by the client and service provider.

User smart devices send the data toward the controller, and the controller has access to the sensor. To transfer and receive data from the sensor, the client account with the service provider is verified. Once verification succeeds, then information access is granted to the controller. In this case, local devices are nodes and the controller acts as a cluster head and sensor storage section along with information retrieval point at sensor center acts as a base station.

The rest of the paper is described as under: Sect. 2 provides in-depth into different mechanisms that can be used to conserve the energy of sensors, Sect. 3 gives a comparative study of techniques, Sect. 4 gives conclusion and future scope and the last section gives references.

2 Sensor Energy Conservation Mechanisms

Considering energy efficiency during data transmission from node side to the base station is a state-of-the-art problem. Leading technologies in terms of both hardware and software are considered to maximize the lifetime of the network. This section briefly describes the mechanism used to provide energy efficiency during data transmission.

2.1 LEACH

Razaque et al. (2016) and Prasad et al. (2018): LEACH is a low energy adaptive clustering protocol. This is a hierarchical protocol that is used to conserve energy during data transmission. Nodes (clients) transfer data to the cluster head (controller), and aggregated packets at base stations are compressed and transmitted toward the base station. The stochastic algorithm is followed by nodes to determine whether it becomes a cluster head or not. Nodes that have become cluster head cannot become cluster head again for P rounds, and each node has a 1/P probability of becoming a cluster head. TDMA approach is used by nodes to communicate with each cluster head. There are different approaches followed by researchers to enhance LEACH protocols that are given in Table 1.

2.2 DEEC

A distributed energy-efficient clustering protocol is used to enhance energy efficiency that is not possible through the LEACH protocol. The DEEC protocol is based on selecting multiple cluster heads in one round rather than a single cluster head per round, thereby increasing the rate at which packets are transferred toward the destination. DEEC protocol is worked upon by researchers as described in Table 2.

2.3 MDEEC

Modified DEEC approach uses power-based and distance-based approach for forming clusters. Data will be transmitted from multiple cluster heads to base station and hence rate at which data is transmitted enhanced greatly. Cluster head once selected is neglected from cluster head list. Every node present within cluster can be selected with 1/p probability. Table 3 describes MDEEC protocol enhancement mechanisms.

3 Optimization Mechanisms for Selecting Optimized Sensors for Data Transmission

Optimization mechanism ensures the selection of nodes (sensors) that could improve performance in terms of the rate at which data is transmitted and received. This communication mechanism ensures the transfer of information to the desired sensor center and then information from the center of the sensor to the client side. This section describes optimization mechanisms as under:

3.1 Genetic Algorithm

Elghirani et al. (2018): This is one of the oldest and best approaches for achieving the best in the class objective-based result. This process uses a modular approach that reduces complexity in achieving the desired objective function. This is an iterative approach and increases execution time in achieving the desired result. Different phases associated with GA are discussed as under:

Initialization This phase is the first phase and perhaps the most important one since it is used to initialize the population from which data for operation is selected. This process is also known as the population selection mechanism. Based on sensor prediction, the population can be a collection of

Table 1 LEACH protocol enhancement mechanism

References	Technique	Advantage	Disadvantage
Joshi et al. (2017)	LEACH	Energy-efficient and secure mechanism since cluster head selection considers not only energy efficiency but also CH vicinity with symmetric key integration	Distance between cluster heads is not considered causing early decay of the network.
Mahajan (2014)	Cluster chain weight metrics approach	It reduces the overhead of the network but also reduces the communication cost.	Load distribution is high
Amgoth et al. (2015)	ERA	It saves energy as each node decides itself to join a CH by considering both the residual energy of the CHs and the distance	Not fault tolerant
Razaque et al. (2016)	P-LEACH	Node that has maximum energy is selected as cluster head so it is energy efficient	Communicate overhead does not handle efficiently

Table 2 Comparison of DEEC enhanced approaches

References	Technique	Advantage	Disadvantage
Tiwari and Roy (2015)	The varying power-based clustering algorithm	Clustering algorithm employed saves energy, and packet drop ratio is considerably reduced	Packet drop ratio can be further reduced by employing additional memory with sensors
Kumar (2014)	Performance evaluation of DEEC	Performance of DEEC, EDEEC, TDEEC and other clustering protocols is analyzed. This approach identifies the best possible approach to clustering as TDEEC	A memory-based clustering approach is not suggested
Saini and Sharma (2010)	EDEEC	Enhanced DEEC considers energy to declare node as cluster head. Higher degree of packets able to reach destination using this approach	Memory-based clustering approach is missing, causing degradation of lifetime of network

Table 3 MDEEC enhancement and future enhancement

References	Technique	Advantage	Disadvantage
Preethi et al. (2016)	MDEEC	Is modified distributed clustering protocol in which energy efficiency is achieved	MDEEC without memory efficiency causes lifetime degradation
Chand et al. (2014)	Heterogeneous DEEC	Nodes with different configurations can be selected as cluster head	Priority queue can be established in the future to decrease packet drop ratio

sensors with varying distance$\{x1, x2, x3, xn\}$. The random selection process can be used for the selection of sensors. The next phase evaluates fitness function and checks optimized value obtained after evaluation.

Fitness function evaluation It assigns a fitness value to each node. The probability that an individual is going to be selected depends upon the fitness score.

Selection This phase selects individual having the highest fitness score and lets them pass to the next phase or generation for evaluation. Two pairs of individuals (parent) are selected based on fitness scores. An individual having the highest fitness score is likely to be selected for reproduction.

Crossover This is the most significant phase that is used to decide crossover point at random from within chromosomes.

Offspring are generated by combining genes up to crossover point, and the new population is generated for evaluation.

Mutation This phase is critical and is used to maintain diversity within the population so that convergence can be achieved within a fixed interval of time. The mutation is required of offspring having low random probability. Gene mutation allows optimized results in terms of the objective function.

3.2 Ant Colony Optimization(ACO)

Ant colony optimization (ACO) is another multi-heuristic approach that is used to achieve a better result in terms of optimization function. It is commonly used to solve computational problems. ACO is based upon the properties of

ant's communication mechanism. Ant colony optimization (ACO) is the generation-based algorithm used to determine the problems and optimized solution using the local and global best solution. The ant colony optimization mechanism uses the approach of metaheuristic and finds the solution based on practical ant movements (Wen et al. 2015). ACO has a problem that convergence is slow in nature. To tackle the issue, mutation and crossover can be accommodated within the ant colony algorithm. This scenario includes a hybrid sensor, multi-sensor and aggregate sensor. ACO provides an efficient mechanism to tackle the problems of the sensor where resource optimization is critical.

3.3 Particle Swarm Optimization(PSO)

PSO in image segmentation plays a vital role in minimizing the makespan and flowtime. Particle swarm optimization procedure uses particles as chromosomes. These chromosomes utilize the properties of their parents. The feature extracted becomes mutated in the mutation phase to yield the best possible solution. Reduce makespan is the problem that arises due to the aging of the image segmentation. A set of preventive techniques are utilized to prevent this situation. Initially, it is necessary to classify the faults occurring within the software system. An analytical approach is applied to determine the optimal number of times rejuvenation is required. The accuracy of modeling is determined using metrics such as root-mean-square error and absolute error.

These mechanisms incorporated within the energy conservation of sensors could lead to optimizing results in terms of the lifetime of the network. Also, mechanisms are iterative that could give the best possible holdout rate meaning more packets could be transmitted toward the base station. The next section presents a comparison of different protocols indicating the best possible mechanism for future enhancement.

4 Comparative Study of Techniques of Energy Conservation

Energy conservation mechanisms are researched over but some of them are highlighted in Table 4.

5 Conclusion and Future Scope

This literature provides the in-depth into techniques that can be used to increase the lifetime of the network. To accomplish this objective, multi-heuristic mechanisms can be incorporated within the existing protocol such as a distributed energy-efficient clustering mechanism. The clustering mechanism can be incorporated with a priority queue. Packets dropped due to aggregation and loss of energy from cluster head can be stored within this queue. The priority of the packet can be determined depending upon the order in which the packet arrived within the system. Besides, cluster

Table 4 Techniques used for energy conservation of sensors

Protocol	Year	Merits	Demerits	Remarks
SLGC (El Fissaoui et al. 2017)	2017	• Lower energy consumption in SGLC compared to LEACH	• Large overhead due to complex data communication	It is distributed energy-efficient consumption and distribution protocol
CCM (Ibragimov et al. 2016)	2016	• Energy consumed in the selection of cluster head is less as compared to LEACH	• Chain head selection is complex and has more overhead associated with it	A mixture of flat, hierarchical and location-based routing is combined
GAF (Arioua et al. 2016)	2016	• GAF increases the network lifetime by saving energy • Routing fidelity is maintained	• Large traffic injection and delay are not predictable	It is a location-based least energy consumption protocol
TDEEC (Preethi et al. 2016)	2016	• Modified DEEC clustering protocol provides better performance in terms of energy consumption than DEEC	• Slotting is used; hence, it is more complex	DEEC with time division is considered; hence, overall operation is faster
LEACH (Li et al. 2017)	2015	• Every node in a cluster may become cluster head depending upon the amount of energy node possessed • Collisions are avoided since LEACH protocol is accompanied by time division multiple access mechanism	• Difficult to implement in large networks • Lack of uniformity in the selection of cluster head	The earliest protocol associated with clustering

(continued)

Table 4 (continued)

Protocol	Year	Merits	Demerits	Remarks
PANEL (Discipline 2015)	2015	• The panel is energy efficient that ensures load balancing and long network lifetime • Supports asynchronous applications	• Clusters are predetermined • To determine the geographic position information, special conditions are needed, which is not always available	This is an efficient node selection algorithm for handling cluster
TTDD (Rohankar et al. 2015)	2015	• Resolve the numerous mobile sinks and moving problem of the sink in large-scale WSNs • Suitable to event detecting WSNs among irregular data traffic	• Large latency • Low energy efficiency • TTDD requires sensor nodes to be stationary and location-aware	It is a two-tier energy consumption minimization protocol
PEGASIS (Science et al. 2015)	2015	• Uniform load balancing • Reduce cluster head selection overhead • Packet drop ratio decreases	• High delays in transmission • Scalability is the least • Time-varying topologies make it complex to use	Load balancing is handled efficiently in this protocol as compared to LEACH
TSC (Xu and Zhao 2015)	2015	• Redundant data is reduced	• Asymmetric node balance	Modularity is provided by dividing the network into concentric circles; hence, better energy consumption is achieved
PASCCC (Jan et al. 2014)	2014	• Priority-based data transformation • Packet drop ratio is low	• Energy consumption is high	Priority is assigned but the starvation problem can be present
SEP (Pal et al. 2013)	2013	• It is better in terms of packet drop ratio	• More complex as compared to LEACH	Energy consumption is less as compared to previous algorithm
LEACH- VF (Singh and Singh 2014)	2010	• Solve the problem of the area with overlapped sensing coverage and sensing hole • In LEACH-VF, some nodes can be moved to coverage inside the cluster	• Poor energy efficiency • Load balancing is not up to the mark	Area independence is achieved
TEEN (Ibrahim and Tamer 2016)	2010	•Data transmission can be controlled by varying two thresholds •Well suited for time critical applications	•Whenever thresholds are not meet , the node will not communicate •Data may be lost if CHs are not able to communicate with each other	Hierarchical routing protocol that is used to minimize energy consumption of clustering algorithm
HEED (Liu et al. 2009)	2009	•Routing Scheme used is fully distributed •Local Communication is supported for least complexity •More uniform in nature •High Energy Efficiency and reliability	•Communication Overhead is high due to random cluster head selection •Extra Energy consumption in selection of cluster head	Better connectivity of cluster heads
EECS (Shang 2009)	2009	•Achieve Load Balancing •Clusters are variable in size	•Communication overhead is high •Energy Consumption is exceedingly high	Energy efficient protocol used commonly at media access control layer within data link layer
DEEC (Shah et al. 2016)	2009	•Dynamic node selection •Better than Leach in terms of energy consumption	•Complex in nature •Lifetime can be further improved	Better as compared to LEECH
UCS (Ozdemir 2007)	2007	•Cluster head formed are heterogeneous •Variable sized clusters	•Limited Implementation framework •Residual energy is low	Commonly used protocol in unequal cluster sized environment
CCS (Advisor and Committee 2007)	2007	•Least Energy Consumption •Packet drop ratio decreases	•Asymmetric Energy Consumption •Time duration is high	It is network coding based protocol for energy efficiency

head selection can be done with a multi-heuristic approach to optimize the mechanism of cluster head selection. In the future, all of the suggested strategies can be tested using the tools of networking like NS3 or standardized tools provided with the help of MATLAB.

References

Advisor, D., & Committee, D. (2007). *Communication security in wireless sensor*. Berlin: Springer.

Amgoth, T., Jana, P. K., & Thampi, S. (2015). Energy-aware routing algorithm for wireless sensor networks. *Computers and Electrical Engineering, 41*(C), 357–367.

Arioua, M., Assari, Y., Ez-zazi, I., & Oualkadi, A. (2016). Multi-hop cluster based routing approach for wireless sensor networks. *Procedia Computer Science, 83*, 584–591.

Chand, S., Singh, S., & Kumar, B. (2014). Heterogeneous HEED protocol for wireless sensor networks. *Wireless Personal Communications, 77*(3), 2117–2139.

Cheikh, E., Saad, C., Mostafa, B., & Abderrahmane, H. (2014). Energy efficient enhancement of TDEEC wireless sensors network protocol based on passive RFID implementation. *Springer, 3*(5), 6647–6653.

Discipline, C. (2015). 6dqwdu 3do 6lqjk. *IEEE Access, 45*, 687–695.

El Fissaoui, M., Beni-hssane, A., Saadi, M. (2017). Mobile agent protocol based energy aware data aggregation for wireless sensor networks. *Procedia Computer Science, 113*, 25–32.

Elghirani, A., Subrata, R., Zomaya, A. Y., & Al Mazari, A. (2018). Performance enhancement through hybrid replication and genetic algorithm co-scheduling in data grids. In *16th IEEE/ACS International Conference on Computer Systems and Applications*, pp. 436–443.

Ibragimov, M., Lee, J., Kalyani, M., Namgung, J., Park, S., Yi, O., Kim, C. H., & Lim, Y. (2016). CCM-UW security modes for low-band underwater. In *Wireless Personal Communications*. IEEE.

Ibrahim, A. A., & Tamer, A. K. (2016). SEC-TEEN : A secure routing protocol for enhanced efficiency in wireless sensor networks. In *IEEE Access*, pp. 621–631.

Jan, M. A., Nanda, P., He, X., & Liu, R. P. (2014). PASCCC: Priority-based application-specific congestion control clustering protocol. *Computer Networks, 74*, 92–102.

Joshi, J., Rathod, J., & Wandra, K. (2017). Performance enhancement of LEACH for secured data transmission. *IEEE Access, 10*(May), 2–5.

Kumar, R. (2014a). Evaluating the performance of DEEC variants. *IEEE Access, 97*(7), 9–16.

Kumar, S. (2014b). DE-LEACH: distance and energy aware LEACH. *IEEE, 88*(9), 36–42.

Li, P., Jiang, W., Xu, H., & Liu, W. (2017). Energy optimization algorithm of wireless sensor networks based on LEACH-B. In *IEEE Access*.

Liu, M., Cao, J., Chen, G., & Wang, X. (2009). An energy-aware routing protocol in wireless sensor networks. In *IEEE*, 445–462.

Mahajan, S. (2014). An energy balanced QoS based cluster head selection strategy for WSN, Egypt. *Informatics Journal, 15*(3), 189–199.

Ozdemir, S. (2007). Secure and reliable data aggregation. In *IEEE Explore*, pp. 102–109.

Pal, R., Sindhu, R., & Sharma, A. K. (2013). *SEP-E (RCH): Enhanced stable election protocol based on redundant cluster head selection for HWSNs* (pp. 104–114). Berlin: Springer.

Prasad, D. R., Naganjaneyulu, P. V., & Prasad, K. S. (2018). Modified LEACH protocols in wireless sensor networks—A review. In *IEEE Access*, pp. 681–688.

Preethi, A., Pravin, E., & Sangeetha, D. (2016). Modified balanced energy efficient network integrated super heterogeneous protocol. In *2016 International Conference on Recent Trends in Information Technology. ICRTIT 2016*.

Razaque, A., Abdulgader, M., Joshi, C., Amsaad, F., & Chauhan, M. (2016). P-LEACH: Energy efficient routing protocol for wireless sensor networks. In *2016 IEEE Long Island Systems, Applications and Technology Conference*, pp. 1–5.

Rohankar, R., Katti, C. P., & Kumar, S. (2015). Comparison of energy efficient data collection techniques in wireless sensor network. *Procedia Computer Science, 57*, 146–151.

Saini, P., & Sharma, A. K. (2010). E-DEEC—Enhanced distributed energy efficient clustering scheme for heterogeneous WSN. In *2010 First International Conference on Parallel, Distributed and Grid Computing, PDGC—2010*, pp. 205–210.

Science, P. C., Authors, T., This, E. B. V., By-nc-nd, C. C., Chairs, C. P., Authors, T., This, E. B. V., By-nc-nd, C. C., & Chairs, C. P. (2015). vol. 52, pp. 641–646, 2015. Available online at www.sciencedirect.com.

Shah, T., Javaid, N., & Qureshi, T. N. (2016). Energy efficient sleep awake aware (EESAA) intelligent sensor network routing protocol. In *IEEE Access*, pp. 1–6.

Shang, F. (2009). A single-hop active clustering algorithm for wireless. In *IEEE Access*, pp. 397–406.

Singh, A., & Singh, A. K. (2014). *Clustering protocol for wireless networks* (365–374). Amsterdam: Elsevier.

Tiwari, T., & Roy, N. R. (2015). Modified DEEC: A varying power level based clustering technique for WSNs. In *2015 International Conference Computer Science. ICCCS 2015*, pp. 170–176.

Wen, W., Wang, C., Wu, D., Xie, Y. (2015). An ACO-based scheduling strategy on load balancing in sensor computing environment. In *IEEE Access*.

Xu, Q., & Zhao, J. (2015). Multi-head track-sector clustering routing algorithm in WSN. *ACM*, 707–713.

Data Acquisition Using IoT Sensors for Smart Manufacturing Domain

Pooja Kamat, Malav Shah, Vedang Lad, Priyank Desai, Yaj Vikani, and Dhruv Savani

Abstract

The Internet of things (IoT) showed gigantic development in recent trends of industrial, medical and environmental applications. Due to the huge computational power in the cloud, opportunities for complete industrial device automation have emerged. The uninterrupted monitoring and beforehand fault detection of the machines build efficient process control in the automation process. Analysing data acquired from various IoT sensors with the help of suitable data processing algorithms combined with artificial intelligence (AI) can help achieve predictive maintenance of industrial equipment, production lines as well as home appliances. This will significantly help in improving the service life of appliances as well as reduce the servicing cost by diagnosing active faults. This research paper focuses on developing an IoT-based fault detection system by connecting various sensors to the equipment and capturing their data using the sensors and storing them in the cloud platform for further analysis. Further data analytics applied on the accumulated sensor data can be useful to carry out predictive maintenance of the equipment.

Keywords

IoT • Predictive maintenance • Fault detection • Industry 4.0

1 Introduction

Today, Internet of things is being considered as the second most important advancement in technological world after Internet. It is a type of intelligent system that connects many devices to the Web so that they can communicate and exchange information with each other. Many mechanical industries are currently using IoT for achieving their goals and in increasing their efficiency. IoT can also be seen to play an important part in the environment as well as medical fields. The paper is organized as follows: the following subsections provide further introduction to usage of IoT devices in fault detection and predictive maintenance in machinery.

1.1 Introduction to Fault Detection in Manufacturing Machines

A product manufacturing process consists of various sequential steps. The manufacturing assembly for a product consists of multiple machinery set-ups that works for an extended period. The most elusive yield issues in such huge assembly lines can be intermittent machinery or component failures that randomly occur over time (Iqbal et al. 2019). There is no perceptible consistency in the inability of occurring events, and they happen randomly. It becomes too time-consuming and negatively impacting to find out the faults manually in such huge manufacturing lines (Okaro et al. 2019).

Alternatively, if faulty equipment keeps on running, it may lead to the production of defective products, or it may further damage itself. Due to the incompetence in diagnosing the failure of machines, safety accidents are prone to occur frequently (Kim et al. 2019). An unexpected failure may result in a devastating accident and financial losses depending on the interaction among industrial equipment. This, in turn, may lead to massive loss to industry in terms of

P. Kamat (✉) · M. Shah · V. Lad · P. Desai · Y. Vikani · D. Savani
Department of Computer Science and Information Technology, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune, 412115, India
e-mail: pooja.kamat@sitpune.edu.in

money, labour and time. Such losses can be prevented by applying techniques like predictive maintenance (He et al. 2019). Early detection and maintenance can help in avoiding the faults that turn into critical problems.

1.2 Introduction to Predictive Maintenance

Predictive maintenance for the industry is a technique used for preventing machine failures by analysing data and patterns to identify the faults beforehand (Sang et al. 2020). Predictive maintenance has shown a lead in a rise in investment return, around 25–30% decrease in maintenance costs, 70–75% reduction in breakdowns and 35–45% decrease in downtime (Fiix. Predictive maintenance. https://www.fiixsoftware.com/maintenance-strategies/predictive-maintenance/). Various technologies, like IoT and cloud platforms combined, help develop predictive maintenance systems.

Cloud computing is the accessibility of computer system resources without direct supervision by the user, especially computing power and data storage. It is mainly used in describing data that is available to a large number of users through the Internet. Nowadays, cloud computing is providing a boost to support IoT by providing computational power which can be dynamically changed according to the requirement (Annamalai et al. 2019).

For collection of data from the mechanical devices, multiple sensors having different functionality are being used. A few of them include temperature sensor, humidity sensor, and accelerometer and vibration sensor. With the help of IoT, we can collect this data accurately and quickly. Combining IoT and cloud computing can be useful in monitoring different services and processing the obtained data for further analysis and computing (Compare et al. 2019).

Artificial Intelligence enabled techniques when applied on mukti-sensor data can assist in performing predictive maintainence of machinery by early detection of faults thereby improving the service life of the machinery (Lee et al. 2019).

1.3 Introduction to Internet of Things (IoT)

The Internet of things can be considered as an intelligent system that interconnects various machines, devices or objects each of which has unique identifiers. They are also capable of conveying data or instructions without the need of any computer or human intervention.

The meaning of IoT has advanced because of the union of various innovations, real-time analytics, machine learning (ML), sensors and embedded systems. Standard fields of remote sensor systems, control structures, embedded systems and robotization add to authorizing the IoT (Bhatter et al. 2020). The manufacturing developments have great significance in the economic development of many countries, and the constant claim for better efficiency with higher quality at a cheaper rate is an important topic these days.

Also, because of the inefficiency in analysing the faults of mechanical hardware in time, relating security mishaps happen quite frequently (Killeen et al. 2019). In an IoT domain, countless mechanical machine data can be gathered in a brief time frame. Many different sensors like temperature and humidity, vibration, acceleration, etc., have been utilized, or various sensors of a similar sort have been consolidated to gather constant operational status information identified within the various pieces of mechanical hardware (Sahal et al. 2020). Given the IoT along with cloud storage and analysing the data collected can significantly increase the accuracy of detecting faults beforehand, this has become a profoundly applicable research subject.

The Internet of things or IoT is never again exploratory; it is standard. Organizations are grasping it for a severe edge and creative contributions. In principle, IoT is the idea of giving machines, objects or individuals the capacity to naturally move information to a system without any correspondence from the PC.

IoT is presently allowing organizations to make smart products, empower improved activities and assist with improving business choices driven by data analytics (Plaza Bonilla et al. 2019). It can alter how organizations follow and oversee business work processes.

2 Literature Review

Dhamandea and Chaudhari (2018) in their research have tried to extract faults in compound gear-bearings. As mentioned in their paper, they have tried to utilize time–frequency method. By using this method, they have experimentally measured the compound deficiencies. Such deficiencies help in finding out faults within the external as well internal parts of the bearing together. Faults like two or three teeth of the gear having corner damage can be easily found out with this. Vibration estimation was done at distinctive speed and load conditions with the help of vibration sensors to improve the effectiveness of the diagnosis (Dhamande and Chaudhari 2018).

Glowacz and Glowacz (Vibration-Based Fault Diagnosis of Commutator Motor, 2018) have researched about fault detection in electric motors based on a commutator. They have tried to determine faults using vibration signals generated by vibration sensor and acoustic sensor. After analysing various vibration signals, they have tried to classify the states of the motor in three distinct categories, namely a healthy working motor with no faults, a motor with a sprocket or tooth damage or a motor where the rotor coil is damaged (Zhao et al. 2019).

Glowacz (Acoustic based fault diagnosis of three-phase induction motor 2018) in his research has written about detection of faults in induction motor with 3 stages. He has utilized acoustic sensors to screen four states of the 3-phase induction motor. These states include a solid induction motor, a motor which has a flawed squirrel cage ring, a motor which has its rotor bar damaged and a motor which has its two rotor bars with a flaw or broken. The achieved results helped develop a fault detection method using acoustic signals (Glowacz and Glowacz 2018).

Pérez et al. (2019) have researched in the field of designing IoT circuits which can be used for monitoring the health of refrigerators that are majorly used for cold chain purposes. They have mentioned about smart monitoring designs using Sigfox and IoT-based sensors. An IoT-based PCB is also outlined in their paper to detect faults in refrigerators that use routine compressors as well as non-inverter technology. Around two thousand refrigerators and coolers that are a part of cold chain were monitored. Sigfox has been used to wirelessly communicate and send data to the servers of the cloud service. The system monitored various aspects which include measure of the internal temperature of the freezer and measure of the power consumption inclusive of voltage and current. It also helped in controlling the compressor with an alarm system for operational failures. It is a low-cost system which can be utilized in routine temperature control systems. The most important part of the circuit is the temperature sensor (Li et al. 2020).

Mahajan et al. (2017) have surveyed the emerging research work on IOT based on home and kitchen appliances and created a smart refrigerator that enables on/off control through mobile application, details of the items to be ordered, indication when ice is ready, detects volume of liquid in bottles, alert system when hot items are placed, energy saving system during winters, indication of open door for long period, overweight sensor, expiry alert of product, and provides temperature reading. They used temperature sensors, proximity sensors, load sensors and gas sensors to achieve the above-mentioned tasks (Glowacz 2018).

Velasco et al. (2019) in their research have effectively created a refrigerator smart inventory observing framework using an Arduino sensor network which comprised 6 weight sensors, a camera and 2 ultrasonic sensors. The main control box was associated wirelessly with an android application through the Web through cloud (Pérez et al. 2019).

3 Implementation and Methodology

The Figure 1 diagram below shows the proposed methodology designed for the implementation of the system. It depicts a process where the sensors are connected to a machinery or a home appliance for acquiring data.

Primarily, we have fetched the temperature and humidity data of the refrigerator cabin with the help of DHT11 sensor controlled by a Raspberry Pi 3B+ which also acts as gateway and helps storing the data locally in a csv file format. Further, the data is also uploaded to Google Cloud Platform where it can be analysed for predictive maintenance. All the important steps about the implementation of methodology design are as below:

- Data acquisition and storing the data in csv format
- Directory monitoring for uploading the data to cloud
- Alerting the user for faulty data (Fig. 1).

The two main components of the designed system include the DHT11 sensor (Fig. 2) and its controller Raspberry Pi 3B+ (Fig. 3). DHT11 is a sensor for measuring temperature and humidity of the surroundings. It contains a capacitive sensing element which has dual electrodes with a substrate which can hold moisture as a dielectric between them. As the humidity changes, a change in capacitance occurs between them. For measuring the temperature, a negative temperature coefficient thermistor is used which causes a decrease in the resistance with rise of temperature. Raspberry Pi 3B+ is used as a microcontroller to control this sensor. It is a Linux-based computer which also contains a set of GPIO pins. These pins allow us to control electronic components including various sensors for physical computing and programming which helps develop various IoT systems.

The trials for the above implementation process were taken on a LG refrigerator which is running for 20 years. The system was implemented using a Raspberry Pi 3B+ as a sensor controller. A DHT11 temperature and humidity sensor was used to acquire the cabin temperature and humidity of the refrigerator. The data acquired was first stored in a local csv file managed by the Raspberry Pi which runs on Raspbian operating system. The data was acquired by
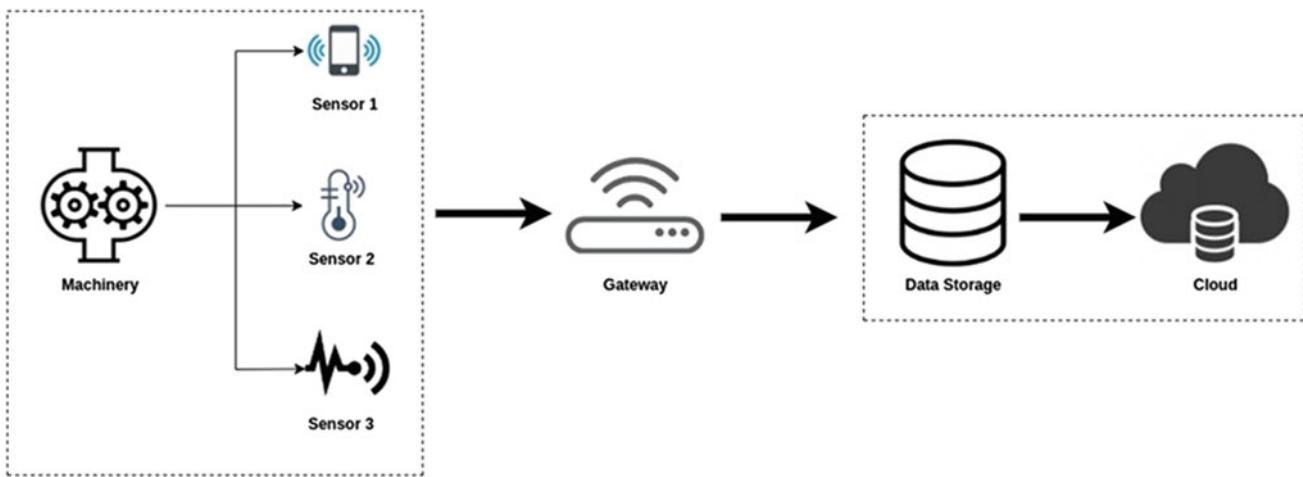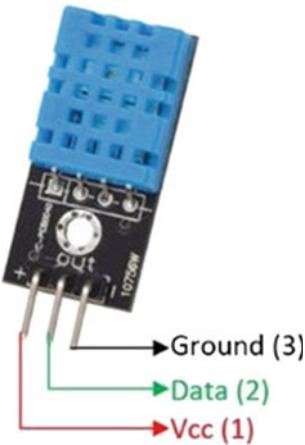
Fig. 1 Process adopted for data acquisition and cloud storage

Fig. 2 DHT11 pinout (https:// components101.com/sites/ default/files/component_pin/ DHT11%E2%80% 93Temperature-Sensor-Pinout.jpg)

Fig. 3 Raspberry Pi 3B+ (https://aws.robu.in/wp-content/uploads/ 2018/07/robu-5–7.jpg)

running Python script which also handles the csv file. Further, Python scripts were coded to upload the data simultaneously to the Google Cloud Storage.

4 Results

Below are the results obtained by acquiring data with the help of DHT11 temperature and humidity sensor from a refrigerator.

4.1 Data Overview

The below image shows csv file generated as the data is acquired after the execution of Python script (Fig. 4).

The image below shows the data uploaded to Google Cloud Storage after the data is stored in a csv file using a Python script (Fig. 5).

After the data is stored on Google Cloud Storage, it is further stored in a Google BigQuery Table where it is

queried for abnormal data like the temperature of the refrigerator cabin above 4 °C. The following image shows the results after querying the BigQuery Table (Fig. 6).

4.2 Graphical Overview of Data

Normal Temperature Variation The below graph indicates the normal usage of refrigerator where the temperature is usually observed nearer to 1 °C. A few peaks indicate that the refrigerator was used or opened at that moment of time and again the temperature begins to drop from there. The humidity is also observed constant without much variations (Fig. 7).

Faulty Temperature The below graph indicates that the refrigerator has some fault, or it is loaded heavily as the temperature is around 10 °C. The refrigerator is taking a lot

Fig. 4 Data stored in csv file

	date	time	tempCelsius	tempFarenh	humidity
1	date	time	tempCelsius	tempFarenh	humidity
2	05-13-2020	16:03:30	4	39.2	49
3	05-13-2020	16:04:33	4	39.2	48
4	05-13-2020	16:05:33	4	39.2	77
5	05-13-2020	16:06:34	4	39.2	48
6	05-13-2020	16:07:35	4	39.2	47
7	05-13-2020	16:08:38	4	39.2	47
8	05-13-2020	16:09:38	4	39.2	76
9	05-13-2020	16:10:39	4	39.2	47
10	05-13-2020	16:11:39	4	39.2	46
11	05-13-2020	16:12:40	4	39.2	46
12	05-13-2020	16:13:41	4	39.2	46
13	05-13-2020	16:14:41	4	39.2	46
14	05-13-2020	16:15:42	4	39.2	45
15	05-13-2020	16:16:42	4	39.2	46

Fig. 5 CSV files uploaded to Google Cloud Bucket

temperature-sensor-data

| OBJECTS | CONFIGURATION | PERMISSIONS | RETENTION | LIFECYCLE |

Buckets > temperature-sensor-data

UPLOAD FILES   UPLOAD FOLDER   CREATE FOLDER   MANAGE HOLDS   DELETE

Filter   Filter by object or folder name prefix

Name	Size	Type	Created time
temp_sensor_data_10_05_2020.csv	3.5 KB	text/csv	May 14, 2020, 4:15:04 PM
temp_sensor_data_11_05_2020.csv	6.3 KB	text/csv	May 12, 2020, 4:39:05 PM
temp_sensor_data_12_05_2020.csv	4.7 KB	text/csv	May 13, 2020, 6:14:23 PM
temp_sensor_data_13_05_2020.csv	5.6 KB	text/csv	May 13, 2020, 7:28:30 PM
temp_sensor_data_14_05_2020.csv	5.6 KB	text/csv	May 14, 2020, 5:24:56 PM

Fig. 6 Result obtained after querying the BigQuery Table


```
Sensor Data when temperature exceeds 4 degree Celsius:
            Date        Time        Celsius      Humidity
            2020-05-11  11:59:00    5            88
            2020-05-11  12:00:00    5            88
            2020-05-11  12:01:00    6            88
            2020-05-11  12:43:00    5            88
            2020-05-11  12:45:00    6            88
            2020-05-11  12:46:00    6            88
            2020-05-11  12:47:00    5            88
```

Fig. 7 Normal temperature graph
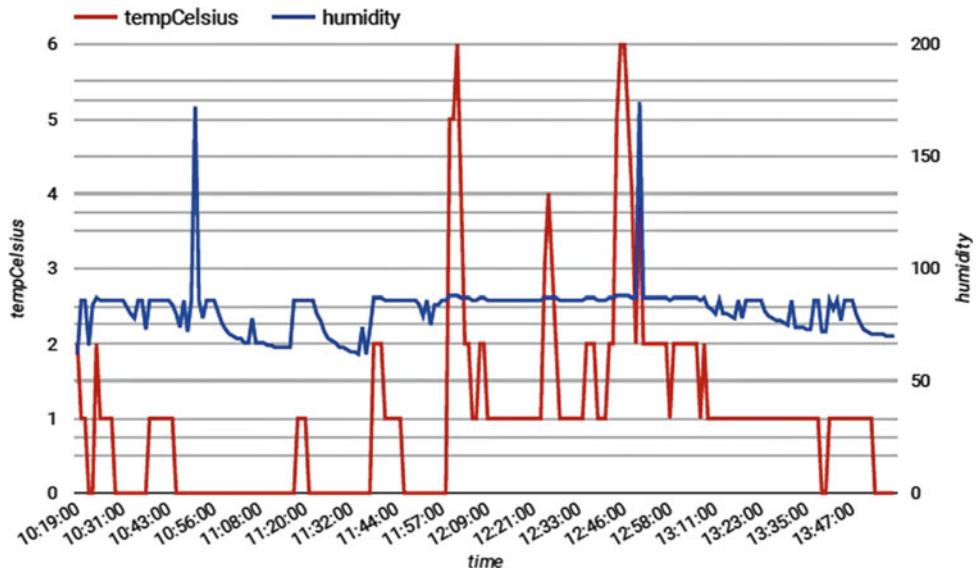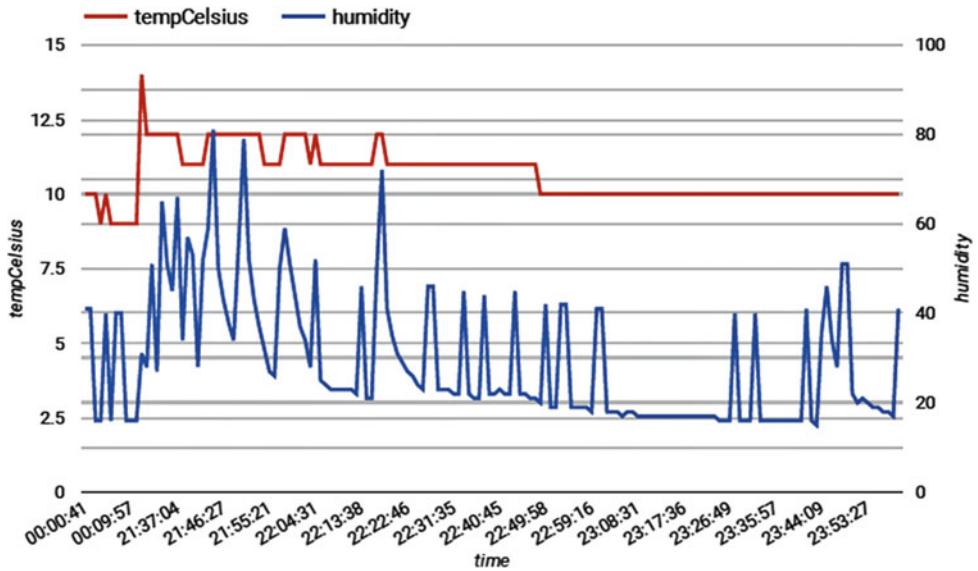
Fig. 8 Faulty temperature graph
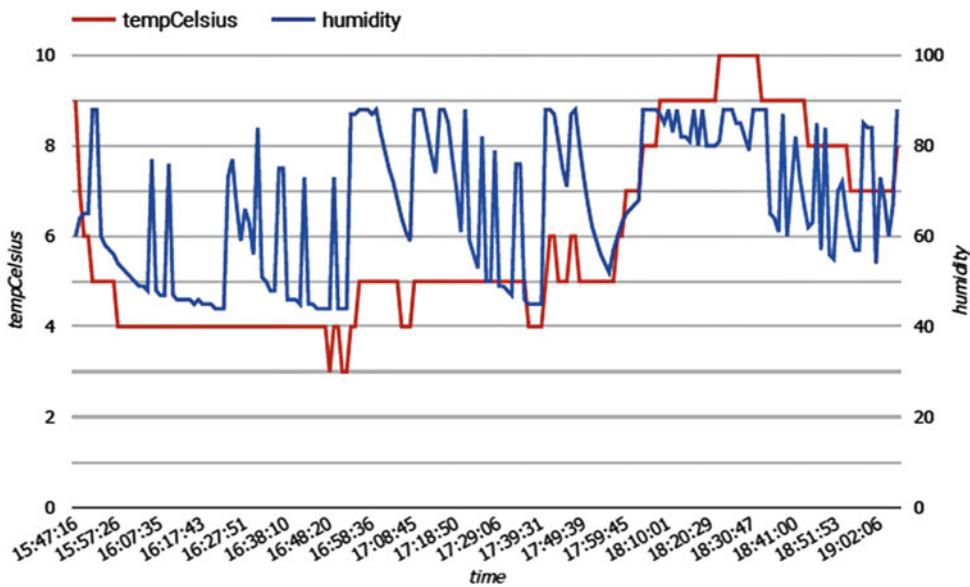
of time to cool down due to overloading or some fault in the cooling system. But the humidity is also variating much which also suggests overloading. This analysis can help detect overloading or active fault (Fig. 8).

Partly Overloaded/Faulty This graph shows a lot of variation in temperature, but the fridge is cooling at a faster rate than the above shown faulty data graph which means that either something warm is kept inside the fridge or the door is opened frequently and maybe there is no fault in the fridge as the cooling time is quicker than the faulty data (Fig. 9).

5 Conclusion and Future Scope

This paper demonstrates the research work and a methodology design for implementing predictive maintenance and fault detection in industrial machinery as well as home appliances. The focus of this research is mainly on designing a system which can be used to generate data using various sensors which can detect faults and store it on a cloud platform for further analysis. Even though most of the modern industries are based on Industry 4.0 principles, it is very important to detect early faults in the production

Fig. 9 Partial faulty temperature graph

machinery which may help saving money and time. Predictive fault detection and maintenance also helps in increasing the life of home appliances like refrigerators.

Our research shows how the data can be generated using various sensors, and it can be uploaded to Google Cloud Storage for further analysis. This methodology if implemented in today's modern era of IoT would definitely bring a change in fault detection and maintenance systems of mega industries.

The system designed in the research also requires some refinements in terms of backing up of data locally if there is an Internet connectivity fault. It also requires a power backup as the controllers and sensors may stop working due to power failure.

This research can be further integrated with a data analysis system which will help analyse the generated data for a more precise fault detection and predictive maintenance. An application can also be integrated with the system for live alerts which would help detect faults spontaneously.

References

Annamalai, S., Udendhran, R., & Vimal, S. (2019). Cloud-based predictive maintenance and machine monitoring for intelligent manufacturing for automobile industry. In *Novel Practices and Trends in Grid and Cloud Computing* (pp. 74–89). IGI Global.

Bhatter, S., Verma, A., & Sinha, S. (2020). Application of IoT in predictive maintenance using long-range communication (LoRa). In *Innovation in Electrical Power Engineering, Communication, and Computing Technology* (pp. 147–155). Springer, Singapore.

Compare, M., Baraldi, P., & Zio, E. (2019). Challenges to IoT-enabled predictive maintenance for Industry 4.0. *IEEE Internet of Things Journal*, 7(5), 4585–4597.

Dhamande, L. S., & Chaudhari, M. B. (2018). Compound gear-bearing fault feature extraction using statistical features based on time-frequency method. *Measurement, 125,* 63–77.

Fiix. Predictive maintenance. https://www.fiixsoftware.com/maintenance-strategies/predictive-maintenance/

Glowacz, A. (2018). Acoustic based fault diagnosis of three-phase induction motor. *Applied Acoustics, 137,* 82–89.

Glowacz, A., & Glowacz, W. (2018). Vibration-based fault diagnosis of commutator motor. *Shock and Vibration.*

He, Q. P., Wang, J., & Shah, D. (2019). Feature space monitoring for smart manufacturing via statistics pattern analysis. *Computers & Chemical Engineering, 126,* 321–331.

https://aws.robu.in/wp-content/uploads/2018/07/robu-5–7.jpg

https://components101.com/sites/default/files/component_pin/DHT11%E2%80%93Temperature-Sensor-Pinout.jpg

Iqbal, R., Maniak, T., Doctor, F., & Karyotis, C. (2019). Fault detection and isolation in industrial processes using deep learning approaches. *IEEE Transactions on Industrial Informatics, 15*(5), 3077–3084.

Killeen, P., Ding, B., Kiringa, I., & Yeap, T. (2019). IoT-based predictive maintenance for fleet management. *Procedia Computer Science, 151,* 607–613.

Kim, E., Cho, S., Lee, B., & Cho, M. (2019). Fault detection and diagnosis using self-attentive convolutional neural networks for variable-length sensor data in semiconductor manufacturing. *IEEE Transactions on Semiconductor Manufacturing, 32*(3), 302–309.

Lee, S. M., Lee, D., & Kim, Y. S. (2019). The quality management ecosystem for predictive maintenance in the Industry 4.0 era. *International Journal of Quality Innovation*, 5(1), 4.

Li, J., Yao, X., Wang, X., Yu, Q., & Zhang, Y. (2020). Multiscale local features learning based on BP neural network for rolling bearing intelligent fault diagnosis. *Measurement, 153,* 107419.

Mahajan, M. P., Nikam, R. R., Patil, V. P., & Dond, R. D. (2017, March). Smart refrigerator using IOT. *International Journal of Latest Engineering Research and Applications (IJLERA), 2,* 86–91. ISSN: 2455-7137

Okaro, I. A., Jayasinghe, S., Sutcliffe, C., Black, K., Paoletti, P., & Green, P. L. (2019). Automatic fault detection for laser powder-bed fusion using semi-supervised machine learning. *Additive Manufacturing, 27,* 42–53.

Pérez, E. V., Ortega, O. B., & Villa, J. L. (2019, February). IoT circuit design to monitor cold chain refrigerators. In *2019 Latin American Electron Devices Conference (LAEDC)* (Vol. 1, pp. 1–5). IEEE.

Plaza Bonilla, D., Álvaro-Fuentes, J., Bareche Sahún, J., Pareja Sánchez, E., Justes, É., & Cantero-Martínez, C. (2019). No-tillage systems linked to reduced soil N_2O emissions in Mediterranean agroecosystems. *Science for Environment Policy, 519.*

Sahal, R., Breslin, J. G., & Ali, M. I. (2020). Big data and stream processing platforms for Industry 4.0 requirements mapping for a predictive maintenance use case. *Journal of Manufacturing Systems, 54,* 138–151.

Sang, G. M., Xu, L., de Vrieze, P. T., Bai, Y., & Pan, F. (2020). Predictive maintenance in Industry 4.0

Velasco, J., Alberto, L., Ambatali, H. D., Canilang, M., Daria, V., Liwanag, J. B., & Madrigal, G. A. (2019). Internet of things-based (IoT) inventory monitoring refrigerator using arduino sensor network. arXiv preprint arXiv:1911.11265.

Zhao, R., Yan, R., Chen, Z., Mao, K., Wang, P., & Gao, R. X. (2019). Deep learning and its applications to machine health monitoring. *Mechanical Systems and Signal Processing, 115,* 213–237.

Text Classification Using FP-Growth Association Rule and Updating the Term Weight

Santosh K. Vishwakarma, Akhilesh Kumar Sharma,
Sourabh Singh Verma, and Meghna Utmal

Abstract

Text classification plays a vital role in many real-life applications. There are different methods for text classification primarily Naive Bayes classifier, support vector machine, etc. A good text classifier must efficiently classify large set of unstructured documents with optimal accuracy. Many techniques have been proposed for text classification. In this paper, we propose an integrated approach for text classification which works in two phases. In initial preprocess phase, we select the frequent terms and adjust the term weight by use of information gain and support vector machines. Second phase consists of applying Naïve Bayes classifier to the document vector. The experiment has been performed on the open research dataset of Forum of Information Retrieval (FIRE). In association rule, the correlation between data items is obtained with no requirement of external knowledge, whereas in classification, attention is given to small set of rules with the help of external knowledge. The proposed work uses FP-growth algorithm with absolute pruning for obtaining frequent text sets, and then, Naïve Bayes classifier model is used for training and constructing a model for classification. Our experimental result shows increase in efficiency while comparing with other traditional text classification methods.

Keywords

Text classification • FP-Growth • Naive bayes classifier • FIRE • Weight adjustment, etc.

1 Introduction

The abundance of data led to the generation of the new field named as data mining. Data collected in large databases becomes raw data for the knowledge discovery technique. By using statistical and machine learning technique, valuable information is retrieved from vast amount of data by the technique of data mining. It is a multidisciplinary field with a major impact in scientific and commercial environment. Data mining has got vital importance due to wide availability of large data and the requirement of converting this into valuable information (Han and Kamber 2000).

Moreover, it represents the automatic process to discover patterns and relations between data stored in large databases called data warehouses, the final product of this process being the knowledge, meaning the significant information provided by the unknown elements (Data Mining et al. 2008).

This technology also identifies patterns of data in the already existed data, to help users understand the existing information and predict for the future conditions based on existing information (Chen 2012). There are various types of technologies, i.e., frequent pattern mining, association rule mining, clustering, classification and prediction.

There were two major types of learning techniques: Supervised(classification) such as Bayesian, neural network, decision tree, genetic algorithms, fuzzy set, K-nearest neighbor and unsupervised (clustering) such as association rules, K-means, PAM, K-Medoid (Fayyad et al. 1996; Srikant and Agrawal 1997). Association rule mining is a most relevant and popular technique for data mining. The patterns discovered with the data mining technique can be

S. K. Vishwakarma · A. K. Sharma (✉) · S. S. Verma
SCIT Manipal University Jaipur, Jaipur, Rajasthan, India
e-mail: akhileshshm@gmail.com

S. K. Vishwakarma
e-mail: santoshscholar@gmail.com

S. S. Verma
e-mail: ssverma80@gmail.com

M. Utmal
Gyan Ganga College of Technology, Jabalpur, India
e-mail: meghna.utmal@ggits.org

represented by association rules (Srikant and Agrawal 1997; Han and Fu 1995).

There are two steps involved in determining frequent itemset which satisfies the minimum support and minimum confidence in association rule mining. With the help of frequent itemset, it is easier for businesses to make decisions as cross marketing, catalogue design and customer shopping behavior analysis.

The technique which is employed to classify records and adopted in data mining is classification. Decision learning and classification is deployed by this approach. The system is trained by the classification algorithm to analyze the training data in learning. The accuracy of classification rules is estimated by the testing data in classification. If accuracy is found acceptable, rules can be applied to the new data tuples. These pre-classified examples are used to determine the parameters for proper discrimination. The algorithm then encodes these parameters into a model called a classifier (Junrui et al. 2012).

We can view association rule mining and classification rule mining as the complementary approaches. For association rule mining, the discovering rule is not predetermined. The rule which is used to find a small set of databases to build an accurate class model and apply the model to classify new data is called classification rule mining. Classification rule mining uses only one predetermined target class.

2 Related Work

Liu et al. (2001) studied that the associative classification or classification based on association rules (CBA) is an integrated technique that applies the methods of both association rule mining and classification. The paper suggests that CBA is a two steps process. At the beginning, it finds frequent itemset with the help of association rules techniques, and the next step deploys the rules for classification of dataset. The current paper suggests that CBA algorithm is the best based on its accuracy rule such as C4.5

Previous algorithms brought up the idea of using an association rule for classification called as CBA algorithms (Liu et al. 1998). In order to discover frequent itemset, Apriori algorithm is implemented which requires multiple scanning of training dataset by CBA (Data Mining et al. 2008).

Further work is done on a new associative classification algorithm: Classification based on Multiple Association Rules (CMAR). The experimental result shows that CMAR provides better efficiency and accuracy compared with CBA algorithm. The accuracy of CMAR is achieved by using multiple association rules for classification. The efficiency of CMAR is achieved by efficient frequent pattern method, FP-growth, construction of a class distribution-associated FP-tree, mined association rule retrieve and store by using CR-tree structure (Li et al. 2001; Karthik et al. 2016).

Hossein et al. (2016) have classified news into various groups so that users can identify the most popular news groups in the desired country at any given time. Based on term frequency-inverse document frequency (TF-IDF) and support vector machine, Dsouza and Ansari (2015) studied the text classification process, which aims to assign a document to one or more categories based on its content. Weka-Lib SVM classifier is used to classify multi-domain documents of classification.

Wikarsa and Thahir (2015) investigated on the emotions of Twitter users. Preprocessing, processing and validation are the three main phases involved in text mining. Zhou et al. (2014) worked on the automation of prediction process of bug report data by combining data mining and text mining techniques. This automation works by summarizing the bug reports and classifying it into three different levels of probability. Data grafting techniques are employed to bridge the two stages. Finally, the comparison is made of the experiment result with previous studies on the same dataset.

Liu and Fu (2015) proposed work suggests that K-means algorithm has two major drawbacks which are improved in this paper. The method proposed the concept of the smallest rule covering whole set. It has solved two big limitations of K-means algorithm effectively.

Li et al. (2014) experimented on classification algorithms, along with three filtering schemes. The filtering technique is analogous to the preprocessing technique where original dataset is reduced to simpler one. Rahman et al. (2010) paper discusses the technique for classifying mining text using classification with association rule. Kamruzzaman et.al (2010) use word relation instead of using words to derive feature set from pre-classified document. Naive Bayes classifier is then used on derived features along with genetic algorithm.

3 Methodology

In our experiments, the open research dataset provided by Forum of Information Retrieval (FIRE) is used. The database consists of various documents related to movies, sports, technology, etc. The dataset consists of a collection of more than 60,000 documents of various unknown labels. FIRE dataset adapts TREC document style format. The document in the dataset in its original form consists of three fields named DOC, DOCNO and TEXT. DOC is a header field, and each document starts with this. DOCNO has unique identifier which is assigned to each document in the dataset. TEXT field contains the unstructured text data. For simplicity of the experiments, we have removed the DOC and DOCNO fields from the document, and the text part has

```
<DOC>
<DOCNO>1070101_sports_story_7205760.utf8</DOCNO>
<TEXT>
The Telegraph - Calcutta : Sports Hussey backs Moody  Michael Hussey Sydney: Batsman Michael Hussey wants
Tom Moody to succeed John Buchanan as Australias next coach when the job becomes vacant after the World
Cup in April, reports said on Sunday. The  former Australian allrounder has been coaching Sri Lanka for 18
months and been widely credited with the sides recent good form, including 11 wins from their past 13 one-
day Internationals. I know Tom well, Hussey told a newspaper. (AGENCIES)
</TEXT>
</DOC>
```

Fig. 1 FIRE Doc File

been kept as unchanged. One of the snapshots of the FIRE doc is shown in Fig. 1.

Terms having low term frequency values are pruned from the database. However, they are not the only sufficient parameters for removing all unwanted words from the database. Stop word list which consists of more than 300 words is used for text preprocessing. The words are also stem based on Porter's algorithm. Initially, preprocessing of the dataset involves majorly tokenization, removal of stop words, case transformation and stemming. The preprocessing involves removal of stop words which does not have any important significance to be used in the classification process and can be filtered out before processing with the actual text. Another important objective is to resolve inconsistency and replace missing values.

In vector space model, the proximity can be traced by utilizing different measures which covers word similarity between vectors. The cosine similarity measure has been used to gain the proximity between two documents in the vector space representation.

After the preprocessing of dataset, association rule mining has been applied to discover frequent patterns that appear together in a large database. The FP-growth algorithm, one of the most useful approaches for association rule mining, has been used for finding the frequent pattern. The working of the FP-growth algorithm consists of two phases. In the initial phase, it compresses the database into a compact tree form, known as the FP-tree, and in later phase, it extracts the frequent patterns by traversing the tree. During experiments, the minimum support and confidence values are set as 0.2 and 0.8, respectively. The gain theta value is set to 2.0, while the Laplace value is set as 1.0

The algorithm has an upper edge with other association rule mining algorithms as it requires only few database scans and subsequently reducing the number of counts. It supports the ideology of divide and conquer methodology by decomposing the larger database into small segments of chunks and getting the frequent items at the early stage.

The advantage of applying FP-growth method is that many of the less frequent words are pruned from the intermediate result, i.e., before classification. The extracted words and their set have been selected for training the system for the model.

After getting the frequent word list from the previous step, we deploy two weight adjustment methods for our document vector which strive the purpose of ranking the terms according to their discriminating power and normalize the term weight compared to the reference values. First the weight by information gain method uses the information gain ratio of label attribute to calculate the value of un-label attribute and assigns the weight accordingly. Second, we used SVM method for weight adjustment which computes attributes weights with the coefficients of the normal vector of a linear SVM. The weight modification procedure brings about a sensible decrease in the modeling costs.

After getting the frequent words list from the previous step, Naïve Bayes classifiers have been used for the training purpose. It can predict class membership probabilities such as the probability that a given tuple belongs to a particular class. It is also known as Naïve Bayesian classifier. It assumes that the effect of attributes is independent given the class, this assumption is called a class conditional independence in which the classes are mutually exclusive and exhaustive.

The input to the validation process is the modified term weight after getting frequent itemset through FP-growth algorithm and subsequent weight adjustment by the method of information gain and support vector machine.

Table 1 Comparison with all measures

Parameters	Classification method			Proposed method
	KNN	Random forest	Naïve Bayes	FP-Growth + Naïve Bayes
Accuracy (%)	72	63	85	93
Kappa	0.85	0.72	0.91	0.92
Correlation	0.55	0.78	0.76	0.9
Recall (%)	73	76	82	79
Precision (%)	75	72	81	89

Table 2 Comparison with other work for split ratio of FIRE

	Accuracy (%)		
FIRE split ratio (%)	Rahman et al. (2010)	Kamruzzaman et al. (2010)	Proposed approach
50	78	83	87.2
60	81	84.9	88.6
70	83.7	86.4	90.3
80	86.4	88.6	91
90	88.2	90.7	93.2

4 Result Analysis

A unique identifier that is assigned to every document is DOCNO. TEXT field contains the actual news articles in plain text. For experimental design, the standard data mining tool Rapid Miner tool (https://rapidminer.com/) has been used. The result of the proposed approach has been evaluated with various standard data mining metrics such as accuracy, kappa, correlation, weighted mean precision and recall.

The proposed approach for text classification has been compared with the traditional methods such as K-nearest neighbor, Naïve Bayes and random forest with the standard parameters of performance measurement. Table 1 gives the comparative results with all these measures.

Based on the various evaluation parameters, we find that the proposed method outperforms in most of the metrics.

In the next phase, we compared our results with the base paper of Rahman et al. (2010) and Kamruzzaman et al. (2010) for the similar dataset. The training data has been split according to the 90–10% criteria of which 90% as training set while the 10% for testing data for the first level. Then, the split ratio has been gradually decreased by 10% for other test conditions. The linear sampling has been used to evaluate the result. The accuracy values are summarized in Table 2.

In contrast to the existing work, the proposed algorithm gives increased accuracy at various training levels. Classifying a document relies upon the related terms created from training dataset as calculated by the frequent pattern algorithm. So, the quantity of training document is important in producing the quantity of word sets used to decide the class of another document. The higher number of words set from the training dataset reduces the classification error for new document. From Table 2, it can be stated that the proposed method has higher level of accuracy with all the training levels between 90 and 50% with a unit of 10.

5 Conclusion

Text mining is an emerging research area whose goal is to discover additional information from hidden patterns in unstructured large textual collection. This paper focuses on the integration of two well-known data mining algorithms for text classification with weight adjustment. The FIRE dataset consists of an average of 50–100 words in a text document, so the proposed method needs to be evaluated with the larger document and corpora. It has also been found that the frequent pattern algorithm prunes few terms which are not frequent, but they have significance in the classification process. Although the results of the proposed approach are quite encouraging, still we need to perform the method with a greater number of predefined classes. It has been found that a new way of classifiers can be build which makes association rule mining techniques applicable to classification tasks and help to solve several important problems with the existing classification systems.

References

Agrawal, R., & Srikant, R. (1994). *Fast algorithms for mining association rules in large databases*. VLDB 1994.

Chen, L. (2012). The research of data mining algorithm based on association rules. In *International Conference on Computer Application and System Modeling*

Data Mining, CINECA site. http://open.cineca.it/datamining/. Accessed January 15, 2008.

Dsouza, K. J., Ansari, Z. A. (2015). A novel data mining approach for multi variant text classification. In *IEEE International Conference on Cloud Computing in Emerging Markets*.

Fayyad, U., Piatetsky Shapiro, G. & Smyth, P. (1996). Data mining to knowledge discovery: an overview. In: *Advances in knowledge discovery and data mining*, Cambridge, USA, pp. 1–3.

Han, J., & Fu, Y. (1995). Discovery of multiple-level association rules from large databases. Very large data bases (VLDB'95), Zürich, Switzerland, September 1995, pp. 420–431.

Han, J., & Kamber, M. (2000). *Data mining: concepts and techniques*. San Francisco, CA: Morgan Kaufmann Publishers.

Hossein, S. M., Araghi, M. S., & Farahani, M. M. (2016). A novel text mining approach based on TF-IDF and support vector machine for news classification. In *2nd IEEE International Conference on Engineering and Technology (ICETECH)*, 17th & 18th March, 2016, Coimbatore, TN, India.

Junrui, Y., Lisha, X., & Hongd, H. (2012). A classification algorithm based on association rule mining. In *International Conference on Computer Science and Service System*.

Kalpana, R., & Bansal, K. L. (2014). Comparative study of data mining tools. *International Journal of Advanced Research in Computer Science and Software Engineering Research Paper, 4*(6). ISSN: 2277 128X.

Kamruzzaman, S. M., Haider, F., & Hasan, A. R. (2010). *Text classification using association rule with a hybrid concept of naive Bayes classifier and genetic algorithm*. arXiv preprint arXiv: 1009.4976

Karthik, P., Saurabh, M., & Chandrashekhar, U. (2016). Classification of text document using association rule mining with critical relative support-based pruning. In *Conference on Advances in Computing, Communications, and Informatics (ICACCI)*, September 21–24, 2016, Jaipur, India.

Li, W., Han, J., & Pei, J. (2001). *Accurate and efficient classification based on multiple-class association rule*. CMAR.

Li, J. J., Fong, S., & Li, Y. Z. (2014). Hierarchical classification in text mining for sentiment analysis. In *2014 International Conference on Soft Computing & Machine Intelligence*.

Liu, G., & Fu, W. (2015). An association rules text mining algorithm fusion with K-means improvement. In *2015 4th International Conference on Computer Science and Network Technology (ICCSNT 2015)*.

Liu, B., Hsu, W., & Ma, Y. (1998). *Integrating classification and association rule mining in knowledge discovery in databases*.

Liu, B., Ma, Y., & Wong, C.-K. (2001). Classification using association rules: weaknesses and enhancements. Data mining for scientific applications.

Moreno, M. N., & Segrera, S. (2005). *Association rules: Problems, solutions and new applications*. ISBN: 84-9732-449-8

Rahman, C. M., Sohel, F. A., Naushad, P., & Kamruzzaman, S. M. (2010). *Text classification using the concept of association rule of data mining*. arXiv preprint arXiv:1009.4582

Srikant, S., & Agrawal, R. (1997). Mining generalized association rules. *Future Generation Computer Systems, 13*, 2–3.

Vishwakarma, S. K., Lakhtariab, K. I., Bhatnagar, D., & Sharma, A. K. (2015). Monolingual information retrieval using terrier: FIRE 2010 experiments based on n-gram indexing. In *3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)*.

Wikarsa, L., & Thahir, S. N. (2015). *A text mining application of emotion classifications of twitter's users using naïve based method*. IEEE.

Zhou, Y., Tong, Y., Gu, R., & Gall, H. (2014). Combining text mining and data mining for bug report classification. In *2014 IEEE International Conference on Software Maintenance and Evolution*.

Addressing Transparency Vis-a-Vis Privacy in Portability of Health Insurance Through Blockchain

Shrawan Kumar and Ashwani Kumar

Abstract

A blockchain is a community ledger deal out in excess of a set-up that testimony operations (memorandums send commencing individual system knot to a further) carry out in the middle of network contributors. Every operation is confirmed by network nodes according to a mainstream agreement method prior to being added to the block chain. Recorded information is able to not be revolutionized or wipe away, and the past of each operation can exist re-formed by the side of in the least time. Authors have been proposed a system using block chain mechanism for health insurance entails institution of burly procedures for health data collection and compilation right from grass root level. The Recommended technique bestows the precise to the policyholder of health insurance to relocate the credit gained him for pre-existing conditions and time vault, keeping outs in case he chooses to switch the insurance provider.

Keywords

Blockchain • Insurance • Network nodes • Healthcare • Ledger

1 Introduction

Product development has adorned each and every aspect of business and insurance is no exception. While more than 55% of customers are ready to explore new insurance models, only 26% of insurers are exploring such models (Rawte and Anuradha 2015). Insurance products traded decades ago have lost their sheen and shine, and newer improved products have substituted them which have made portability a wide prevalent choice with the policyholders. Portability gives the right to the policyholder of health insurance to transfer the credit gained him for pre-existing conditions and time bound exclusions in case he chooses to switch the insurance provider. Portability of health insurance requires establishment of strong procedures for health data collection and compilation right from grass root level. Traditional paper-based health records have no practical value in today's regime of electronic information exchange, and therefore, maintenance of electronic health records (EHRs) has been considered to be a feasible option (Tang et al. 2019). It has been observed that the e-health data aggregated may contain sensitive information on each individual such as the name, age, and HIV status, may damage the person's reputation and trust of the company, and hence, robust privacy protection mechanisms are also required. Some studies have proposed an efficient and secure e-health data release scheme with differential privacy to provide the necessary privacy guarantee (Li et al. 2015; Xiao et al. 2010). With the introduction of the US law Health Insurance Portability and Accountability Act (HIPAA) in 1996, policies, technology, and record-keeping at medical facilities, health insurance companies, HMOs, and healthcare billing services are all impacted. According to Health Insurance Portability and Accountability Act (HIPAA), the medical insurance claim process is carried out by healthcare providers, insurance companies, and clearinghouses (World Insurance Report 2019). Further in 2009, the Health Information Technology for Economic and Clinical Health Act (HITECH) widened privacy and security protections imposed by HIPPA.

More recently, the European Union's General Data Protection Regulation (GDPR), which was made operational on May 25, 2018, envisaged a new set of rules governing the privacy and security of personal data replacing all of Europe's earlier privacy laws and thus having a far reaching impact on the data driven insurance industry.

S. Kumar · A. Kumar (✉)
Department of Computer Science and Engineering, Vardhaman College of Engineering, Hyderabad, India
e-mail: ashwani.kumarcse@gmail.com

Currently, Web-based facilities do exist regarding procurement and maintenance data for all types of health insurance policies issued by various insurance of providers which can be accessed by the new company to which a policyholder wishes to port his policy. But the existing algorithms are neither fair nor transparent. Further, many of them are not available online and not adaptive (Vahdati 2018). To worsen the situation, insurance frauds have not only tormented the lives of innocent people but also the insurance industry. Insurance frauds may be committed at any point ranging from application stage to portability to settlement of final claims (Vahdati 2018). According to the Mckinsey & Company report of 2017, nearly 5–10% of insurance claims are fraudulent.

The insurance industry is working together with the health providers on things like fraud detection and prevention on one hand and improving the client experience by adhering to sound data management principles like data privacy and effective data usage. A thorough review of the related work throws light on the possibility of weaving a blockchain-based network between insurance and health providers so that twin goals of transparency and privacy are met in one go. Thus, our model is novel as it not only imparts transparency to the system but also checks fraudulent opportunities arising out of insurance portability option.

Motivation for writing this paper came out of observation of breeding possibilities of fraud in the Indian Insurance sector which may be committed by any policyholder while porting the health insurance policy from one insurance company to the other. Say a health insurance policy is lapsing on January 1 and the policyholder ports it to another company on November 30 against no claim bonus prior to the date of lapse. Now, during this one month, the policyholder meets a health hazard which he had insured and takes the claim from his previous insurance company. As the portability request has already been processed, by any chance the second insurance company is not able to take cognizance of this incident unless the policyholder himself notifies it to the new insurance company. So, there is a need to devise a system so as to adjust the benefit given to the policyholder at the time of portability. We propose to deploy blockchain-enabled technology where all insurance providers collaborate with healthcare providers (i.e., hospitals or private clinics) without undergoing any additional process of negotiating with insured seeking portability.

Blockchain is a public distributed database which holds the encrypted ledger. It is encrypted to keep the details of the people involved in it completely anonymous. A block is a collection of all the recent transactions that have happened and is verified. We group those transaction details using the hash code and then store in a block chain. Once a transaction is verified by the miner, that block becomes a permanent part of the blockchain, and the chain keeps growing. It is the belief that in every ten minutes the block is created and the blockchain grows accordingly. The number of transactions performed in a time frame that are grouped in a block and then stored in a blockchain. A ledger is maintained to hold the record of all the transactions. If we want to change any specific transaction, the change or modification in block is not possible because all the participants in the distributed environment have the copy of all the records. In this if anybody wants to modify the record, that record must be verified by the specified miner. Once the miner verifies the transaction, then only the record can be uploaded in the system, and the copy of that updated ledger will be available to all in the distributed environment. Every block uses the previous hash code. Every block has specific hash code associated with it, used in identifying factors for that block. This hash is oriented with a very complex hashing algorithm. If we make a minute change in hash input, it makes a highly different output as whole. We cannot reverse engineer this hash code as well. The algorithm is designed in such a way that no one can get the complete data by reverse engineering the hash code. We have the complete hash details of every transaction that has happened as part of that block. There could be multiple transactions in a ledger, so every verified and validated transaction gets added to block, thereby ensuring that transactions cannot be manipulated. The ledger is generated by the people using software that solves the mathematical problems.

The use of the blockchain-enabled technology in applications for healthcare and health insurance has been investigated by several researchers. More than 55% of insurance firms have implemented innovative technologies like machine learning, artificial intelligent, and advanced analytics to quantify risks (Rawte and Anuradha 2015).

It has been observed that if the insurers are able to record transactions on the blockchain at each point in the transactional lifecycle from seeking a quotation to binding a policy contract, the immutable life record of that policy or the policyholder can be traced (Nath 2016). Blockchain technology offers many advantages and disadvantages in the insurance sector (e.g., car insurance, farming insurance, delay insurance, and home insurance) which can be generalized and applied to other sectors. The advantages include using smart contracts to improve customer experience and lower operating costs in case, fraud prevention, data entry/identity verification, pay-per-use insurance, and peer-to-peer insurance. However some of these may be case sensitive (Xinchi 2018).

Another study was conducted to address the performance and security concerns of insurance processes by designing a blockchain-enabled solution for the insurance industry. The objective was (a) to automate and speed up business processes in the insurance industry, from client registration and policy issuance to claims handling, (b) to make fraud

detection easier using decentralized digital repository, (c) to make client data confidential and accessible only to the authorized parties, (d) to reduce administrative and operational costs, and (e) to enable regulators and auditors to detect suspicious transaction patterns and market behaviors. The authors not only discussed the main design requirements, corresponding design propositions, and encode various insurance processes as smart contracts but also conducted extensive experiments in order to figure out performance of the suggested framework and security of the proposed design (Raikwar et al. 2018).

2 Literature Survey

By taking the example of parametric insurance, a study has shown that in the insurance industry, blockchain-based smart contracts can enable the automation of simple life insurance policies, thus reducing costs of administration, and provide a platform for new insurance products where transparency, trust, and simplicity offer value (Cohn 2017).

Another research proposed blockchain-based medical insurance storage system which is expected to help an insurance company in obtaining patient's medical expenditure records. By taking four parties viz. patients, hospitals, servers, and insurance companies in the model along with Ethereum blockchain and small memory and CPU, the proposed system enjoys special advantages, e.g., decentralization, tamper-resistance, etc. (Zhou et al. 2018). In another study, a self-organizing framework for insurance based on IoT and blockchain has been proposed which recognizes even the use of cryptocurrencies for making payments using of peer-to-peer communication protocols (Vahdati 2018).

A related work cited that the breeding inefficiencies of the current model of electronic data handling of the patients cause wastage of time, money and also delays patient care. Cloud-based EHRs also suffer centralized problem, i.e., cloud service center and key-generation center, and therefore, blockchain-based EHRs and an authentication scheme for blockchain-based EHRs have been proposed (Tang et al. 2019). In the same vein, another study focused on developing an efficient, interoperable, and highly secure blockchain network to store and manage electronic health records (EHR) of all patients would enable seamless access to historic and real-time patient data while eliminating the burden and cost of data reconciliation (Shah et al. 2018). Blockchain may provide a solution to both secure patient health data from unauthorized breaches and at the same time make access to such data easier for patients (Kshetri 2018).

One study highlighted the potential use of blockchain technology in association with mobile-based healthcare applications, thus imparting patient centric care as well as offering patients' complete authority over the sharing and privacy of their data (Clim 2019). In a related work, a privacy-preserving DML model has been proposed for a permissioned blockchain network to resolve such important issues for tackling the issues of privacy, security, and efficiency. It has been shown that machine learning fits better in a permissioned blockchain with differential privacy than restrictive applications in a permission-less blockchain (e.g., cryptocurrencies) (Kim et al. 2019). Safe and convenient data sharing of personal health records is vital to improving the interactions and collaborations between insurance and healthcare industry. Therefore, smart contracts present an opportunity for automating the adjudication process in insurance making claims transparent to the healthcare provider and insurer, exposing potential errors, and frauds that can be corrected or investigated in a much timelier manner. Another benefit of creating these pre-established agreements via smart contracts is to ensure involved participants are up-to-date and properly notified as policies or rules change (Zhang et al. 2018). In a study, a model incorporating blockchain technology in smart contracts has been suggested with the objective of improvising the insurance sector in order to make it more transparent. All important information related to investments, realized profits, repayments, deadlines, history and future business strategy will be shared with the client through a blockchain network. All the contracts will be modernized and transformed into smart contracts which will be automatically and intelligently executed for speedy refunds to the policyholders leaving no room for compensations for fake incidents (Gatteschi 2018).

Another research proposed deployment of a blockchain-enabled mobile application to collect health data from personal wearable devices, manual input, and medical devices, and synchronizing data to the cloud for data sharing with healthcare providers and health insurance companies. Moreover, for scalable and performance considerations, a tree-based data processing and batching method is adopted to handle large data sets of personal health data collected and uploaded by the mobile platform (Meskini and Aboulaich 2019). Health insurance fraud means deliberately deceiving the health insurance company, and as a consequence, healthcare benefits are paid illegitimately to an individual or group.

The main purpose of fraud is financial benefit. The settlement of health insurance claims is one of the most tedious tasks of the healthcare sector as claims are prone to fraud and can consume the time and energy of the patient and healthcare provider. Thus, data structures must be used to store patient information, medical service record, and insurance payments, as well as provider-insurer agreements in the distributed ledger. The authors used the Hyperledger Fabric blockchain to implement and evaluate the system design and found that their approach is not only feasible but also time efficient (World Insurance Report 2019). Kumar

et al. (Kumar 2018; Kumar and Srivastava 2020; Kumar et al. 2019; Kumar and Satyanarayana Reddy 2021) proposed an object detection method for blind people to locate objects from a scene. They have used machine learning-based methods along with single SSMD detector algorithm to develop the model.

3 Proposed Model

As already discussed, in the current scenario if any patient ports a health insurance policy before its due date and registers a claim against the existing policy, the claim details are not transferred to the new insurance policy provider. There is a chance in the existing system that the patients hide their medical history while porting or discontinuing with the old policy provider. This model is proposed to preserve the privacy of the patient and impart (Fig. 1).

3.1 Entities of the Proposed Model

Patient The primary entities in our model are the patient, who is insured by the insurance company and requests for insurance policies. The patient submits claim requests and receives refunds, and the agent, who acts on behalf of the client and processes the client's requests to the blockchain network. An agent can have multiple clients.

Healthcare Provider/Hospital Once the patient visits the healthcare provider which may be any of the hospitals (public or private), a case file for that patient is created and simultaneously uploaded to the blockchain network. Now, this network can be used for information sharing with other healthcare providers as well as insurance companies where both the later parties will have the right to access data from the patient. Every request for previous health data will be recorded in the blockchain, thus imparting transparency among all parties.

Database Database is software used to store and retrieve information for future prospective. A case file is updated into the hospital database. A block is generated with the details of the patient and the diagnosed disease. A block is a collection of all the recent transactions that have happened and is verified. The details will be verified by the health insurance provider, if correct details the block is created. Once a verified block is created, it cannot be altered by anyone.

Blocks Block will hold block header and block body. In the block header, there will be information of the previous block hash, time stamp, merkle root, block id, and signature. Timestamps show the blocks are connected in chronological order, acquire the details of the block regarding when the block was created and what transaction happened. Merkle root is used to hold the hash code of the blocks. Signature is used for authentication purposes. Block body will hold the details of the different transactions along with the generated hash code.

Ledger A ledger is a kind of database where confirmed transactions are recorded. Ledger is also called distributed databases. A ledger is maintained to hold the record of all the transactions. If anyone wants to modify the details of any
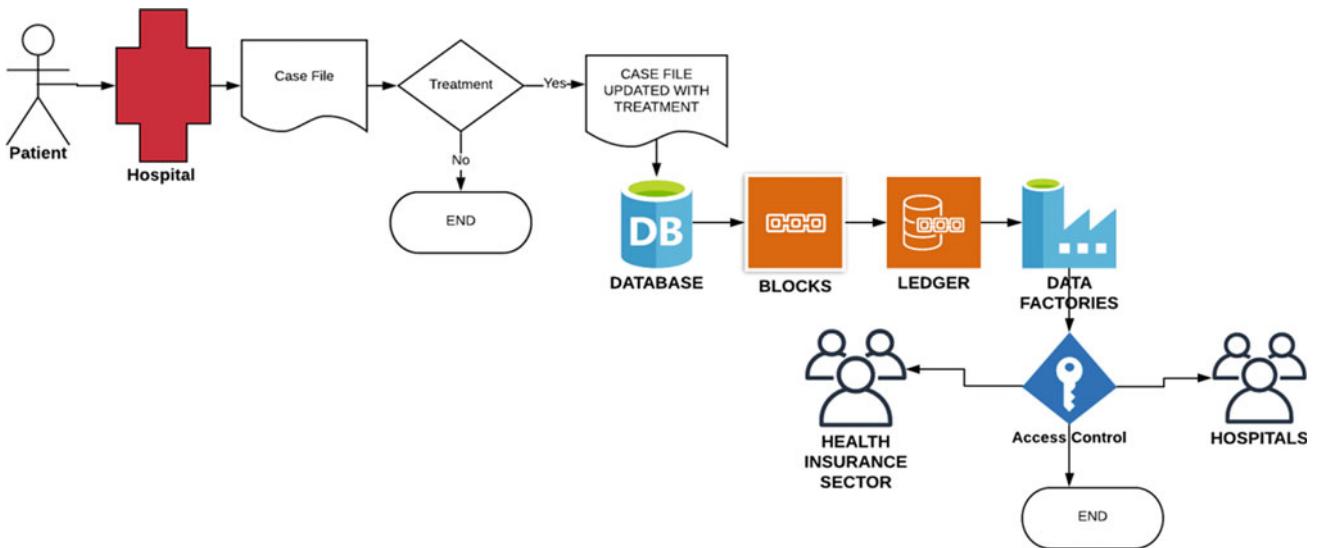
Fig. 1 Proposed model to preserve the privacy of the patient

patient, it is not possible. Once entry is recorded in a ledger, it cannot be modified, because it has a certain hash code. In our model, when the patient will approach the hospital for diagnosis or hospitalization, a digital document regarding his/her health will be generated, the next level Authority Setup algorithm to generate their master secret keys. Authority Setup algorithm will verify the detail, and the details will be updated to the ledger.

Data Factories These are the kind of repositories used for storing and processing data. It can be a cloud server. The patient history can be mined only by the health insurance providers and hospitals. The patient details will not be available on a public forum.

4 Conclusion

In this paper, researchers have been proposed the solution to addressing transparency and privacy in portability of health insurance all the way through blockchain technique. Suggested method confers the specific to the policyholder of health insurance to move the credit gained him for pre-existing conditions and time jump barring in case he chooses to switch the insurance provider. The aim is also to work in an ecosystem policy by integrating several partners from other fields (travel agencies, telecom, market, etc.) because the final goal is to promote, not only the insurance sector, but the economy as a whole.

References

Clim, A., et al. (2019). Data exchanges based on blockchain in m-Health applications. *Procedia Computer Science, 160*, 281–288.

Cohn, A., et al. (2017). *Smart after all: Blockchain, smart contracts, parametric insurance, and smart energy grids.* https://georgetownlawtechreview.org/wp-content/uploads/2017/04/Cohn-West-Parker-1-GEO.-L.-TECH.-REV.-273.pdf. Accessed on April 3, 2020.

Gatteschi, V., et al. (2018). To blockchain or not to blockchain: That is the question. *IT Professional, 20*(2), 62–74. https://doi.org/10.1109/mitp.2018.021921652. Accessed on April 3, 2020.

Kim, H., Kim, S.-H., Hwang, J. Y., & Seo, C. (2019). Efficient privacy-preserving machine learning for blockchain network. *IEEE Access*, 1–1. https://doi.org/10.1109/access.2019.2940052.

Kshetri, N. (2018). Blockchain and electronic healthcare records [cybertrust]. *Computer, 51*(12), 59–63. https://doi.org/10.1109/mc.2018.2880021.

Kumar, A. (2018). A review on implementation of digital image watermarking techniques using LSB and DWT. In *The Third International Conference on Information and Communication Technology for Sustainable Development (ICT4SD 2018), held during August 30–31, 2018 at Hotel Vivanta by Taj, Goa, India.*

Kumar, A., & Satyanarayana Reddy, S. S. (Eds.). (2021). *Advancements in security and privacy initiatives for multimedia images.* Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-7998-2795-5.

Kumar, A., & Srivastava, S. (2020). Object detection system based on convolution neural networks using single shot multi-box detector. *Procedia Computer Science, 171,* 2610–2617.

Kumar, A., Reddy, S. S. S. S., & Kulkarni, V. (2019). An object detection technique for blind people in real-time using deep neural network. In *2019 Fifth International Conference on Image Information Processing (ICIIP)*, Shimla, India, pp. 292–297. https://doi.org/10.1109/iciip47207.2019.8985965.

Li, H., Dai, Y., & Lin, X. (2015). Efficient e-health data release with consistency guarantee under differential privacy. In *2015 17th International Conference on E-Health Networking, Application & Services (HealthCom)*. https://doi.org/10.1109/healthcom.2015.7454576.

Liang, X., Zhao, J., Shetty, S., Liu, J., & Li, D. (2017). Integrating blockchain for data sharing and collaboration in mobile healthcare applications. In *2017 IEEE 28th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC)*. https://doi.org/10.1109/pimrc.2017.8292361.

Meskini, F. Z., & Aboulaich, R. (2019). Multi-agent based simulation of a smart insurance using Blockchain technology. In *2019 Third International Conference on Intelligent Computing in Data Sciences (ICDS)*, Marrakech, Morocco, 2019, pp. 1–6. https://doi.org/10.1109/icds47004.2019.8942270. Accessed on April 3, 2020.

Nath, I. (2016). Data exchange platform to fight insurance fraud on blockchain. In *2016 IEEE 16th International Conference on Data Mining Workshops (ICDMW)*. https://doi.org/10.1109/icdmw.2016.0121.

Raikwar, M., Mazumdar, S., Ruj, S., Sen Gupta, S., Chattopadhyay, A., & Lam, K.-Y. (2018). A blockchain framework for insurance processes. In *2018 9th IFIP International Conference on New Technologies, Mobility and Security (NTMS)*. https://doi.org/10.1109/ntms.2018.8328731.

Rawte, V., & Anuradha, G. (2015). Fraud detection in health insurance using data mining techniques. In *2015 International Conference on Communication, Information & Computing Technology (ICCICT)*, Mumbai, pp. 1–5.

Shah, B., Shah, N., Shakhla, S., & Sawant, V. (2018). Remodeling the healthcare industry by employing blockchain technology. In *2018 International Conference on Circuits and Systems in Digital Enterprise Technology (ICCSDET)*. https://doi.org/10.1109/iccsdet.2018.8821113.

Tang, F., Ma, S., Xiang, Y., & Lin, C. (2019). An efficient authentication scheme for blockchain-based electronic health records. *IEEE Access*, 1–1. https://doi.org/10.1109/access.2019.2904300. Accessed on April 3, 2020.

Vahdati, M. (2018). *A self-organized framework for insurance based on internet of things and blockchain.* IEEE. https://doi.org/10.1109/ficloud.2018.00032. Accessed on April 1, 2020

World Insurance Report 2019. https://worldinsurancereport.com/. Accessed on April 3, 2020.

Xiao, Y., Xiong, L., & Yuan, C. (2010). Differentially private data release through multidimensional partitioning. In *Secure data management*. Springer, pp. 150–168.

Xinchi, H., et al. (2018). Toward privacy-assured health insurance claims. In: *2018 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData)*, Halifax, NS, Canada, 2018, pp. 1634–1641.

Zhang, P., Schmidt, D. C., White, J., & Lenz, G. (2018). Blockchain technology use cases in healthcare. *Advances in Computers*. https://doi.org/10.1016/bs.adcom.2018.03.006.

Zhou, L., Wang, L., & Sun, Y. (2018). MIStore: A blockchain-based medical insurance storage system. *Journal of Medical Systems, 42*, 149. https://doi.org/10.1007/s10916-018-0996-4. Accessed on April 3, 2020.

Improving Work Ethics Among Skilled Construction Workers Using Web-Based Systems

Adedeji Olushola Afolabi, Ibukun Afolabi, Sanjay Misra, Tomisin Faith Akinbo, and Ravin Ahuja

Abstract

The construction industry suffers from many unethical practices which lead to quality problems in the sector. With many clients dissatisfied with the workmanship of skilled labor, the study developed a web-based system to improve work ethics among skilled construction workers. The framework was developed using use case and system block diagram. In this study, HTML, CSS, MySQL and Java programming language were used in the design of the web-based system. The result was presented using screenshot. The designed interface includes the registration page, make request, make payment and rate the level of workmanship. With the introduction of the payment platform and rating system for skilled laborers, the work ethics is intended to be improved. This web-based system can be deployed by skilled labor outsourcing firms to enhance the work ethics of their skilled labor workers.

1 Introduction

In the study by Afolabi et al. (2018), the skilled labor in the construction sector plays a crucial role due to their skill set and in turn their input affects the final outcome of products in the construction industry. Afolabi et al. (2016) further pointed out that attaining quality on construction projects is hinged on the abilities of the skilled laborer. Therefore, there is need to attract, retain and encourage the best talents among skilled laborers so as to deliver quality products to prospective clients in the construction sector, whereas the construction sector has been perceived to have a poor image due to the challenges related to the poor workmanship in the sector. The study by Afolabi et al. (2018) reported issues about cost and time overrun, quality deficiencies, low-profit margins for contractors and building collapse are examples of the result of poor productivity of skilled laborers. To improve the image of the construction sector and the productivity of workers, there is need to enhance the work ethics and professionalism in the sector. In the studies by Vee and Skitmore (2003), Pearl and Bowen (2005), Fan and Fox (2005), Mohamad and Abdul-Aziz (2009), the construction industry suffers from many ethical issues. As Dindi (2016) pointed out, ethics is important for the construction, however, the construction industry continues to experience some form of ethical problems. In the Transparency International (2005), the construction industry finds itself in an ethical dilemma as it was regarded as the most fraudulent sector worldwide. The susceptibility of the sector to unethical practices is due to the capital-intensive nature of the sector. According to Adnan et al. (2012), the detrimental

A. O. Afolabi · T. F. Akinbo
Department of Building Technology, Covenant University, Ota, Nigeria
e-mail: adedeji.afolabi@covenantuniversity.edu.ng

T. F. Akinbo
e-mail: tomisin.akinbo@covenantuniversity.edu.ng

I. Afolabi
Department of Computer and Information Sciences, Covenant University, Ota, Nigeria
e-mail: ibukun.fatudimu@covenantuniversity.edu.ng

S. Misra (✉)
Department of Computer Engineering, Covenant University, Ota, Nigeria
e-mail: sanjay.misra@covenantuniversity.edu.ng

R. Ahuja
ShriVishwkarma Skill University, Gurgaon, India
e-mail: ravinahujadce@gmail.com

413

effects of unethical practices in the construction sector are long lasting, thereby increasing the poor reputation risk.

The construction industry including the maintenance sector is one of the largest employers in the Nigerian economy (Loosemore et al. 2003; Fagbenle et al. 2012; Afolabi and Oyeyipo 2017). However, there is still shortage been reported in several studies on skilled laborers in the construction sector (Afolabi et al. 2018; Erlich and Grabelsky 2005; McGrath-Champ et al. 2011). However, the studies by Afolabi et al. (2018) and Afolabi et al. (2018) have suggested the use of information technologies in locating the appropriate skilled labor needed per time by contractors. Albeit, there is need to be concerned about the productivity and the work ethics of workers in such sector. There is still the need to measure the performance of the skilled labor on the job. The International Labour Organization, ILO (2018) noted that the use of online digital labor platforms have transformed the landscape of the world of work by disrupting existing business models.

Using online systems for sourcing for skilled labor is one thing. But, using information technologies to manage ethical practices is the idea that this study posits. Mohamad and Abdul-Aziz (2009) argued that it is a firm's responsibility to get employees to respond positively to moral values. So, firms during their recruitment and selection process are looking for candidates that are ethical. Using ethics as a criteria in selection and promotion decisions is a suggestion put forward by Mortensen et al. (1989). Mohamad and Abdul-Aziz (2009) noted that a worker's contribution in terms of his or her values and behavior at work should be a performance measurement criteria which should be included with the technical capabilities of the employee. Goessl (2013) noted that businesses that practice and promote strong ethic base are more profitable on the long run due to their commitment to sound moral values among their leadership and employees. Therefore, in this study, it is expected that a web-based system would be developed to help improve the work ethics of skilled labor workers in the construction industry.

2   Review of Related Literature

Several studies have been carried out on professionalism and ethical considerations in the construction industry (Mohamad and Abdul-Aziz 2009; Abdul-Rahman et al. 2010). Many of the studies have been concerned with the quality deficiency that result from poor ethical standards among construction stakeholders. As Besterfield et al. (2003) argued in their study that quality in the construction industry is dependent on ethical behavior of the professionals. In simple terms, ethical behavior is simply doing the right things in the right way. Therefore, Abdul-Rahman et al. (2010) opined that low ethical standards will ultimately lead to quality problems in the construction sector. Many of the past researches have focused on the work ethics of construction professionals while neglecting skilled laborers. As earlier stated in this study, skilled laborers form the crux of quality attainment in any construction project. There is need to consider the work ethics among them. Afolabi et al. (2016) affirmed that the place of craftsmanship is central to the needs of the construction industry. Construction firms have complained about the poor work ethics among skilled laborer. Consequently, leading to poor work done on repairs and new construction sites. Hence, construction firms have found it hard to fill vacant spaces for competent skilled laborers (Odusami and Ene 2011; Oluwale et al. 2013; Oseghale et al. 2015). In the Nigerian scenario, it has been hard filling vacant positions for painters, carpenters, bricklayers and plumbers with adequately skilled workers (Oluwale et al. 2013; Oseghale et al. 2015). The major problem in the shortage of skilled laborers in Nigeria has been finding the competent ones.

In order to successfully locate the skilled laborers needed per time on a construction project, (Afolabi et al. 2018) designed a web-based system to connect the skilled laborers with where they are needed. Contractors are able to search via the web-based skilled labor recruiting platform based on input variables such as age, years of experience, type of skill, attitude to work, expected wages and so on. Other recruitment platforms have been developed for other sectors in the economy (Oluwagbemi and Akinsaya 2010; Parkar et al. 2011; Akinyede and Daramola 2013). With these kind of platforms, ethics can be put forward as an assessment performance metrics of workers from the firm's leadership. For instance, customer satisfaction, attitude and behavior feedback have been well used in ride-hailing services, in banking, use of SIM card (Balachandran and Bin Hamzah 2017; Etminani-Ghasrodashti and Hamidi 2019; Oyediran et al. 2019; Ogwueleka et al. 2015). The use of customer satisfaction feedback in these online platforms has increase competition in the transportation industry, increased professionalism and service quality. The trip characteristics of the ride-hailing services such as been able to check the details of the driver, the cost of trip and ability to rate the driver afterwards are determinants that engender riders toward the online ride-hailing apps. Other e-commerce platforms also use this feedback mechanisms from customers to monitor the quality of their service and improve client satisfaction. If this can be achieved in other sectors,

the construction industry can use online platforms to monitor the productivity of their workers by getting customer feedback on skilled laborers.

3 System Design and Implementation

The study developed a web-based system to improve work ethics among skilled construction workers. In the system design, the study followed the patterns of the unified modeling language (UML) used in Afolabi et al. (2019a, b). The UML used use case diagrams and system block diagram. The coding language included HTML for the interface, CSS, MySQL for the database and Java programming language in the NetBeans IDE. In the use case diagram, shown in Fig. 1, there are two main users—the skilled labor firm administrator and the client/customer. In Fig. 1, there are three main interface the administrator can access, whereas the client/customer can access four main interfaces.
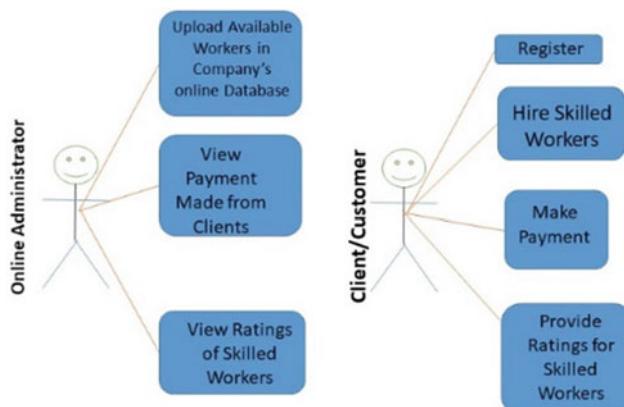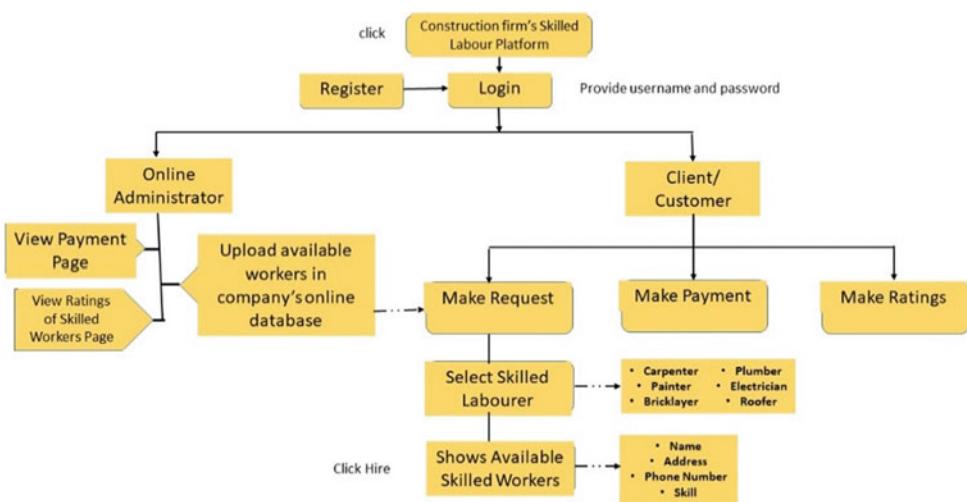
Fig. 1 Use case diagram for the web-based system to improve work ethics. *Source* Author's design

In the UML diagram, the system block diagram in Fig. 2 showed the flow of the process in the web-based system.

The web-based system for skilled labor rating was developed and presented in screenshots. Figure 3 showed the registration page for the web-based system. Clients/Customers can access the web-based system for skilled labor rating via a URL on an Internet-connected laptop or smart device. In Fig. 3, the clients/customers can open an account by supplying input variables of name, address, username and password. Figure 4 showed the login page which highlighted the username and password of the clients/customers in need of skilled labor for their maintenance works.

Once the clients/customers log into the web-based system, they are ushered into the homepage of the web-based system for skilled labor rating. The homepage which comprises of the About page, Services page and logout icon. The Make Request icon is also visible. The client/customer can then make a request which leads to Fig. 5. In Fig. 5, the clients/customers can fill the form by supplying information of Name, Email, and Message and click send. This leads to Fig. 6 which showed the different skilled labor within the skilled labor outsourcing firm. Once the client/customer clicks the skilled labor needed, Fig. 7 showed the list of available skilled labor within the vicinity of the client/customer. The customer is able to access the Name, Address, Phone Number and Job Type of the skilled labor needed and then click on Hire in Fig. 7. This sends an alert to the skilled labor that has been hired to report for work at the client/customer's house for the maintenance work needed. Figure 8 is the essential part of this study which encourages good work ethics among skilled laborers. The web-based system aims to get client/customer feedback on payment and rating of skilled labor works on maintenance works. Figure 8 showed the rating platform for the skilled

Fig. 2 System block diagram for the web-based system to improve work ethics. *Source* Author's design
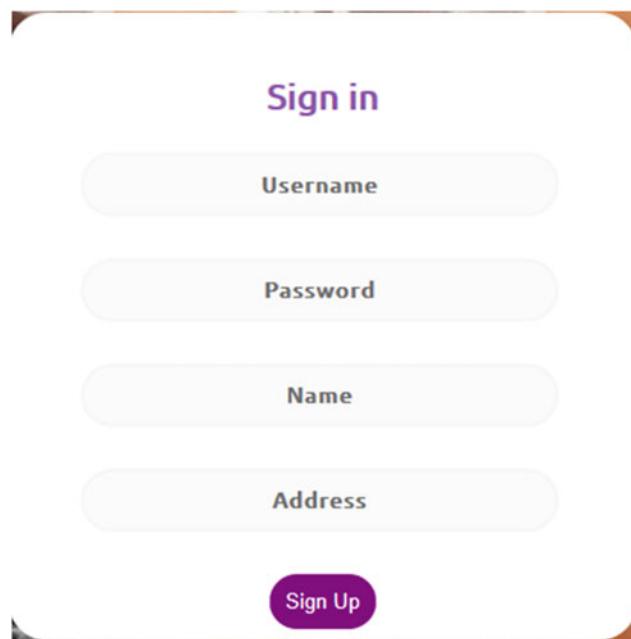
Fig. 3 Registration page in the web-based system for skilled labor rating
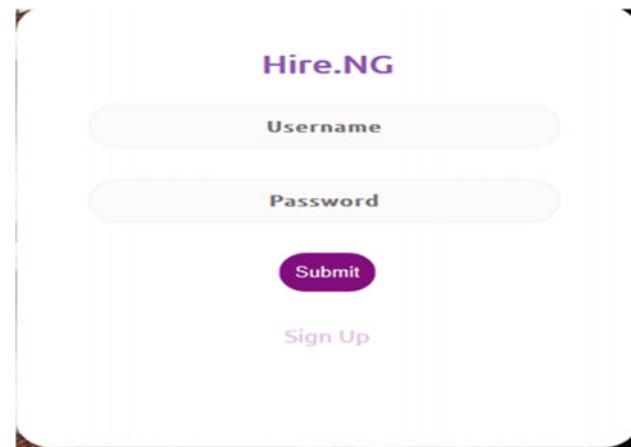
Fig. 4 Login page in the web-based system for skilled labor rating

labor performance. The rating system uses a 1–5-star performance rating.

Figure 9 showed a screenshot of the database of the skilled labor outsourcing firm and the skilled laborers they have stored. In Fig. 10, a sample of the Java programming language is shown. The study when compared with previous studies showed that other studies did not engender a client/customer feedback rating system. In this web-based system, it is depicted in Fig. 8; the rating assessment of the work is done. This is in line with the unethical practices of graft, corruption, payment woes, and bribery which this study intends to help curtail through an online paying system. With the advantage of an online client/customer feedback system, the skilled laborers can develop better work ethics on the job. This is an assertion that has worked in other industries such as e-commerce and ride-hailing industries (Balachandran and Bin Hamzah 2017; Etminani-Ghasrodashti and Hamidi 2019). The use of client/customer satisfaction feedback in these online platforms has increased competition, increased professionalism and service quality.

Fig. 5 User make request page in the web-based system for skilled labor rating
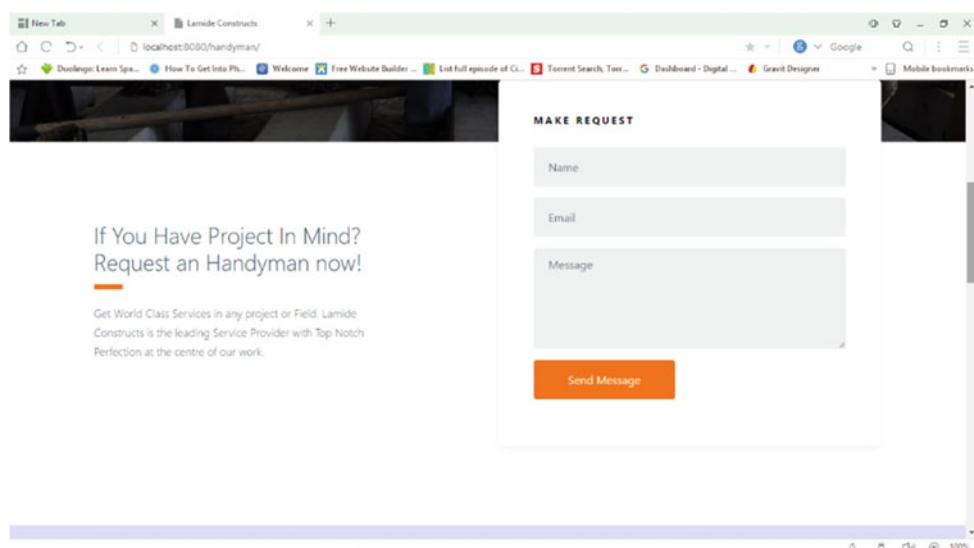
Fig. 6 Selection of skilled laborer in the web-based system for skilled labor rating
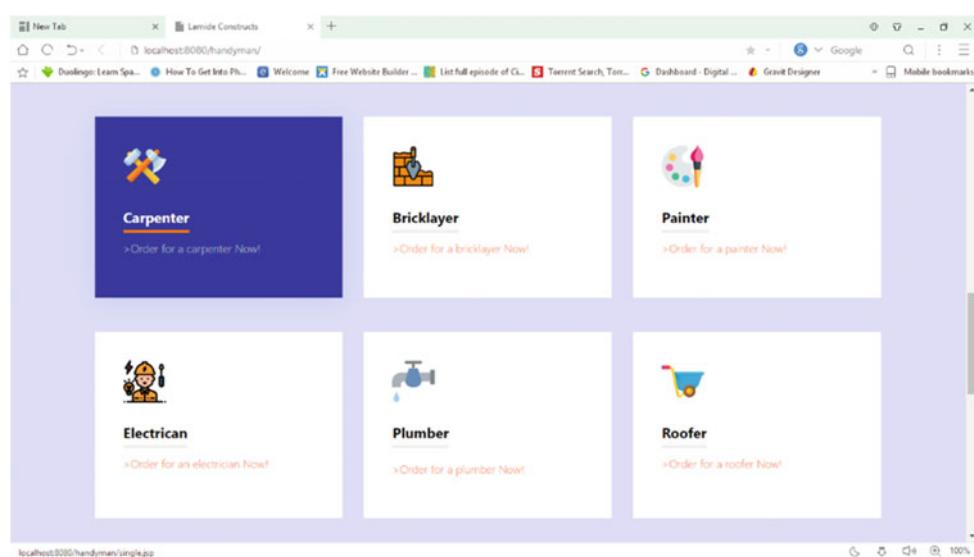
Fig. 7 Available skilled laborers' page in the web-based system for skilled labor rating
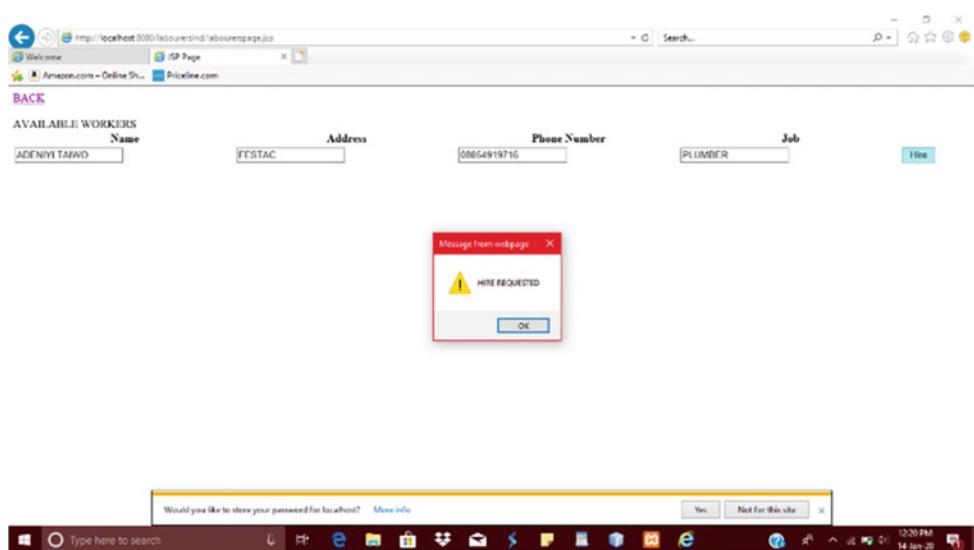
Fig. 8 Rating page in the web-based system
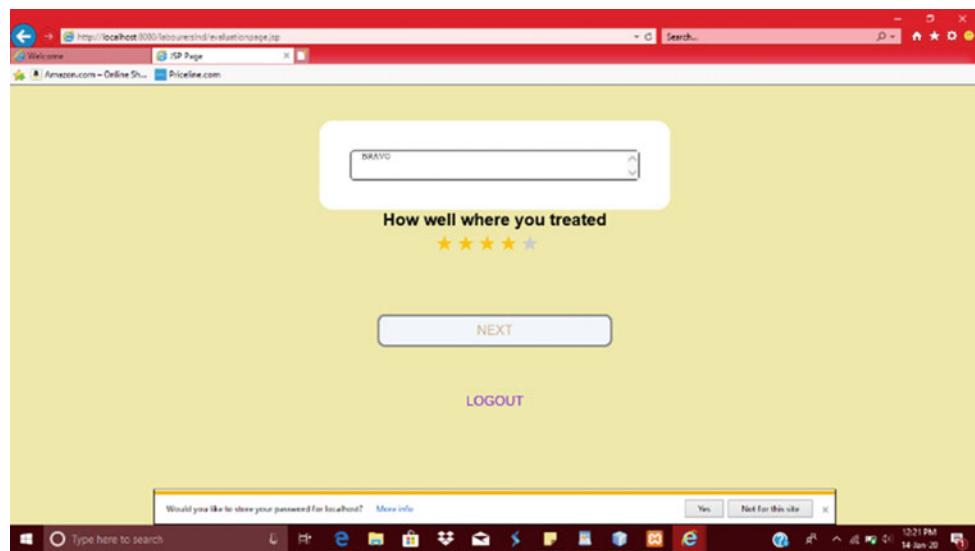
Fig. 9 Company database of skilled labor workers
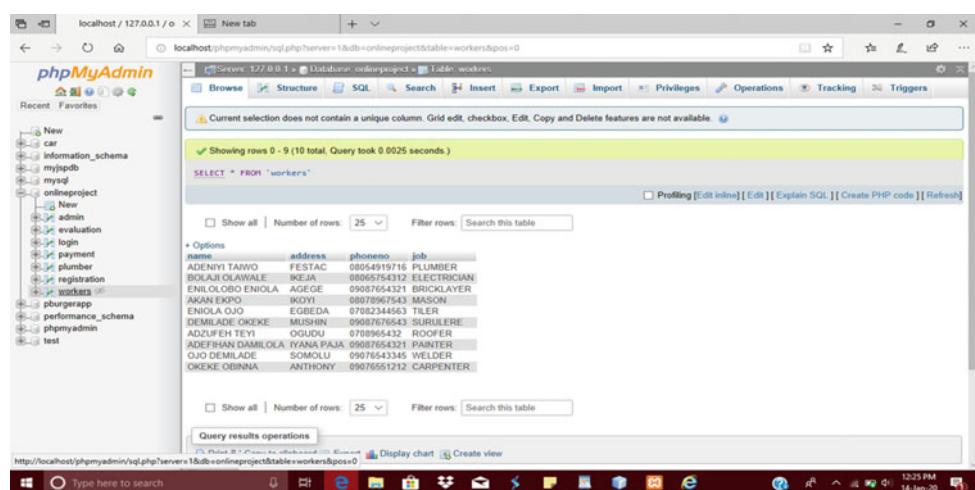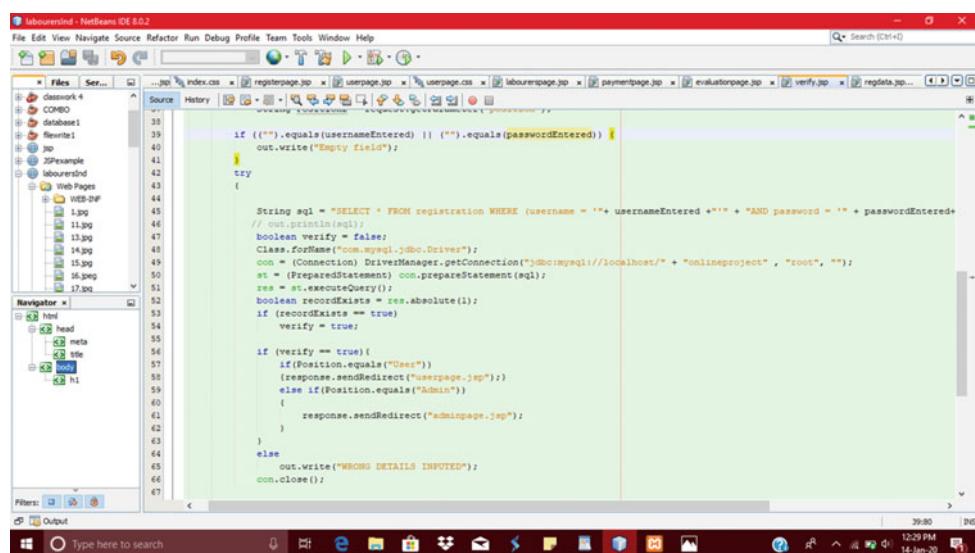
Fig. 10 Sample of Java programming language in NetBeans IDE

4 Conclusion

The study developed a web-based system to improve work ethics among skilled construction workers. In this study, HTML, CSS, MySQL and Java programming language were used in the design of the web-based system. The result was presented using screenshot. The designed interface includes the registration page, make request, make payment and rate the level of workmanship. With the introduction of the payment platform and rating system for skilled laborers, the work ethics is intended to be improved. This web-based system can be deployed by skilled labor outsourcing firms to enhance the work ethics of their skilled labor workers.

References

Abdul-Rahman, H., Wang, C., & Yap, X. W. (2010). How Professional ethics impact construction quality: Perception and evidence in a fast developing economy. *Scientific Research and Essays, 5*(23), 3742–3749.

Adnan, H., Hashim, N., Mohd Yusuwan, N., & Ahmad, N. (2012). Ethical issues in the construction industry: Contractor's perspective. *Procedia—Social and Behavioral Sciences, 35,* 719–727.

Afolabi, A., Afolabi, I., Eshofonie, E., & Akinbo, F. (2019). Improving employability skills through a web-based work integrated learning database for construction students. In: S. Misra et al. (Eds.), ICCSA 2019, LNCS 11623, Chapter 31, Springer Nature, pp. 1–11.

Afolabi, A. O., Emeghe, I., Oyeyipo, O., & Ojelabi, R. A. (2016). Professionals' preference for migrant craftsmen in lagos state. *Mediterranean Journal of Social Sciences, 7*(1), 501–508.

Afolabi, A., Eshofonie, E., & Akinbo, F. (2019). Development of an alumni feedback system for curriculum improvement in building technology courses. In: S. Misra et al. (Eds.), ICCSA 2019, LNCS 11623, Chapter 21, Springer Nature, pp. 1–9 (2019).

Afolabi, A. O., Fagbenle, O., Ojelabi, R., Amusan, L., Tunji-Olayeni, P., & Daniyan, V. (2018). Development of a web-based human resource sourcing system for labour only contracts. In *Construction Research Congress 2018: Construction Information Technology—Selected Papers from the Construction Research Congress 2018,* April 2018, pp. 736–746.

Afolabi, A., & Oyeyipo, O. (2017). The perception of future decision makers on the building profession. *Malaysian Construction Research Journal, 21*(1), 55–73.

Afolabi, A., Oyeyipo, O., Ojelabi, R., & Amusan, L. (2018b). Construction professionals' perception of a web-based recruiting system for skilled labour. *Journal of Theoretical and Applied Information Technology, 96*(10), 2885–2899.

Akinyede, R. O., & Daramola, O. A. (2013). Neural network web-based human resource management system model. *International Journal of Computer Networks and Communications Security, 1*(3), 75–87.

Balachandran, I., & Bin Hamzah, I. (2017). The influence of customer satisfaction on ride-sharing services in Malaysia. *International Journal of Accounting & Business Management, 5*(2), 814–826.

Besterfield, D. H., Michna, C. B., Besterfield, G. H., & Sacre, M. B. (2003). *Total quality management* (3rd ed.). USA: Prentice Hall.

Dindi, A. (2016). Ethics in construction. *The Quantity Surveyor, 20*(1), 1–5.

Erlich, M., & Grabelsky, J. (2005). Standing at the crossroads: The building trades in the twenty-first century. *Labor History, 46*(4), 421–445.

Etminani-Ghasrodashti, R., & Hamidi, S. (2019). Individuals' demand for ride-hailing services: Investigating the combined effects of attitudinal factors, land use, and travel attributes on demand for app-based taxis in Tehran, Iran. *Sustainability, 11*(5755), 1–19.

Fagbenle, O. I., Lawal, P. O., & Omuh, I. O. (2012). The influence of training on bricklayers' productivity in Nigeria. *International Journal of Management, Sciences and Business Research, 1*(7), 1–13.

Fan, C. N. L., & Fox, P. W. (2005). *Ethical Issues in the construction industry.* Hong Kong: Construction Industry Institute.

Goessl, L. (2013). Understanding the relationship between business and ethics. *Inside Business, 360.*

International Labour Organization, ILO. (2018). *Digital labour platforms and the future of work: Towards decent work in the online world.* Geneva: International Labour Office, ILO.

Loosemore, M., Dainty, A., & Lingard, H. (2003). *Human resource in construction projects' strategic and operational approaches.* London: Spon Press.

McGrath-Champ, S., Rosewarne, S., & Rittau, Y. (2011). From one skill shortage to the next: The Australian construction industry and geographies of a global labour market. *Journal of Industrial Relations, 53*(4), 467–485.

Mohamad, N., & Abdul-Aziz, R. (2009). Towards improving ethical practices in the construction industry. In *Global Innovation in Construction Conference,* Loughborough, UK, pp. 492–502.

Mortensen, R. A., Smith, J. E., & Cavangh, G. F. (1989). The importance of ethics to job performance: An empirical investigation of manager's perceptions. *Journal of Business Ethics, 8,* 253–260.

Odusami, K. T., & Ene, G. U. (2011). *Tackling the shortage of construction skills in Nigeria. A paper presented at a2-day national seminar organized by the Nigerian Institute of Quantity Surveyors, vision 20–2020.* Strategic Industry Development within National Development Goals in Abuja.

Ogwueleka, F. N., Misra, S., Colomo-Palacios, R., & Fernandez, L. (2015). Neural network and classification approach in identifying customer behavior in the banking sector: A case study of an international bank. *Human Factors and Ergonomics in Manufacturing & Service Industries, 25*(1), 28–42.

Oluwagbemi, O. O., & Akinsaya, A. (2010). Development of a medical staff recruitment system for teaching hospitals in Nigeria. *International Journal of Natural and Applied Sciences, 6*(1), 116–124.

Oluwale, B. A., Jegede, O. O., & Olamade, O. O. (2013). Technical and vocational skills depletion in Nigeria and the need for policy intervention. *International Journal of Vocational and Technical Education, 5*(6), 100–109.

Oseghale, B. O., Abiola-Falemu, J. O., & Oseghale, G. E. (2015). An evaluation of skilled labour shortage in selected construction firms in Edo state, Nigeria. *American Journal of Engineering Research (AJER), 4*(1), 156–167.

Oyediran, O., Omoshule, A., Misra, S., Maskeliūnas, R., & Damaševičius, R. (2019). Attitude of mobile telecommunication subscribers towards sim card registration in Lagos State, Southwestern Nigeria. *International Journal of System Assurance Engineering and Management, 10*(4), 783–791.

Parkar, V. V., Shinde, P. P., Gadade, S. C., & Shinde, P. M. (2011). Utilization of Laravel framework for development of web based recruitment tool. *Journal of Computer Engineering,* 36–41.

Pearl, R., Bowen, P., & Makanjee N. (2005). Professional ethics in the South African construction industry—A pilot study. In *The Queensland University of Technology Research Week International Conference*, July 4–8, 2005, Queensland University of Technology, Brisbane, Australia.

Transparency International. (2005). *The global corruption report 2005*. London: Pluto Press.

Vee, C., & Skitmore, M. (2003). Professional ethics in the construction industry. *Engineering, Construction and Architectural Management, 10*(2), 117–127.

From Modeling to Code Generation: An Enhanced and Integrated Approach

Oluwasefunmi Tale Arogundade, Olutimi Onilede, Sanjay Misra, Olusola Abayomi-Alli, Modupe Odusami, and Jonathan Oluranti

Abstract

Information system drives every aspect of human endeavor, and it is a major stakeholder in human existence. Systems with poor modeling suffer a lot from poor implementation down to poor performance due to lack of critical subjection and testing. Software modeling is, therefore, of paramount importance in order to achieve a reliable system. There has been a lot of works done in software modeling, and eventually, the Universal Modeling Language was formulated to create a standard for software modeling. Although there have been some development or modeling tools that can be used to model a software system and the design then converted to software codes that can then be perfected, none of these tools has considered security and integrated as a single tool. Therefore, this paper focuses on building an integrated system (all-encompassing system) for building UMLsec-based modeled systems that will convert UML diagrams to code. The system integrates Eclipse Mars incorporated with Papyrus modeling plug-ins and Eclipse Kepler with Java EE incorporated with CARiSMA plug-ins. These four tools were integrated together by an executable application built with NetBeans. The system was tested by modeling an e-government system from the class diagram to analysis and code generation.

1 Introduction

Software modeling is of paramount importance in order to achieve a reliable system (John and Edinbarough 2017). This is one of the areas of enhancing software development process with a focus on tackling complexities (Hovsepyan et al. 2014). A well-defined software development process using appropriate development methods and tools automatically provides high software quality (Wallin 2002). Poorly modeled systems suffer from poor implementation to poor performance due to the lack of critical subjection and testing. There has been a lot of work done in software modeling, and eventually, the Universal Modeling Language was formulated to create a standard for software modeling (Kaur and Singh 2009). The growth of UML recently has helped in the area of communication and documentation with a focus on tasks that do not need a formal semantics tool support (Broy and Cengarle 2011).

With UML standard, there are many challenges and issues about modeling software, particularly, how perfect a model can be translated to the software.

There have been some development or modeling tools that can be used to model a software system and then converted to a software code that can then be perfected, but none of these has been integrated into single automated tool. This paper focuses on building an automated system for building UML-based modeled system that will convert UML diagrams to code and verify such a model.

O. T. Arogundade · O. Onilede
Deparment of Computer Science, Federal University of Agriculture Abeokuta, Abeokuta, Nigeria
e-mail: arogundadeot@amss.ac.cn

O. Onilede
e-mail: oniledeo@babcock.edu.ng

S. Misra (✉) · O. Abayomi-Alli · M. Odusami · J. Oluranti
Department of Electrical and Information Engineering, Covenant University, Ota, Nigeria
e-mail: sanjay.misra@covenantuniversity.edu.ng

O. Abayomi-Alli
e-mail: olusola.abayomi-alli@covenantuniversity.edu.ng

M. Odusami
e-mail: modupe.odusami@covenantuniversity.edu.ng

J. Oluranti
e-mail: jonathan.oluranti@covenantuniversity.edu.ng

Considering existing modeling tools for UML diagrams, there has been none with the capability of converting UML diagrams to programming code and verifying the programmability or compatibility of such code to the programming language to which the diagrams were converted. This problem is impeding the further development in UML such that a solution to it will greatly enhance the software development process. Therefore, this study aims to develop an automated verification system that will enhance some selected modeling platforms in the process of software development. The scope of this study is limited to the automating the verification of UML diagram by converting the class diagram to Java code. The remaining paper is sectioned as: Sect. 2 describes in detail existing studies, while Sect. 3 discusses extensively the proposed system design. Section 4 presents the proposed system methodology, while Sect. 5 explains the implementation and testing, Sect. 6 discusses the results obtained, and the paper concludes in Sect. 7 with future recommendations.

2 Literature Review

An overview of existing literatures by previous researchers is analyzed in this section.

Ciccizzi et al. (2012) gave an efficient implementation from source models based on the combination of Action Language for Foundational UML with UML. Authors further developed an industrial embedded system through exploiting a model-driven engineering approach. The study was able to improve productivity and also combat possible errors relating to code-based approaches. Ringert et al. (2014) introduced a conceptual framework for generating code composition based on MontiArcAutomation. The study was able to effectively integrate generated code in post hoc application-distinct languages for modeling robotics SE. Authors stated the need to widen applications on syntax, approach, and technical solutions. Further subsections discuss the related studies and the comparison of this study to the previous work.

2.1 Related Works

This subsection gives a detailed review of different automated verification tools for UML models.

Arogundade et al. (2018) improved on the design of a reliable UML profile for civil status and rights and validating the model using Object Constraint Language (OCL) and Papyrus. Noyer et al. (2014) employed code generators to generate source code from UML models based on standardized extensible markup language metadata interchange (XMI) format. This method is achieved by conceiving metamodels for application programming model interfaces of UML tools, after which the code generators can produce the source code. Shiferaw and Jena (2018) described an adequate depiction of the UML model as well as the development of an enabling environment for display. The approach identifies system functionality with a platform-independent model and generates executable source code from the model. Thus, the usability of every single object is identified through the UML statechart diagram. Bhullar et al. (2016) presented an approach for code generation using behavioral UML diagrams such as activity diagrams, sequence diagrams, and use case diagrams. The result shows that no method is ideal for giving a 100% code generation. However, some enhancement methods are required to improve the code generation. Yamada (Yamada and Wasaki 2011) presented an approach that models on the design specification of software using formal language and verifies it by the model checker. The approach converts the UML activity diagram automatically into the SPIN model checking code PROMELA. An extension of the SPIN notation PROMELA was used in addition to other primitives for modeling simultaneous object-oriented systems, which comprises class definition, object instantiation, message sent, and synchronization (Jiang 2009). Amirat et al. (2012) presented an automated conversion of UML sequence diagrams with imbricate connected fragment to PROMELA code. This approach is used to simulate the execution and to verify properties written in linear temporal logic with SPIN model checker.

Future studies have shown the tremendous growth in using UML for developing of security-critical systems. A typical instance from Kim et al. (2004) defines a method for specifying role-based access control policies for modeling UML designs (Poniszewska-Maranda 2012; Ray et al. 2004; Cenys et al. 2009). This model allows developers to specify behaviors of violations against the policies. In addition, Breu and Popp (2004) presented an approach for the specification of user rights using UML. The approach is based on first-order logic with a built-in notion of objects and classes with an algebraic semantics and can be realized in Object Constraint Language (OCL). Beckert (Beckert et al. 2002) presented logical reasoning based on UML models using the power of interactive theorem. Franconi et al. (2018) extended the study by Beckert et al. (2002) by identifying and discussing the fragments of OLC using relational algebraic query. Thapa et al. (2010) used the UML metamodel extension mechanism given as profiles to verify whether a UML design model gratifies its domain-distinct security and time-related requirements in an integrated tool environment. UMLsec and MARTE (UML profile for Modeling and Analysis of Real-Time and Embedded systems) were combined into the UML metamodel in tackling both security and timing properties.

Sebastian et al. (2020) investigated model-driven architecture based on scientific evidence by carrying out a systematic literature review on model-driven approaches in software engineering. The authors concluded that the most widely used language for modeling is UML. Sunitha and Samuel (2019) proposed a novel method for the implementation of state diagram comprising hierarchical, concurrent, and history states. Code generation was based on the UML state machine, and experimental results showed that the proposed model is a promising approach compared with other methods.

2.2 Comparison with Our Previous Work

This study is an extended version of previous work on Arogundade et al. (2016) with focus on developing an automated verification system that will enhance some selected modeling platforms in the process of software development. In our previous work, we were able to model with UML and also generated codes but unable to verify the programmability and compatibility of the code generated to Java which was the programming language used. However, this study was able to combine all the various tasks involved from modeling to code generation into a single platform through the development of a simple effective environment. Specifically, the proposed system is expected to automate the process of drawing class diagrams for a system, convert it to Java code, and analyze the diagram in CARiSMA.

To the best of our knowledge, none of the existing studies on binding UML to model checkers has been extended to analyzing UMLsec models. This study is motivated by the need to support security constructs. In addition to the translation of complex data types, which have proven to be an important aspect in supporting cryptography extension.

3 Research Methodology

The aim of modeling software system with UML and developing an integrated tool that convert UML class diagram into readable instructions is to give applicable solution and result which is aided by functional philosophy (Saunders et al. 2019). In order to achieve this result, there are various steps of build and process method derived from design research aspect that should be followed (Amaral 2011). This build and process method differs from design science research methodology strategy. The focus of this research is to design an integrated tool that enables software engineer to model the software using UML class diagram and generate codes from validated class diagram. The process begins with logical induction method to a more understanding of the

nature of challenges faced when the need arises for a structured and efficient model that will aid software engineer deliver their software in time without delay (Saunders et al. 2019).

The steps involved in the build and process approach will be enumerated before presenting the detail of the proposed methodology. The building process was launched on the part of framework for computing research methods which is in unison with the functional approach used (Holz et al. 2006). The relevant and useful aspects to this study were given consideration in the next section.

Framework for Computing Research

- What are we trying to establish?
    - a. (To search for more knowledge)—the researchers look for more information on modeling of software and analyzing the model for validation which will help in formalization of the model in a way that it is easy for a programmer to read and understand.
    - b. (To design an efficient process)—the author will model a software and develop an integrated tool that will convert the class diagram into readable instructions which is comprehensible to software developers.
- Where do we get the needed data from?
    - c. (SWOT)—the writers will review the literatures to know the strength, weakness, opportunities, and threats in the area of software modeling, with UML, analysis, and conversion of validated class diagram to readable and comprehensive codes.
    - d. (Be attentive, interaction)—the authors need to interact with database/IT officers in e-government service in Nigeria to acquaint themselves to the processes followed in carrying out their day-to-day activities. This step is necessary for a proper software process modeling.
    - e. (Model the process)—the authors will use UML to model the e-government domain used for validation.
    - f. (Gathering source)—the researchers will get useful and current information from the domains used in this study and from conceptual analysis of the literatures.
- What is the usefulness of the collected data?
    - g. (For better understanding of the process)—the authors will use the collected data for better understanding of the processes involved in e-government service for a good process modeling.
    - h. (Software modeling, formalization)—the researchers will design UML metamodel using class diagram and formalize with CARiSMA.

- Do the research purpose achieved?
  - i. (Verification of result, conclude)—the writers would have gained more knowledge on software modeling, and the conversion of class diagram by now develops a functioning tool. These authors will be able to verify the outcome of the model.
  - j. (Future work)—the authors will conclude from the design and process modeling and propose a future direction of the work.

3.1 System Design Considerations

This section shows the overall design of the system model incorporating security, portability, openness, and other important factors that make Java to edge other languages to be the focus of the design in this section. In this paper, the system requirement is divided into a functional and non-functional requirement.

Functional Requirement

These are statements of services the system should provide some of which include what response to anticipate from the system when some distinct inputs are administered and the likely behavior of the system, in distinct directions Sommerville (Sommerville 2011). A functional requirement indicates substance that the developer requires to compile in delivering the solution. They are listed below:

- i. The system shall grant the user to close the program when he has finished using the system.
- ii. The system shall grant user login based on their username and password.
- iii. The system will grant the user to choose the task to perform at any point in time.

Non-functional Requirement

These are system properties and constraints on functions provided, e.g., reliability and response time. One major property of the system is that it is portable; i.e., the system is platform-independent.

Apart from this, the system also has the following constraints:

- i. Users must log based on their username and password to use the system.
- ii. The password must be the complexity required.

User Requirements

They explain the needs of end-users from a system. They explain the actions that users must be able to carry out. These requirements are:

- i. Administrator shall be able to login with their username and password.
- ii. Admin must be able to carry out tasks.

3.2 Building the Installer Package

After building the application successfully, there is a need to bundle all the tools together so as to make deployment of the tools on another system to be easy and to eliminate the need for replication of the process of setting up the various components and requirements of the system.

This CARiSMA application was built to extract all the necessary installation files needed in Eclipse Kepler with CARiSMA plug-ins and Eclipse Mars with Papyrus plug-ins into a bundle wrapped together with the automating program to make a complete tool. With this bundle, the system becomes compact and can be copied easily and installable across any platform. Figures 1a, b and 2 show the different interfaces.

4 Implementation and Results

This section discusses the steps utilized in implementing and testing of the proposed system. For effective implementation of the proposed system, some design consideration must be met, such as:

- i. The computer on which the system must be run must have Eclipse Mars, Kepler applications running on them, in addition to the installation of Papyrus and CARiSMA plug-in, respectively.
- ii. The procurement of an appropriate computer system with enough configurations to run this system is an absolute requirement.

The specifications of the system and all the necessary requirements needed to run the proposed system were analyzed.

This system was developed and compiled as a Java executable program which could run on any operating system platform. There was no special installation required for this implementation. The process of deployment of the application is simply by executing build command on NetBeans and then copying the "dist" folder from the project directory as the Java application.

Wherever the dist folder is copied, the program can be launched by opening the folder and running the "emedical.jar" executable program.

**Fig. 1** Sample screen of Papyrus interface
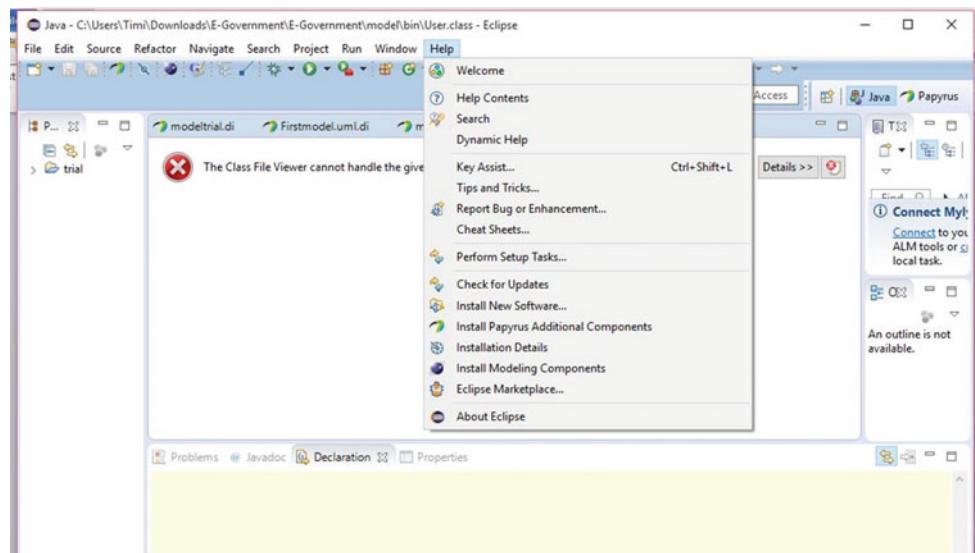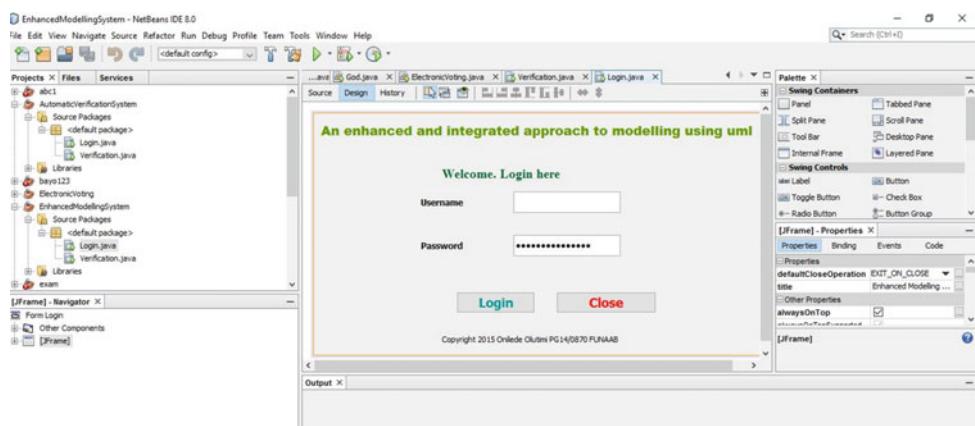
Fig. 2 Screenshot of NetBeans development environment

4.1 System Specification

This system was built with the following specifications:

- i. Interactive and control-based graphical user interface.
- ii. Object-Oriented Development.
- iii. Java 2 Programming Platform.
- iv. Native application.
- v. Multi-operating system compatible program.

4.2 Results

In the system design, a login page where a user is required to login to the system with a valid username and password is presented. The tasks pane will then be displayed to the user.

The user is expected to choose a task, and the system will automatically locate the right tool and open the platform for the task.

Menu Page: This page displays the menu for the administration of the system, indicating all that can be done by a user as depicted in Fig. 3, while Fig. 4 depicts the screenshot of the modeled system.
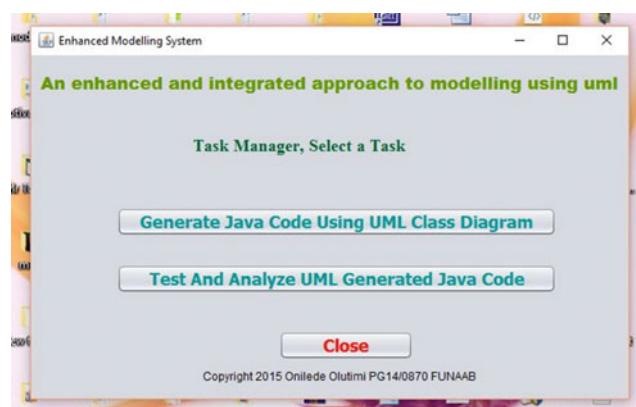
Fig. 3 Screenshot of the menu page
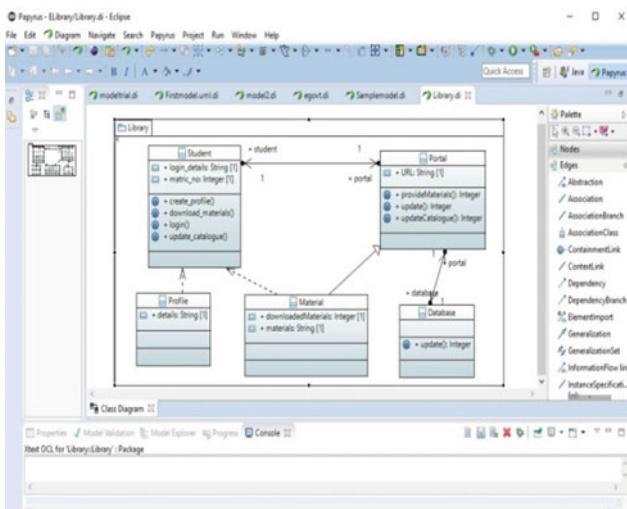
Fig. 4 Modeled system
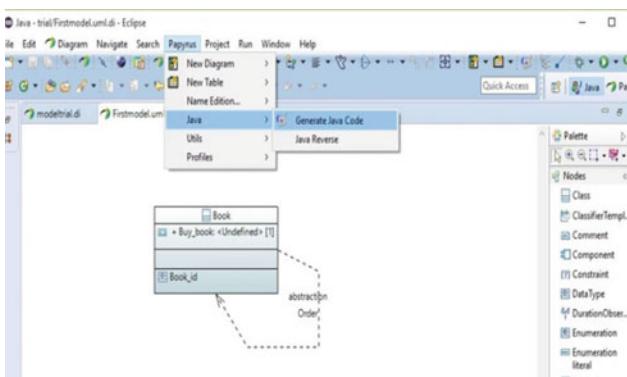
Fig. 5 Generating Java code from the modeled system

Generating Java Code: From the interface, the user can generate Java code for the diagram by going to Papyrus menu, selecting Java option and finally generating Java code as shown in Figs. 5 and 6.
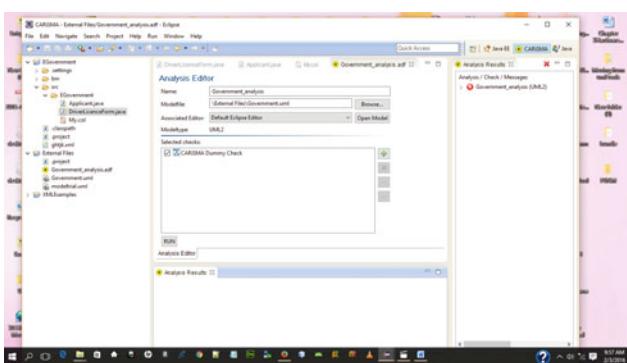
Fig. 6 Analyzing the generated code

5 Conclusion

The concept, design, construction, and implementation of this study clearly demonstrate the role of technology in driving the majority of human activities in the world today. Thus, there is no limit to the application of technology, as demonstrated in this study.

The concept and operation of this system are such that when the user intends to build an enterprise or large software, instead of going through the tedious process of writing all the code to build the software, such developer can use this tool such that he can come up with the class diagram of the system as a model and possibly build stereotypes needed to build a secure and robust system. These class diagrams can then be drawn by the Papyrus software development modeler. After drawing all the class diagrams of classes and stereotypes involved in Papyrus, it will then be converted to ODI file that will then be transported to Eclipse Kepler on which CARiSMA the analysis tool is installed.

The ODI file will be analyzed by CARiSMA, and a report on the usability and conformity of the class diagrams will be reported by the CARiSMA plug-in.

The proposed system can be adopted or implemented by any software modeler.

However, challenges identified during the implementation of the system include the difficulty and time consumption in conceptualizing the operation of the system. In addition, integrating three major Java studios on one system can also be tedious and especially while trying to configure CARiSMA and Papyrus. Finally, the development of the proposed system was quite challenging but exploratory and exposing.

Future Research Direction

The future recommendation is to develop a more robust system with a focus on UMLSecrisk. We intend to explore in-depth understanding on how to implement stereotypes with class diagram for a more enhanced system.

References

Amaral, J. N., et al. (2011). *About computing science research methodology*. Edmonton, Alberta, Canada. https://doi.org/10.1.1.124.702.

Amirat, A., Menasria, A., Oubelli, M. A., & Younsi, N. (2012). Automatic generation of PROMELA code from sequence diagram with imbricate combined fragments. In *2nd International Conference on the Innovative Computing Technology (INTECH 2012)*, pp. 111–116. IEEE.

Arogundade, O.'T., Adubiagbe, H. K., Ojokoh, B. A., & Mustapha, A. M. (2016). Design and validation of e-motoring services model. *FUTA Journal of Research in Sciences, 12*(2), 307–324.

Arogundade, O. T., Ogunyinka, B. A., Mustapha, A. M., & Asahiah, F. O. (2018). A validated model for secured e-government services: A case study of civil status and rights. *Journal of Science and Technology (IJoST), 2*(1), 92–112.

Beckert, B., Keller, U., & Schmitt, P. H. (2002). Translating the object constraint language into first-order predicate logic. In *Proceedings of the VERIFY Workshop at Federated Logic Conferences (FLoC)*, pp. 113–123.

Bhullar, N. S., Chhabra, B., & Verma, A. (2016). Exploration of UML diagrams based on code generation methods. In *International Conference on Inventive Computation Technologies (ICICT)*, Vol. 2, pp. 1–6. IEEE.

Breu, R., & Popp, G. (2004). Actor-centric modeling of user rights. In: *International Conference on Fundamental Approaches to Software Engineering*, pp. 165–179. Berlin, Heidelberg: Springer.

Broy, M., & Cengarle, M. V. (2011). UML formal semantics: Lessons learned. *Software & Systems Modeling, 10*(4), 441–446.

Cenys, A., Normantas, A., & Radvilavicius, L. (2009). Designing role-based access control policies with UML. *The Journal of Engineering Science and Technology Review, 2*(1), 48–50.

Ciccozzi, F., Cicchetti, A., Sjödin, M. (2012). Full code generation from UML models for complex embedded systems. In: *Second International Software Technology Exchange Workshop (STEW)*, Kista.

Franconi, E., Mosca, A., Oriol Hilari, X., Rull, G., & Teniente López, E. (2018). OCLFO: first-order expressive OCL constraints for efficient integrity checking. *Software and Systems Modeling*, 1–23

Holz, H. J., Applin, A., Haberman, B., Joyce, D., Purchase, H., & Reed, C. (2006). Research methods in computing. In: *Working Group Reports on ITiCSE on Innovation and Technology in Computer Science Education—ITiCSE-WGR 2006* (p. 96). New York: ACM Press. https://doi.org/10.1145/1189215.1189180

Hovsepyan, A., Van Landuyt, D., Michiels, S., Joosen, W., Rangel, G., Fernandez Briones, J., & Depauw, J. (2014). Model-driven software development of safety-critical avionics systems: An experience report. In: *1st International Workshop on Model-Driven Development Processes and Practices Co-located with ACM/IEEE 17th International Conference on Model-Driven Engineering Languages & Systems*, Vol. 1249, pp. 28–37.

Jiang, P., & Jonsson B. (2009). Using SPIN to model check concurrent algorithms, using a translation from C. In: *2nd Swedish workshop on multi-core computing (MCC09)*, pp. 1–9.

John, B., Kadadevaramath. R. S., & Edinbarough, I. A. (2017). A brief review of software reliability prediction models. *International Journal for Research in Applied Science and Engineering Technology (IJRASET), 5*(4), 990–997.

Kaur, H., Singh, P. (2009). UML (Unified Modeling Language): Standard language for software architecture development. In *International Symposium on Computing, Communication, and Control (ISCCC, 2009). Proceedings of CSIT*, Vol. 1, pp. 118–125.

Kim, D. K., Ray, I., France, R., & Li, N. (2004). Modeling role-based access control using parameterized UML models. In: *International Conference on Fundamental Approaches to Software Engineering*, pp. 180–193. Berlin, Heidelberg: Springer.

Noyer, A., Iyenghar, P., Pulvermueller, E., Pramme, F., Engelhardt, J., Samson, B., & Bikker, G. (2014). Tool independent code generation for the UML—Closing the gap between proprietary models and the standardized UML model. https://doi.org/10.5220/0004870701170125. In *Proceedings of the 9th International Conference on Evaluation of Novel Approaches to Software Engineering (ENASE-2014)*, pp. 117–125. ISBN: 978-989-758-030-7.

Poniszewska-Maranda, A. (2012). UML representation of extended role-based access control model with the use of usage control concept. In: *International Conference on Availability, Reliability, and Security*, pp. 131–145. Berlin, Heidelberg: Springer.

Ray, I., Li, N., France, R., & Kim, D.-K. (2004). Using UML to visualize role-based access control constraints. In *Conference: 9th ACM Symposium on Access Control Models and Technologies, Yorktown Heights*, New York, USA.

Ringert, J. O., Roth, A., Rumpe, B., & Wortmann, A. (2014). Code generator composition for model-driven engineering of robotics component & connector systems. In *MORSE 2014—1st International Workshop on Model-Driven Robot Software Engineering*, vol. 1319, pp. 66–77. York, Great Britain (2014).

Saunders, M. N. K., Lewis, P., & Thornhill, A. (2009). Understanding research philosophy and approaches to theory development. In: *Research Methods for Business Students* (pp. 128–170). Harlow: Pearson.

Sebastián, G., Gallud, J. A., & Tesoriero, R. (2020). Code generation using model driven architecture: A systematic mapping study. *Journal of Computer Languages, 56,* 100935.

Shiferaw, M.K., & Jena, A.K. (2018). Code generator for model-driven software development using UML models. In: *2nd International Conference on Electronics, Communication and Aerospace Technology (ICECA)*, pp. 1671–1678. IEEE.

Sommerville, I. (2011). *Software Engineering* (9th ed.).

Sunitha, E. V., & Samuel, P. (2019). Automatic code generation from UML state chart diagrams. *IEEE Access, 7,* 8591–8608.

Thapa, V., Song, E., & Kim, H. (2010). An approach to verifying security and timing properties in UML models. In: *15th IEEE International Conference on Engineering of Complex Computer Systems*, pp. 193–202. IEEE.

Wallin, C. (2002). *Verification and validation of software components and component-based software systems*. Extended Report, Artech House.

Yamada, Y., & Wasaki, K. (2011). Automatic generation of SPIN model checking code from UML activity diagram and its application to web application design. In: *7th International Conference on Digital Content, Multimedia Technology, and its Applications*, pp. 139–144. IEEE.

Performance Evaluation of Grid Connected SPV System Through FRC and ANFIS Techniques

Debasish Pattnaik, Sanhita Mishra, Ganesh Prasad Khuntia, Ritesh Dash, and Sarat Chandra Swain

Abstract

Inexhaustible grid interfacing framework is being elevated generally with a specific end goal to safe watch the utilization of ordinary sources of energy. Grid interconnection of high end inexhaustible sources with that of the grid causes unsettling influences and prompts the perpetual shutdown of the inverter. Customary controller, for example, linear controller and nonlinear controller perform well under adjusted state of activity; however, this controller ends up slow amid grid unsettling influences. Controller in view of AI techniques has been created in this way to deal with make the controller stable amid adjusted and un-adjusted state of activity. MATLAB Simulink-based framework has been created for checking the legitimacy of the proposed controller.

Keywords

Current control techniques • Fuzzy • Artificial neural fuzzy inference system • Solar PV system

1 Introduction

Sun-oriented photovoltaic grid associated framework has extensive variety of utilizations beginning from independent framework grid associated applications. Expanding in the productivity of sun powered cell additionally builds the execution of sunlight-based photovoltaic grid associated network. Expanding in the sun powered photovoltaic network associated grid additionally builds the power quality issues to which it is associated. Power quality issues, for example, variety in the voltage level at the point of PCC, peak hour control taking care of limit and THD presented in the electrical cable (Pradanovic & Green, 2003; Jang, 1993). Being a discontinuous wellspring of vitality, solar photovoltaic framework must be competent to disconnect itself amid grid fault condition. Islanding task is an imperative element of an inexhaustible grid connected framework (Adamidis & Tsengenes, 2010).

Numerous analysts have concentrated on the present control loop and voltage control loop utilized as a part of the inverter controller circuit to control the expectations of grid connected PV system. Calculation in view of linear and nonlinear system is most appropriate for outlining the present controller (Kusagur et al., 2010; Schonardie & Martins, 2008). However, these controllers require a nitty gritty scientific examination for their execution and plan. Again from security perspective, these controllers do not demonstrate tasteful execution amid transient condition and grid aggravation condition, for example, single line to ground fault condition. Astute strategies, for example, fuzzy and neural network-based controller can be connected to these issues (Yang et al., 2010, 2011; Selvaraj & Rahim, 2009). Aim of AI-systems over customary procedures is they do not require any detailed numerical investigation for their implementation and thus is anything but difficult to actualize and ends up vigorous amid grid fault condition.

Artificial neural network methods have picked up the fame in the controller design due to its flexibility to the circumstance to which it is associated. Preparing strategy connected to this controller drives the controller to carry on like a human neural control activity where it applies its experience to discover a choice under fluctuating grid condition. Inverter current control topologies have been picked for this situation as it interfaces both the sustainable power sources and that of the network for control (Yao & Xiao, 2013).

D. Pattnaik · S. Mishra · G. Prasad Khuntia · S. Chandra Swain
SoEE, KIIT University, Bhubaneswar, India

R. Dash (✉)
School of EEE, REVA University, Bengaluru, India

429

2 Fuzzy Control Techniques

This segment displays a fuzzy logic controller, which works under both adjusted and lopsided condition. This is conceivable because of the nonattendance of mathematical induction. Nonlinear system can be best taken care of by fuzzy rationale controller (Singh et al., 2019, 2020). Here, the execution of the controller is tried both under adjusted and unequal condition.

(a) Proposed Control Strategies

Schematic diagram of the proposed control strategies is shown in Fig. 1.

The proposed current controller comprises two fundamental parts (a) DC voltage to be kept up crosswise over capacitor (b) Coupling inductor (Lf). DC voltage required to be kept up at the input of inverter is controlled by an external voltage controlled loop, and important gate signal was delivered by inward current control loop. Coupling inductor is utilized to smoothen the swell of consonant current infused from inverter to the network.

In the proposed work, fuzzy rationale controller-based PWM controller is utilized to create required switching signal for the inverter. Exchanging signal along these lines acquired is enhanced and given to PWM converter for network synchronization. The required DC connect voltage is in this way kept up consistent by a fuzzy rationale controller.

(b) Design of Fuzzy logic Controller for Inner Current Control Loop

Schematic diagram of fuzzy rationale controller is shown in Fig. 2.

The proposed fuzzy rationale controller has two information (a) Current error (b) Change in current error. With a specific end goal to cover the whole scope of error, proposed fuzzy rationale controller has five numbers Of MFs. These MFs are regular for both input and output. Triangular membership work is utilized to cover the scope of factors, with two inputs and five variable capacity, and 25 level sets

can be gotten. Membership functions for information and output factors are appeared in Fig. 3.

DC voltage at the input of inverter is controlled by a capacitor. This capacitor typically gives steady voltage and the required real power request by the grid. Under relentless activity condition, extra real power request must be equivalent to control supply by the inverter with some measure of extra power misfortunes (Pattanaik et al., 2020). Fuzzy rationale controller is executed to keep up a steady voltage over the capacitor at the input of inverter. Fuzzy rationale control factors are picked in agreement to the dynamic execution of the controller. Mistake and change in error are thought to be the contribution of controller. Thus, real power request introduced at the grid output side is thought to be output of the fuzzy rationale controller (Fig. 4; Table 1).

3 Design of ANFIS Controller

ANFIS utilizes Takagi-Surgeon fuzzy induction framework fort task. Output of ANFIS normally utilizes combination mix of input factors with some steady factors. These linear joined factors are for the most part regardless as weight work. Last output of the ANFIS structure is normally a weighted aggregate normal of the information changed into output. Fundamental ANFIS structure comprising two information, for example, x and y and one yield z is appeared in Fig. 5.

Rule for Takagi-Surgeon fuzzy inference system becomes an If and Then statement. Rule-1 = If x is $A1$ and y is $B1$, then $f1 = P1x + q1x + r1$. Rule-2 = If x is $A2$ and y is $B2$, then $f2 = P2x + q2x + r$.

Layer-1:

In this layer for every node i, square node function becomes $O1, i = \mu A, i(x)$ where $i = 1, 2$ $O1, i = \mu B, i(y)$ where $i = 1, 2$. Here, x speaks to contribution to node I or layer-1, and "A" and "B" speak to linguistic factors connected to that specific node. The linguistic factors can be either a triangular or Gaussian participation work. Parameters ascribed to layer-1 are named as preface parameter.

Fig. 1 Schematic strategies of current controller
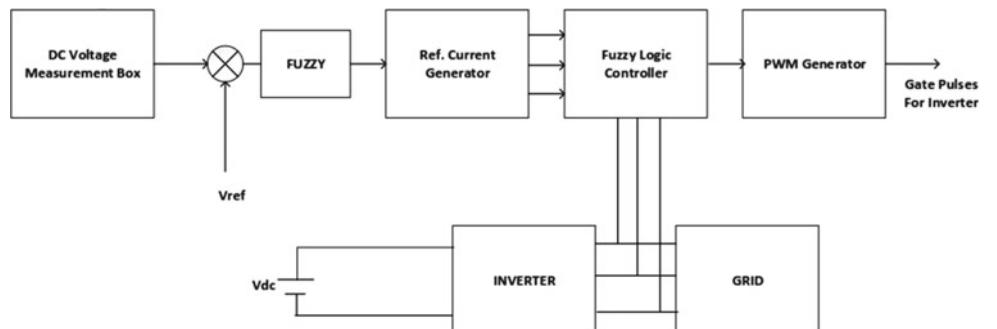
**Fig. 2** Schematic diagram for fuzzy rationale controller
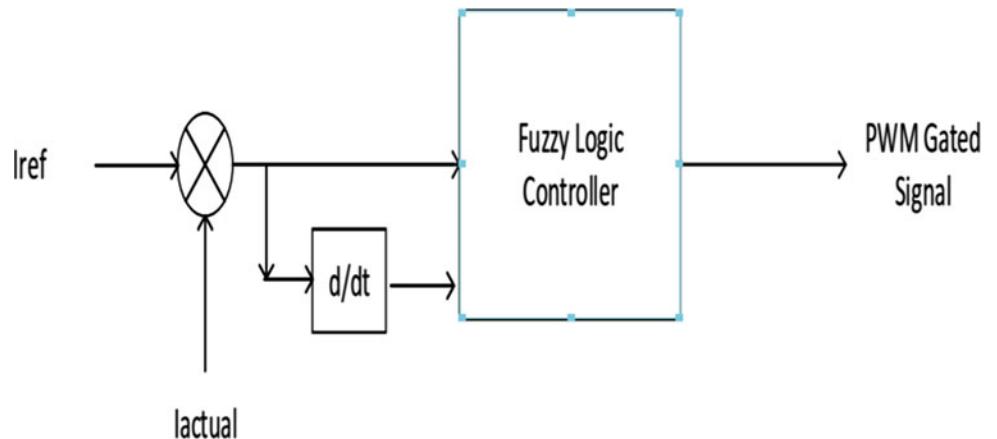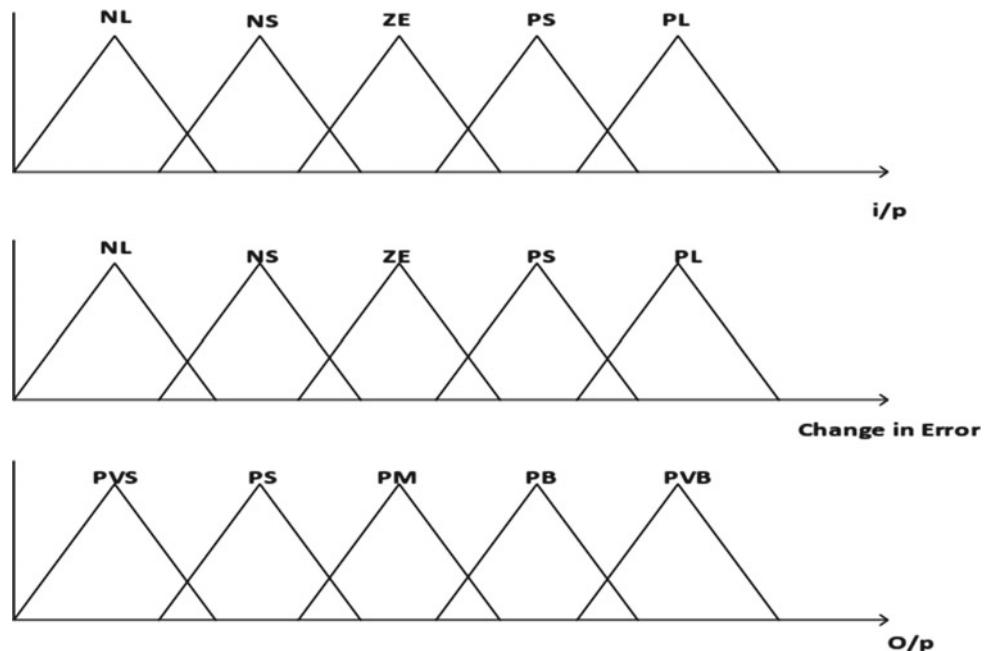
Fig. 3 MF for input, change in error and output current controller

Layer-2:

Node level for layer-2 is π. Output of layer-2 is the product of all incoming signals.

$$O1, \quad i = \mu A, i(x) \quad \text{where } i = 1, 2.$$

Output of layer-2 represents the strength of fuzzy rule.

Layer-3:

Node level for this layer is N. It represents the ratio of strength of fuzzy rule to sum of strength of fuzzy rules.

$$O3, \quad i = wi = wi/(w1 + w2) \quad \text{for } i = 1, 2.$$

Output of layer-3 represents the normalized.
Strength of fuzzy rule.

Layer-4:

This layer referred as adaptive node. Node function for layer-4 can be written as
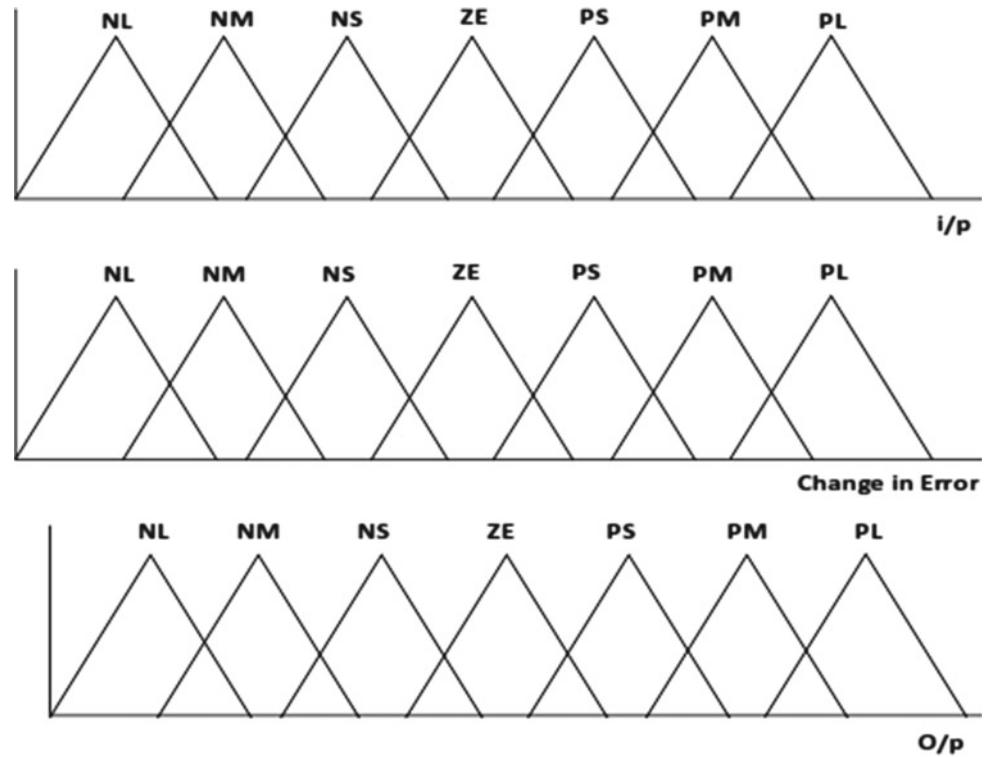
$$Oq, i = wifi = wi(p1x + qiy + ri).$$

Layer-5:
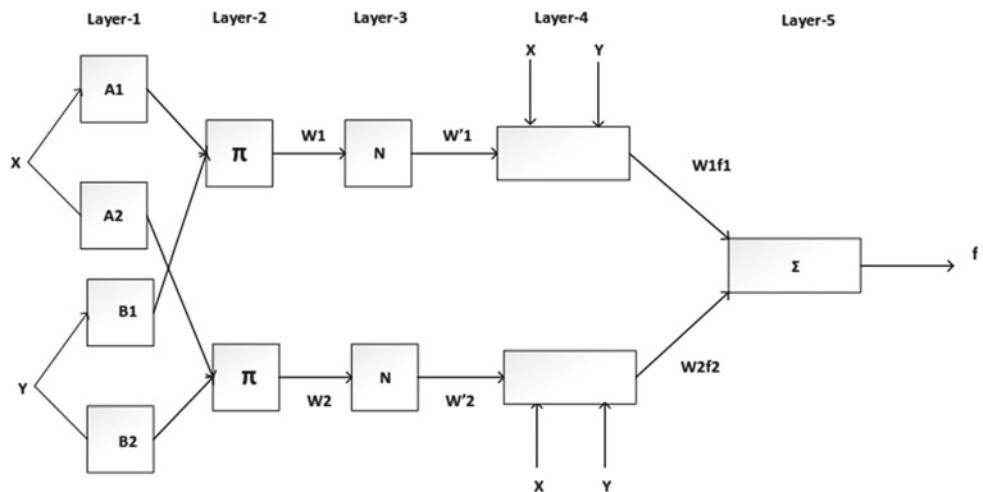
Output of layer-5 represents the weighted sum average of the linearly variable input. The output equation for its layer can be written as

$$Oc, i = \sum wifi.$$

$$Oc, i = \Sigma wifi.$$

Fig. 4 Fuzzy rationale variable

Table 1 Rule table for membership function

d/dt e	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	ZE
NM	NL	NL	NL	NM	NS	ZE	PS
NS	NL	NL	NM	NS	ZE	PS	PM
ZE	NL	NM	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PM	PL	PL
PM	NS	ZE	PS	PM	PL	PL	PL
PL	NL	NM	PS	ZE	PS	PM	PL

Fig. 5 Basic ANFIS structure

This confirms that adaptive neural fuzzy inference system (ANFIS) is similar to that of Takagi-Surgeon type fuzzy inference system.

4   Simulation

Framework for grid associated solar PV was researched with MATLAB-based Simulink programming. Proposed fuzzy and ANFIS-based framework was examined through controller at various working point for checking the approval of controller. Square chart for controller of PI-systems is appeared in Fig. 6.

Results acquired from PI controller are encouraged into fuzzy rationale box for additional process and preparing of information for producing the FIS petition for the controller. Gaussian surface membership work is utilized as a part of the FIS record. Nine numbers of MFs containing FIS document were created utilizing experimentation strategy. Input and output participation work was appeared in Figs. 7 and 8 individually (Fig. 9).

From the unfaltering state reaction of PI controller, it is discovered that underlying overshoot of 24.9% does not have critical execution and in this way making the framework reaction slow under unique condition. However, fuzzy rationale-based PI controller has critical change in the execution under steady condition. As appeared in Fig. 10, fuzzy PI controller postures 0 overshoot while in the task (Figs. 11 and 12).

Direct and quadrature pivot current status is appeared in Figs. 13 and 14. For keeping away from the age, direct and quadrature pivot current status is appeared in Figs. 13 and 14. For keeping away from the age of reactive power by inverter, quadrature axis current is normally kept up at zero level. Thus, immediate pivot current is kept up at 1.27. Fuzzy-based controller tries to keep up the Id current status by limiting the fault exhibits in the framework to right around zero level. This can be found after some time scale run between 1.78 and 2.5 s.

Figure 13 shows that a percentage of modulation index of 1 is maintained by the controller for producing effective output.

Fig. 6 PI-controlled current control techniques for grid connected PV system
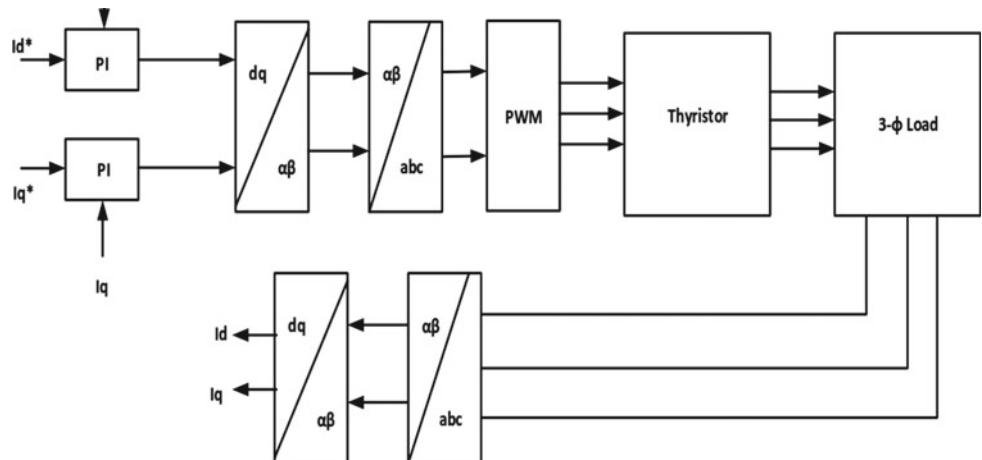
Fig. 7 Fuzzy logic input based on Gaussian surface membership function
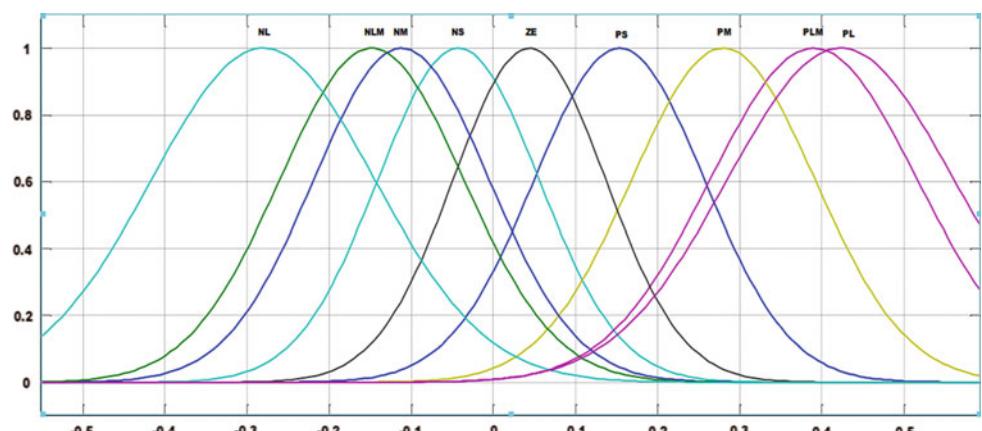
**Fig. 8** Fuzzy logic output based on Gaussian surface membership function

**Fig. 9** Steady state response of PI controller
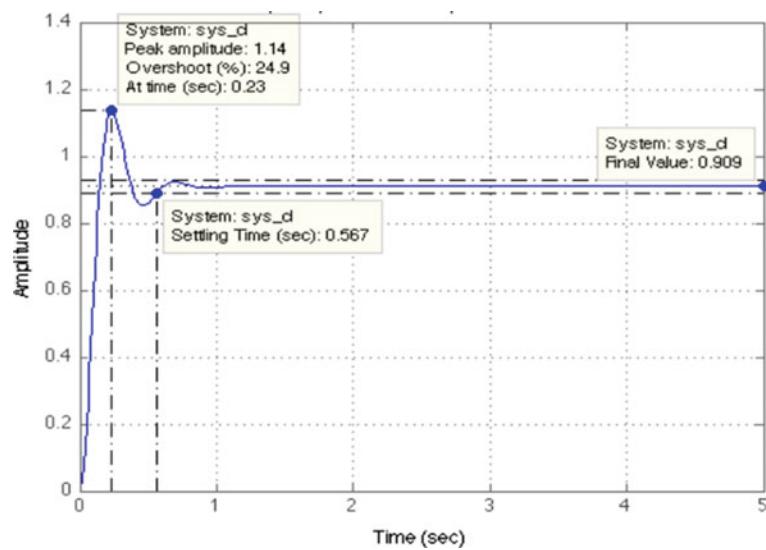
**Fig. 10** Time response of fuzzy PI controller
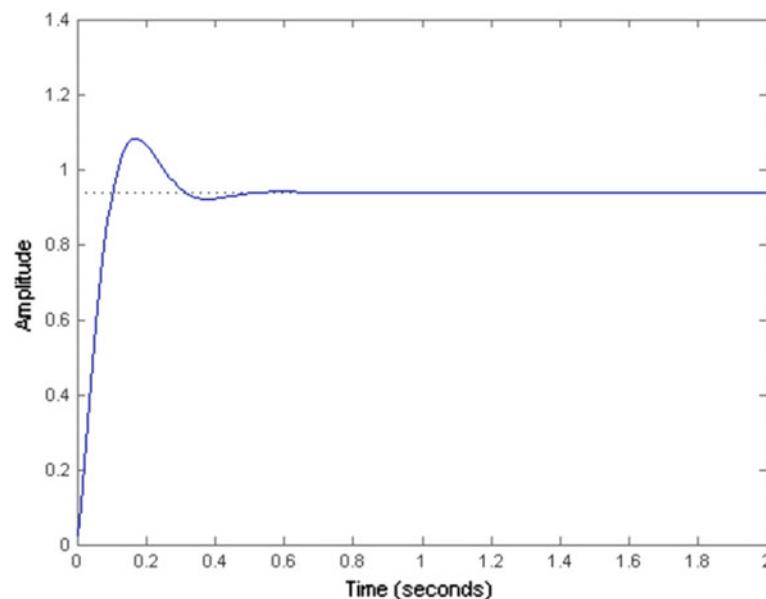
Fig. 11 Reference voltage and fuzzy controlled voltage—outer voltage control loop for inverter
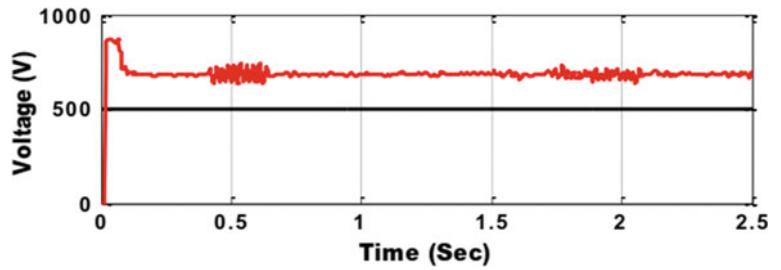

**Fig. 12** Percentage of modulation index maintained by inverter
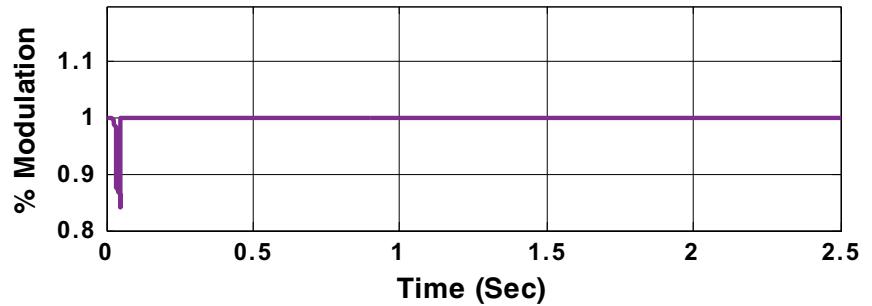


Fig. 13 Direct axis current status
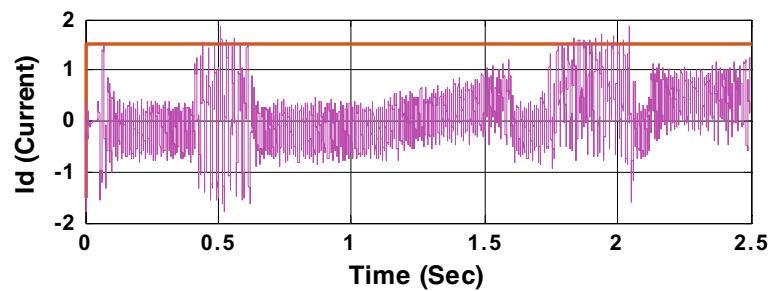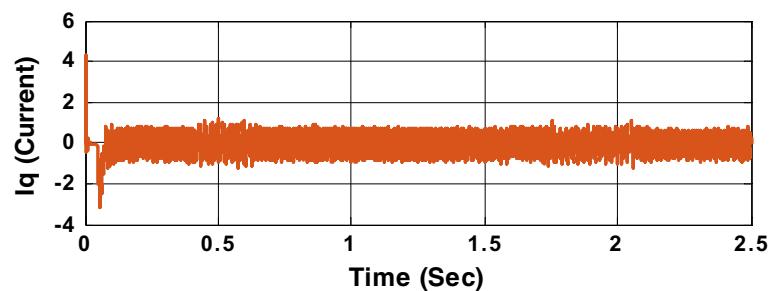
Fig. 14 Quadrature axis current status

ANFIS-based controller for PI controller requires some measure of exact information for their execution. Along these lines, it is required to gather the information from beforehand mimicked PI controller-based framework. Information is to be viewed as with the end goal that less measure of mistake must exist between contributions to yield of the framework. Consequently, information should be prepared and approved before applying the preparation calculation to give choice under factor stacking conditions.

5 Conclusion

In this paper, fuzzy rationale and ANFIS-based controller for input current control loop and external voltage control loop has been illustrated. The MATLAB-based outcome along these lines got for two diverse controller has been portrayed independently. With a specific end goal to have a near investigation among both the controllers, same stage has

been kept up for both controllers. Fuzzy rationale controller gives better execution when contrasted with PI controller. This is on the grounds that fuzzy gives more noteworthy adaptability to PI controller by giving bigger territory to information acknowledgment and interpretation. However, this controller requires a great deal of experimentation technique for showing signs of improvement enhanced outcome.

References

Adamidis, G., & Tsengenes, G. (2010). Three phase grid connected photovoltaic system with active and reactive power control using instantaneous reactive power theory. In *Proceedings of the International Conference on Renewable Energies and Power Quality* (pp. 8–16).

Jang, J.-S.R. (1993). ANFIS: Adaptive-network-based fuzzy inference system. *IEEE Transactions on Power Electronics, 23,* 665–685.

Kusagur, A., Kodad, S. F., & Sankar Ram, B. V. (2010). Modeling design & simulation of an adaptive neuro-fuzzy inference system (ANFIS) for speed control of induction motor. *International Journal of Computer Applications*, *6*(12), 29–44.

Pattanaik, D., Mishra, S., Khuntia, G. P., Dash, R., & Swain, S. C. (2020). An innovative learning approach for solar power forecasting using genetic algorithm and artificial neural network. *Open Engineering,* *10*(1), 630–641. https://doi.org/10.1515/eng-2020-0073.

Pradanovic, M., & Green, T. (2003). Control and filter design of three phase inverter for high power quality grid connection. *IEEE Transactions on Power Electronics, 18,* 1–8.

Schonardie, M. F., & Martins, D. C. (2008). Application of the dq0 transformation in the three phase grid connected PV system with active and reactive power control. In *Proceedings of IEEE Power Electronics Specialists Conference* (pp. 1202–1208).

Selvaraj, J., & Rahim, N. A. (2009). Multilevel inverter for grid-connected PV system employing digital PI controller. *IEEE Transactions on Industrial Electronics, 56,* 149–158.

Singh, P. K., Kar, A. K., Singh, Y., Kolekar, M. H., & Tanwar, S. (Eds.). (2019). *Proceedings of ICRIC 2019: Recent Innovations in Computing*. LNEE (Vol. 597, pp. 1–920). Springer Nature.

Singh, P. K., Noor, A., Kolekar, M. H., Tanwar, S., Bhatnagar, R. K., & Khanna, S. (2020). *Evolving technologies for computing, communication and smart world*. LNEE (Vol. 694, pp. 1–538). Springer.

Yang, B., Li, W., Zhao, Y., & He, X. (2010). Design analysis of a grid-connected Photovoltaic power system. *IEEE Transactions on Power Electronics, 25,* 992–1000.

Yang, S., Lei, Q., Peng, F. Z., & Qian, Z. (2011). A Robust control scheme for grid-connected voltage source inverters. *IEEE Transactions on Industrial Electronics, 58,* 1002–1009.

Yao, Z., & Xiao, L. (2013). Control of single-phase grid-connected Inverters with non-linear loads. *IEEE Transactions on Industrial Electronics, 60,* 379–383.

Mixed Convection of SPM in Bi-Phase Laminar Flow in a Bounded Vertical Plate

Sasanka Sekhar Bishoyi and Ritesh Dash

Abstract

This paper deals with numerical investigation of two-phase dusty fluid under mixed convection flow. In the present research paper, it is proposed to investigate free forced convective boundary layer along with study and laminate floor for a spherical solid dust particle having uniform radius. Unique distinct parameter and its impact on the particle under different fluid condition surcharge temperature velocity effects have been presented. In order to solve the differential equation, all the governing equations were solved through finite difference method. It is observed that under interaction of different fluid particles the magnitude of velocity and temperature of the carrier fluid has been decreased to a great extent ultimately helping the magnitude of particle velocity and temperature to increase.

Keywords

Boundary layer characteristics • Buoyancy force • Slip velocity • Suspended particulate matter • Two-phase flow • Volume fraction

1 Introduction

Free and forced Convection effect, find many application ranging from cooling of electronic item by fans and heat exchangers placed at suitable position, solar photovoltaic receivers exposed to wind flow and cooling of nuclear reactor during emergency situations are some of the applications of this free and forced Convection affect all the these two effects are comparable to each other but based on its application there are different situations where it has to be used. In contrast to simple physical prototype, two-dimensional laminar mixed convection flow is the best choice for analyzing the flow of fluid particle under different velocity and temperature conditions. In general, file analyzing the two -dimensional mixed convection flow system, the buoyancy forces in flow and its corresponding heat transfer quantity is usually neglected which is a contradiction as buoyancy force influences the flow and temperature of the particle flowing inside the fluid.

In the literature survey, it can be found that a number of two-dimensional laminar flow with different fluid conditions have been analyzed over different surfaces; however in this particular research, a fluid particle having steady and laminar flow with convective boundary layer and incompressible in nature has been considered for analysis which again passes over the flat surface of equal radius. With the adaption of the above parameters different authors have proposed a number of convection equation for two phase flow square Momentum equation for particular his Panda normal condition and the heat exchange during the entire floor condition has been considered in terms of energy equation for different particle under two dimensional particle phase analysis system. Chiu (1962) in their paper have proposed a two-phase boundary layer flow condition analyzed under a semi-infinite plate where they have assumed that the momentum of the particle can be neglected while considering the boundary layer equations. Marble (1963) in their paper have analyzed the two-phase laminar boundary condition over a semi-infinite plate where it has been assumed that the velocity of particle and that of gas are equal to each other. However, the analysis presented in the paper is not applicable for the entire length of the considered plate. Jain and Ghosh (1979) have investigated the boundary layer flow for a gas particle under downstream portion of the plate by employing momentum integral method. Saffmann (1962) in their paper have considered the finite differential techniques for gas particulate flow; however, the particle momentum equation has been neglected in their

S. S. Bishoyi (✉) · R. Dash
Department of Mathematics, CCET & School of EEE, Bhilai, India

S. S. Bishoyi · R. Dash
REVA University, Bangalore, India

paper. Singleton (1965) has studied the compressible gas–solid flow over a flat plate by taking particle momentum equation in normal direction and derived the results in small slip and large slip regions separately. Chamkha (1995, 1996) has derived the equations of gas particulate flow by considering finite volume fraction and electrification of particles. Mishra and Tripathy (2011a, 2011b) have used the momentum integral method as well as finite difference technique with non-uniform grid to study the temperature distribution inside the boundary layer over a flat plate, and their solution is valid towards the far downstream stations of the plate.

The small size of the particle makes it allow to diffuse properly in the considered fluid leading to random motion of particle as that of dusty particle in air. The randomization present in the dusty fluid can be evaluated by applying kinetic theory of gasses which leads to flow of particle along with the concentration and pressure diffusion.

$$\rho_m = \rho_p + \rho\left(1 - \frac{\rho_p}{\rho_s}\right) \tag{1}$$

The factor $\left(1 - \frac{\rho_p}{\rho_s}\right)$ accounts for the volume occupied by the particles in the career fluid. Then, we can write

$$\rho_m \overrightarrow{q_m} = \rho_p \overrightarrow{q_p} + \rho\left(1 - \frac{\rho_p}{\rho_s}\right)\vec{q} \tag{2}$$

2 Mathematical Formulation

Otterman et al. in their paper have demonstrated the boundary layer by assuming equality nature of particulate phase and fluid phase. It has also been demonstrated that the requirement of momentum equation and that of particle momentum equation are not required in the transverse direction, thereby restricting the phase of momentum equation. By considering the above assumptions, the governing two-phase boundary layer equations are

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{3}$$

$$\frac{\partial(\rho_p u_p)}{\partial x} + \frac{\partial(\rho_p v_p)}{\partial y} = 0 \tag{4}$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = v\frac{\partial^2 u}{\partial y^2} + \frac{\rho_s}{\rho}\frac{\varphi}{1-\varphi}\frac{1}{\tau_p}(u_p - u) + g\beta(T - T_\infty) \tag{5}$$

$$u_p\frac{\partial u_p}{\partial x} + v_p\frac{\partial u_p}{\partial y} = v_s\frac{\partial^2 u_p}{\partial y^2} + \frac{1}{\tau_p}(u - u_p) + \left(1 - \frac{\rho}{\rho_s}\right)g \tag{6}$$

$$u_p\frac{\partial v_p}{\partial x} + v_p\frac{\partial v_p}{\partial y} = v_s\frac{\partial^2 v_p}{\partial y^2} + \frac{1}{\tau_p}(v - v_p) \tag{7}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k}{\rho c_p}\frac{\partial^2 T}{\partial y^2} + \frac{v}{c_p}\left(\frac{\partial u}{\partial y}\right)^2 + \frac{\rho_s}{\rho}\frac{\varphi}{1-\varphi}\frac{c_s}{c_p}\frac{1}{\tau_T}(T_p - T) \tag{8}$$

$$u_p\frac{\partial T_p}{\partial x} + v_p\frac{\partial T_p}{\partial y} = \frac{\kappa_s}{\rho_s C_s}\frac{\partial^2 T_p}{\partial y^2} + \frac{1}{\tau_T}(T - T_p) + \frac{\mu_s}{\rho_s C_s}\left[u_p\frac{\partial^2 u_p}{\partial y^2} + \left(\frac{\partial u_p}{\partial y}\right)^2\right] \tag{9}$$

Introducing the non-dimensional variables

$$x^* = \frac{x}{L}, \quad y^* = \frac{y}{L}\sqrt{\text{Re}}, \quad u^* = \frac{u}{U}, \quad v^* = \frac{v}{U}\sqrt{\text{Re}},$$

$$u_p^* = \frac{u_p}{U}, \quad v_p^* = \frac{v_p}{U}\sqrt{\text{Re}},$$

$$T^* = \frac{T - T_\infty}{T_w - T_\infty}, \quad T_p^* = \frac{T_p - T_\infty}{T_w - T_\infty}, \quad \rho_p^* = \frac{\rho_p}{\rho_{p_0}} \tag{10}$$

and after dropping stars, the governing boundary layer Eqs. (6) to (10) yield

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{11}$$

$$u_p\frac{\partial \rho_p}{\partial x} + v_p\frac{\partial \rho_p}{\partial y} = \epsilon\frac{\partial^2 \rho_p}{\partial y^2} \tag{12}$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} - \alpha\frac{1}{1-\varphi}\frac{FL}{U}\rho_p(u - u_p) + \frac{\text{Gr}\,T}{\text{Re}^2} \tag{13}$$

$$u_p\frac{\partial u_p}{\partial x} + v_p\frac{\partial u_p}{\partial y} = \epsilon\frac{\partial^2 u_p}{\partial y^2} + \frac{FL}{U}(u - u_p) + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right) \tag{14}$$

$$u_p\frac{\partial v_p}{\partial x} + v_p\frac{\partial v_p}{\partial y} = \epsilon\frac{\partial^2 v_p}{\partial y^2} + \frac{FL}{U}(v - v_p) \tag{15}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{1}{\text{Pr}}\frac{\partial^2 T}{\partial y^2} + Ec\left(\frac{\partial u}{\partial y}\right)^2 + \frac{2\alpha}{3\,\text{Pr}}\frac{1}{1-\varphi}\frac{FL}{U}\rho_p(T_p - T) \tag{16}$$

$$u_p\frac{\partial T_p}{\partial x} + v_p\frac{\partial T_p}{\partial y} = \frac{FL}{U}(T - T_p) + \frac{\epsilon}{\text{Pr}}\frac{\partial^2 T_p}{\partial y^2} + \frac{3}{2}\text{Pr}\,\epsilon.Ec\left[\left(\frac{\partial u_p}{\partial y}\right)^2 + u_p\frac{\partial^2 u_p}{\partial y^2}\right] \tag{17}$$

Subject to the boundary conditions

$$y = 0: \quad u = 0, \quad v = 0, \quad u_p = u_{pw}(x), \quad v_p = 0,$$
$$\rho_p = \rho_{pw}(x), \quad T = 1, \quad T_p = T_{pw}(x)$$
$$y = \infty: \quad u = u_p = \rho_p = 1, \quad v_p = 0, \quad T = 0, \quad T_p = 0$$

$$(18)$$

3 Methods and Solutions

As

$$\frac{\partial W}{\partial x} = \frac{1.5W_j^{n+1} - 2W_j^n + 0.5W_j^{n-1}}{\Delta x} + o(\Delta x^2) \quad (19)$$

$$\frac{\partial W}{\partial y} = \frac{W_{j+1}^{n+1} - (1 - r_y^2)W_j^{n+1} - r_y^2 W_{j-1}^{n+1}}{r_y(r_y+1)\Delta y} + o(\Delta y^2) \quad (20)$$

$$\frac{\partial^2 W}{\partial y^2} = 2\frac{W_{j+1}^{n+1} - (1+r_y)W_j^{n+1} + r_y W_{j-1}^{n+1}}{r_y(r_y+1)\Delta y^2} + o(\Delta y^2) \quad (21)$$

$$W_j^{n+1} = 2W_j^n - W_j^{n-1} + o(\Delta x^2) \quad (22)$$

and

$$y_{j+1} - y_j = r_y(y_j - y_{j-1}) = r_y \Delta y_j \quad (23)$$

where W stands for either u or v or u_p or v_p or ρ_p or T or T_p.

Here, a general three-point representation of $\frac{\partial W}{\partial y}$ on a non-uniform grid that produces the smallest truncation error is used.

The continuity Eqs. (14) yield

$$v_j^{n+1} = v_{j-1}^{n+1} - \frac{1}{2}\frac{\Delta y}{\Delta x}\left[\left(1.5u_j^{n+1} - 2u_j^n + 0.5u_j^{n-1}\right) + \left(1.5u_{j-1}^{n+1} - 2u_{j-1}^n + 0.5u_{j-1}^{n-1}\right)\right] \quad (24)$$

The diffusion Eq. (15) for particle phase yields

$$a_j^{\blacksquare}\rho_{p_{j-1}^{n+1}} + b_j^{\blacksquare}\rho_{p_j^{n+1}} + c_j^{\blacksquare}\rho_{p_{j+1}^{n+1}} = d_j^{\blacksquare} \quad (25)$$

where

$$a_j^{\blacksquare} = -v_{p_j}^{n+1} r_y^2 \Delta y - 2\epsilon r_y$$
$$b_j^{\blacksquare} = \frac{1.5 p^{\blacksquare} u_{p_j}^{n+1}}{\Delta x} - v_{p_j}^{n+1}\left(1 - r_y^2\right)\Delta y + 2\epsilon(1+r_y)$$
$$c_j^{\blacksquare} = p^{\blacksquare} v_{p_j}^{n+1} \Delta y - 2\epsilon$$
$$d_j^{\blacksquare} = p^{\blacksquare} u_{p_j}^{n+1}\frac{2\rho_{p_j^n} - 0.5\rho_{p_j^{n-1}}}{\Delta x}$$

The momentum Eq. (16) of fluid phase yields

$$a_j u_{j-1}^{n+1} + b_j u_j^{n+1} + c_j u_{j+1}^{n+1} = d_j \quad (26)$$

where

$$a_j = \frac{1}{\Delta x}\left[-p r_y - q\right]$$

$$b_j = \frac{1}{\Delta x}\left[\begin{array}{c} 1.5\left(2u_j^n - u_j^{n-1}\right) + p\left(r_y - \frac{1}{r_y}\right) \\ + q\left(1 + \frac{1}{r_y}\right) + \frac{1}{1-\varphi}\frac{FL}{U}\alpha\Delta x\left(2\rho_{p_j}^n - \rho_{p_j}^{n-1}\right) \end{array}\right]$$

$$c_j = \frac{1}{\Delta x}\left[\frac{1}{r_y}(p - q)\right]$$

$$d_j = \frac{1}{\Delta x}\left[\begin{array}{c} \left(2u_j^n - u_j^{n-1}\right)\left(2u_j^n - 0.5u_j^{n-1}\right) \\ -\frac{\varphi}{1-\varphi}\frac{FL}{U}\alpha\Delta x\left(2\rho_{p_j}^n - \rho_{p_j}^{n-1}\right)\left(-2u_{p_j}^n + u_{p_j}^{n-1}\right) \\ + \frac{\text{Gr}\left(2T_j^n - T_j^{n-1}\right)}{\text{Re}^2}\Delta x \end{array}\right]$$

The momentum Eq. (17) of particle phase in x-direction yields

$$a_j^* u_{p_{j-1}}^{n+1} + b_j^* u_{p_j}^{n+1} + c_j^* u_{p_{j+1}}^{n+1} = d_j^* \quad (27)$$

where

$$a_j^* = \frac{1}{\Delta x}\left[-p r_y - \epsilon q\right]$$
$$b_j^* = \frac{1}{\Delta x}\left[1.5\left(2u_{p_j}^n - u_{p_j}^{n-1}\right) + p\left(r_y - \frac{1}{r_y}\right) \right.$$
$$\left. + \epsilon q\left(1 + \frac{1}{r_y}\right) + \frac{FL}{U}\Delta x\right]$$
$$c_j^* = \frac{1}{\Delta x}\left[\frac{1}{r_y}(p - \epsilon q)\right]$$
$$d_j^* = \frac{1}{\Delta x}\left[\left(2u_{p_j}^n - u_{p_j}^{n-1}\right)\left(2u_{p_j}^n - 0.5u_{p_j}^{n-1}\right) \right.$$
$$\left. + \frac{FL}{U}\Delta x u_j^{n+1} + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right)\Delta x\right]$$

The momentum Eq. (18) of particle phase in y-direction yields

$$a_j^{**} v_{p_{j-1}}^{n+1} + b_j^{**} v_{p_j}^{n+1} + c_j^{**} v_{p_{j+1}}^{n+1} = d_j^{**} \quad (28)$$

$$a_j^{**} = \frac{1}{\Delta x}\left[-p r_y - \epsilon q\right]$$
$$b_j^{**} = \frac{1}{\Delta x}\left[1.5u_{p_j}^{n+1} + p\left(r_y - \frac{1}{r_y}\right) + \epsilon q\left(1 + \frac{1}{r_y}\right) + \frac{FL}{U}\Delta x\right]$$
$$c_j^{**} = \frac{1}{\Delta x}\left[\frac{1}{r_y}(p - \epsilon q)\right]$$
$$d_j^{**} = \frac{1}{\Delta x}\left[u_{p_j}^{n+1}\left(2v_{p_j}^n - 0.5v_{p_j}^{n-1}\right) + \frac{FL}{U}\Delta x v_j^{n+1}\right]$$

The energy Eq. (19) for carrier fluid yields

$$a_j^+ T_{j-1}^{n+1} + b_j^+ T_j^{n+1} + c_j^+ T_{j+1}^{n+1} = d_j^+ \qquad (29)$$

where

$$a_j^+ = \frac{1}{\Delta x}\left[-q\left(0.5 r_y \Delta y v_j^{n+1} + \frac{1}{\text{Pr}}\right)\right]$$

$$b_j^+ = \frac{1}{\Delta x}\left[1.5 u_j^{n+1} + 0.5 q \Delta y v_j^{n+1}\left(r_y - \frac{1}{r_y}\right) + \frac{q(1+r_y)}{\text{Pr}.r_y}\right.$$
$$\left. + \frac{2\alpha}{3\,\text{Pr}}\frac{1}{1-\varphi}\frac{FL}{U}\Delta x \rho_{pj}^{n+1}\right]$$

$$c_j^+ = \frac{1}{\Delta x}\left[\frac{q}{r_y}\left(0.5\Delta y v_j^{n+1} - \frac{1}{\text{Pr}}\right)\right]$$

$$d_j^+ = \frac{1}{\Delta x}\begin{bmatrix} \frac{2\alpha}{3Pr}\frac{1}{1-\varphi}\frac{FL}{U}\rho_{pj}^{n+1}\left(2T_{pj}^n - T_{pj}^{n-1}\right)\Delta x \\ + \Delta x.Ec\left(\frac{u_{j+1}^{n+1}-u_j^{n+1}}{\Delta y}\right)^2 \\ + u_j^{n+1}\left(2T_j^n - 0.5T_j^{n-1}\right) \end{bmatrix}$$

The energy Eq. (20) for particle phase yields

$$a_j^{++} T_{pj-1}^{n+1} + b_j^{++} T_{pj}^{n+1} + c_j^{++} T_{pj+1}^{n+1} = d_j^{++} \qquad (30)$$

where

$$a_j^{++} = \frac{1}{\Delta x}\left[-q\left(0.5 r_y \Delta y v_{pj}^{n+1} + \frac{\epsilon}{\text{Pr}}\right)\right]$$

$$b_j^{++} = \frac{1}{\epsilon x}\left[1.5 u_{pj}^{n+1} + 0.5 q \Delta y v_{pj}^{n+1}\left(r_y - \frac{1}{r_y}\right)\right.$$
$$\left. + \frac{\epsilon q(1+r_y)}{\text{Pr}.r_y} + \frac{FL}{U}\Delta x\right]$$

$$c_j^{++} = \frac{1}{\Delta x}\left[\frac{q}{r_y}\left(0.5\Delta y.v_{pj}^{n+1} - \frac{\epsilon}{Pr}\right)\right]$$

$$d_j^{++} = \frac{1}{\Delta x}\begin{bmatrix} u_{pj}^{n+1}\left(2T_{pj}^n - 0.5T_{pj}^{n-1}\right) + \frac{FL}{U}T_j^{n+1}\Delta x \\ + \frac{3}{2}\text{Pr}.\epsilon.Ec.\Delta x\left\{\left(\frac{u_{pj+1}^{n+1}-u_{pj}^{n+1}}{\Delta y}\right)^2\right. \\ \left. + 2u_{pj}^{n+1}\left(\frac{u_{pj-1}^{n+1}-\left(1+\frac{1}{r_y}\right)u_{pj}^{n+1}+\frac{1}{r_y}u_{pj+1}^{n+1}}{(1+r_y)\Delta y^2}\right)\right\} \end{bmatrix}$$

Here,

$$p = \left(2v_j^n - v_j^{n-1}\right)\frac{\Delta x}{(1+r_y)\Delta y}$$

Calculation of u_{pw} at $y = 0$

As u_{pw} is a function of x only, from Eq. (17), we obtain

$$\frac{\partial u_{pw}}{\partial x} = -\frac{FL}{U} + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right) \qquad (31)$$

By using finite differences, the above equation reduces to

$$\frac{1.5 u_{p1}^{n+1} - 2u_{p1}^n + 0.5 u_{p1}^{n-1}}{\Delta x} = -\frac{FL}{U} + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right)$$

Or,

$$1.5 u_{p1}^{n+1} = -\frac{FL}{U}\Delta x + 2u_{p1}^n - 0.5 u_{p1}^{n-1} + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right)\Delta x$$

Or,

$$u_{p1}^{n+1} = -\frac{2}{3}\frac{FL}{U}\Delta x + \frac{4}{3}u_{p1}^n - \frac{1}{3}u_{p1}^{n-1} + \frac{2}{3}\frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right)\Delta x \qquad (32)$$

Calculation of ρ_{pw} at $y = 0$

As ρ_{pw} is a function of x only, from Eq. (15), we obtain

$$\frac{\partial}{\partial x}\left(\rho_{pw}u_{pw}\right) + \frac{\partial}{\partial y}\left(\rho_{p\infty}v_{pw}\right) = 0$$

$$\Rightarrow u_{pw}\frac{\partial \rho_{pw}}{\partial x} + \rho_{pw}\frac{\partial u_{pw}}{\partial x} = 0 \quad (\because v_{pw} = 0)$$

$$\Rightarrow u_{pw}\frac{\partial \rho_{pw}}{\partial x} - \rho_{pw}\frac{FL}{U} + \frac{\rho_{pw}}{Fr}\left(1 - \frac{1}{\gamma}\right) = 0$$

By using finite differences, the above equation reduces to

$$\Rightarrow u_{p1}^{n+1}\left[\frac{1.5\rho_{p1}^{n+1} - 2\rho_{p1}^n + 0.5\rho_{p1}^{n-1}}{\Delta x}\right]$$

$$= \rho_{p1}^{n+1}\frac{FL}{U} - \frac{\rho_{p1}^{n+1}}{Fr}\left(1 - \frac{1}{\gamma}\right)$$

$$\Rightarrow \rho_{p1}^{n+1}\left[1.5 - \frac{\frac{FL}{U}\Delta x}{u_{p1}^{n+1}}\right] + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right)\frac{\Delta x}{u_{p1}^{n+1}} \qquad (33)$$

$$= 2\rho_{p1}^n - 0.5\rho_{p1}^{n-1}$$

$$\Rightarrow \rho_{p1}^{n+1} = \frac{2\rho_{p1}^n - 0.5\rho_{p1}^{n-1}}{1.5 - \frac{\frac{FL\Delta x}{U}}{u_{p1}^{n+1}}} + \frac{1}{Fr}\left(1 - \frac{1}{\gamma}\right)\frac{\Delta x}{u_{p1}^{n+1}}$$

Calculation of T_{pw} at $y = 0$

As T_{pw} is a function of x only, from Eq. (20), we obtain

$$u_{pw}\frac{\partial T_{pw}}{\partial x} = \frac{FL}{U}\left(1 - T_{pw}\right)$$

By using finite differences, the above equation reduces to

$$\frac{1.5T_{p1}^{n+1} - 2T_{p1}^n + 0.5T_{p1}^{n-1}}{\Delta x} = \frac{FL}{U}\frac{1}{u_{p1}^{n+1}}\left(1 - T_{p1}^{n+1}\right)$$

Or,

$$T_{p1}^{n+1}\left[1.5 + \frac{FL}{U}\frac{\Delta x}{u_{p1}^{n+1}}\right] = 2T_{p1}^n - 0.5T_{p1}^{n-1} + \frac{FL}{U}\frac{\Delta x}{u_{p1}^{n+1}}$$

Or,

$$T_{p1}^{n+1} = \frac{2T_{p1}^n - 0.5T_{p1}^{n-1} + \frac{FL}{U}\frac{\Delta x}{u_{p1}^{n+1}}}{1.5 + \frac{FL}{U}\frac{\Delta x}{u_{p1}^{n+1}}} \tag{34}$$

Calculation of Nusselt Number

$$
\begin{aligned}
\mathrm{Nu}^{n+1} &= -\sqrt{\mathrm{Re}}\left[\frac{\partial T}{\partial y}\right]_{y=0}^{n+1} \\
&= -\sqrt{\mathrm{Re}}\left[\frac{T_{j+1}^{n+1} - \left(1 - r_y^2\right)T_j^{n+1} - r_y^2 T_{j-1}^{n+1}}{r_y\left(1 + r_y\right)\Delta y}\right]_{j=2} \\
&= -\sqrt{\mathrm{Re}}\left[\frac{T_3^{n+1} - \left(1 - r_y^2\right)T_2^{n+1} - r_y^2 T_1^{n+1}}{r_y\left(1 + r_y\right)\Delta y}\right]
\end{aligned}
\tag{35}
$$

Calculation of Skin Friction

$$c_f = \frac{\tau_w}{0.5\rho U^2} = \frac{1}{0.5\rho U^2}\mu\frac{\partial u}{\partial y}\bigg]_{y=0}$$

By using non-dimensional quantities

$$c_f^{n+1} = \frac{2}{U^2\sqrt{\mathrm{Re}}}\frac{\partial u}{\partial \eta}\bigg]_{\eta=0}^{n+1}$$

By using finite differences,

$$
\begin{aligned}
c_f^{n+1} &= \frac{2}{U^2\sqrt{\mathrm{Re}}}\left[\frac{u_{j+1}^{n+1} - \left(1 - r_y^2\right)u_j^{n+1} - r_y^2 u_{j-1}^{n+1}}{r_y\left(1 + r_y\right)\Delta y}\right]_{j=2} \\
&= \frac{2}{U^2\sqrt{\mathrm{Re}}}\left[\frac{u_3^{n+1} - \left(1 - r_y^2\right)u_2^{n+1} - r_y^2 u_1^{n+1}}{r_y\left(1 + r_y\right)\Delta y}\right]
\end{aligned}
\tag{36}
$$

4 Result Analysis

It has already been seen that the Grash of number (Gr) is of importance in case of free convection problem, whereas the Reynolds number is a pertinent parameter in case of forced convection systems. Free convection effects are negligible when $\mathrm{Gr} \ll \mathrm{Re}^2$. At the other extreme free convection dominates when $\mathrm{Gr} \gg \mathrm{Re}^2$. In case of situations where combined free and forced convections are of equal importance is $\mathrm{Gr} \approx \mathrm{Re}^2$.

We choose the following values of the various parameters involved
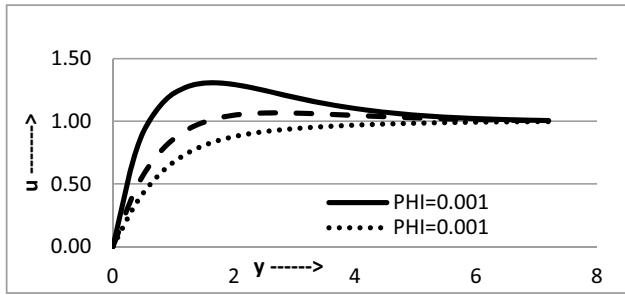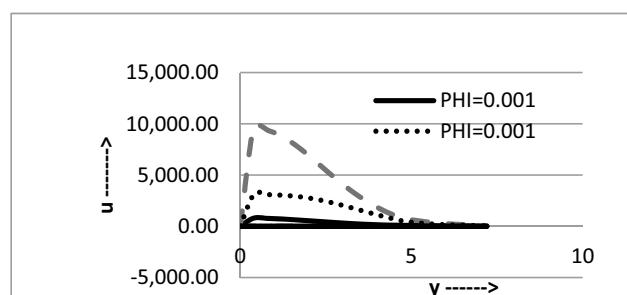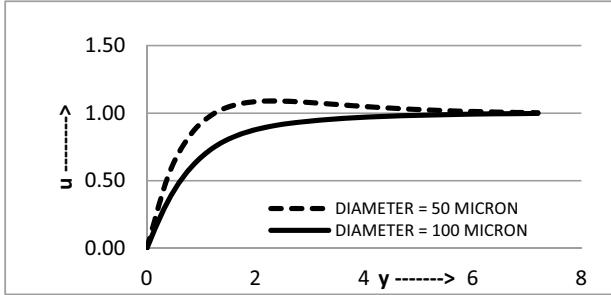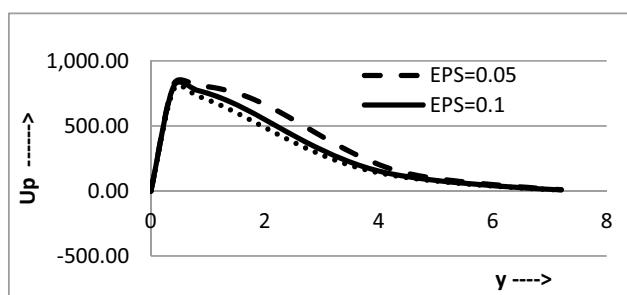
$$\rho = 0.913\,\mathrm{kg/m^3}: \quad \rho_p = 8010\,\mathrm{kg/m^3}; \quad \alpha = 0.1;$$
$$D = 50, 100\,\mu\mathrm{m}; \quad U = 0.45\,\mathrm{m/s}; \quad L = 0.044\,\mathrm{m}; \quad Ec = 0.1,$$
$$\mathrm{Pr} = 0.693; \quad \mu = 22.26 \times 10^{-6}\,\mathrm{kg/m\,s}; \quad \beta = 1/383;$$
$$v = 2.43 \times 10^{-5}\,\mathrm{m^2/s}; \quad T_w = 200\,^\circ\mathrm{C}; \quad T_\infty = 20\,^\circ\mathrm{C},$$
$$\epsilon = 0.05, 0.1, 0.2, \quad \varphi = 0.001, 0.0001, 0.0003$$

Clearly, $\mathrm{Gr} = 0.665 \times 10^6$ and $\mathrm{Re}^2 = 0.660 \times 10^6$, and $\mathrm{Gr} \approx \mathrm{Re}^2$, which is the required condition for free and forced convection.

From Table 1, we have observed that skin friction and heat transfer from plate to fluid are increased with the increase of volume fraction of the particles, whereas the displacement thickness decreases (Figs. 1, 2, 3, 4, 5, 6, 7 and 8).

Table 1 Variation of skin friction coefficient (c_f), displacement thickness and Nusselt number (Nu) for different φ

x	Skin friction (C_f)		Displacement thickness		Nusselt number (Nu)	
	$\varphi = 0.0001$	$\varphi = 0.0003$	$\varphi = 0.0001$	$\varphi = 0.0003$	$\varphi = 0.0001$	$\varphi = 0.0003$
1.2	2.26E−03	2.07E−03	3.41E−03	3.89E−03	1.09E+04	2.53E+03
1.3	4.36E−03	6.09E−03	2.62E−03	2.69E−03	3.18E+04	1.28E+04
1.4	6.25E−03	9.21E−03	2.01E−03	1.65E−03	4.27E+04	1.99E+04
1.5	6.74E−03	9.65E−03	1.86E−03	1.29E−03	4.42E+04	2.22E+04
1.6	6.14E−03	8.73E−03	2.08E−03	1.37E−03	4.18E+04	2.18E+04
1.7	5.26E−03	8.03E−03	2.41E−03	1.57E−03	3.91E+04	2.08E+04
1.8	4.69E−03	8.01E−03	2.61E−03	1.67E−03	3.79E+04	2.03E+04
1.9	4.52E−03	8.18E−03	2.62E−03	1.70E−03	3.81E+04	2.00E+04
2	4.52E−03	7.98E−03	2.54E−03	1.79E−03	3.87E+04	1.97E+04
2.1	4.40E−03	7.20E−03	2.53E−03	2.02E−03	3.88E+04	1.91E+04
2.2	4.08E−03	5.98E−03	2.62E−03	2.37E−03	3.81E+04	1.81E+04
2.3	3.66E−03	4.56E−03	2.76E−03	2.79E−03	3.72E+04	1.69E+04
2.4	3.36E−03	3.23E−03	2.85E−03	3.19E−03	3.67E+04	1.56E+04
2.5	3.34E−03	2.28E−03	2.83E−03	3.44E−03	3.75E+04	1.53E+04
2.6	3.82E−03	2.03E−03	2.70E−03	3.34E−03	3.90E+04	1.71E+04
2.7	4.30E−03	4.86E−03	2.59E−03	2.83E−03	3.95E+04	1.94E+04
2.8	3.71E−03	6.35E−03	2.59E−03	2.30E−03	3.90E+04	1.99E+04
2.9	4.72E−03	4.25E−03	2.65E−03	1.99E−03	3.88E+04	2.08E+04
3	3.65E−03	2.39E−02	2.72E−03	1.18E−03	3.80E+04	2.22E+04

Fig. 1 Variation of u and y

Fig. 3 Variation of u and y

Fig. 2 Variation of u and y

Fig. 4 Variation of Up and y
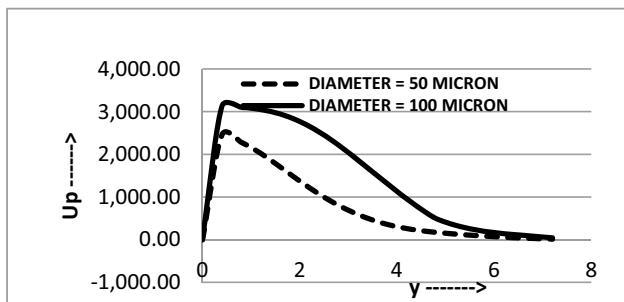
Fig. 5 Variation of *Up* and *y*
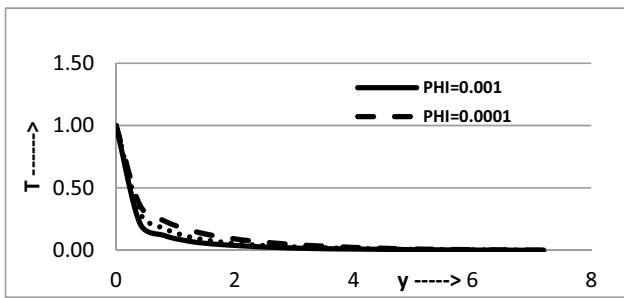

**Fig. 6** Variation of *T* and *y*
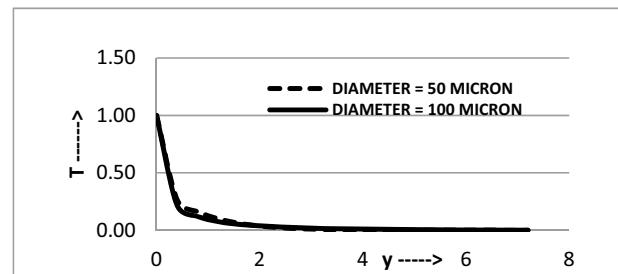
**Fig. 7** Variation of *T* and *y*
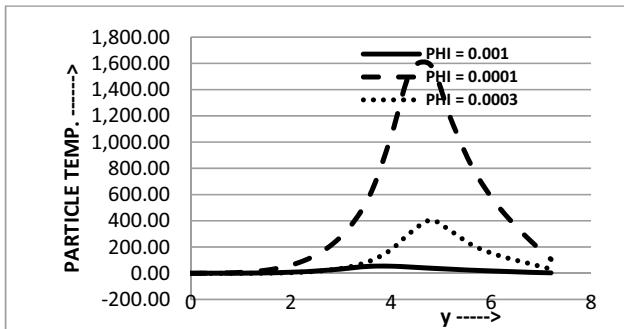
Fig. 8 Variation of *T* and *y*

5 Conclusion

We observe that the presence of the coarser particles helps in decreasing of magnitude of the velocity and temperature of the carrier fluid, but increases particle velocity and temperature. Figures 4 and 8 depict the particle velocity and temperature profile for different values of diffusion parameter. Clearly, increasing in diffusion parameter helps in decrease of the magnitude of the particle velocity and helps in increase in particle temperature.

References

Chamkha, A. J. (1995). Hydro magnetic two phase flow in a channel. *International Journal of Engineering Science, 33*(3), 437–446.

Chamkha, A. J. (1996). Solution for fluid particle flow and heat transfer in a porous channel. *International Journal of Engineering Science, 34*(12), 1423–1439.

Chiu, H. H. (1962). *Boundary layer flow with suspended particles* (Report 620). Princeton University.

Jain, A. C., & Ghosh, A. (1979). Gas particulate laminar boundary layer on a flat plate. *Zeitschrift für Flugwissenschaften und Weltraumforschung*, *3*, 29–37.

Marble, F. E. (1963). Dynamics of a gas combining small solid particles. In *Proceedings of the 5th AGARD Combustion and Propulsion Symposium* (pp. 175–215). Pergamon Press.

Mishra, S. K., & Tripathy, P. K. (2011a). Approximate solution of two phase thermal boundary layer flow. *Reflections Des ERA, 6*(2), 113–148.

Mishra, S. K., & Tripathy, P. K. (2011b). Mathematical and Numerical modeling of two phase flow and heat transfer using non-uniform grid. *Far East Journal of Applied Mathematics, 54*(2), 107–126.

Saffmann, P. G. (1962). On the stability of laminar flow of a dusty-gas. *Journal of Fluid Mechanics, 13*, 120–128.

Singleton, R. E. (1965). The compressible gas–solid particles flow over a semi-infinite flat plate. *ZAMP, 16,* 421–449.

Classification of Arrhythmia Using Machine Learning Techniques

Raisa Saboori, Ahmad Waleed Salehi, Pankaj Vaidya, and Gaurav Gupta

Abstract

Arrhythmia and heart problems are one of the most important health problems in the whole world which leads to various other severe complications, for example, heart attack. As arrhythmia is a type of cardiologic disease, it can be used for pointing out the abnormality from normal heart activity and try to understand about heartbeat whether the heartbeat is normal or not. The main element that only a less number of people informed being discovered as a result of screening indicates that there are missing opportunities to prevent heart disease. There are different methods present for heart. Heart diseases are recognized by capturing information from patient's body and forward results to doctors to reduce the risk of heart attack. So, the researcher always keeps trying to find out the best solution for this problem. The researchers have done huge research on this area, so according to the comparison between various techniques which are used for classification of arrhythmia, they prefer to use machine learning algorithm to achieve high performance and better accuracy.

1 Introduction
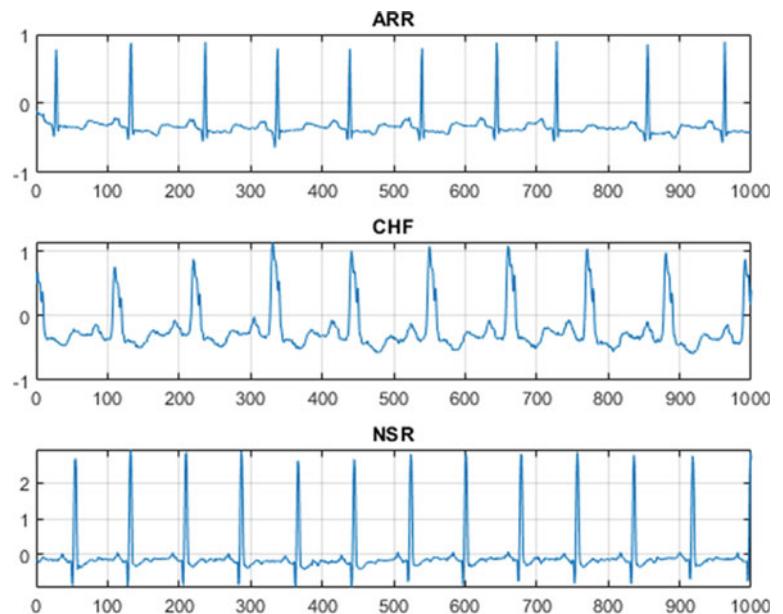
Arrhythmia is a type of cardiologic disease and can be used for pointing out the abnormality from normal heart activity. The heartbeat can be checked out by continuous ECG signals. Usually, cardiologists try to recognize about heartbeat as well as evaluate the complex ECG signals with the purpose of recognition heart activates whether it is normal or not. It reasons that the heart does not efficiently pump blood all over the body (Alfaras et al., 2019).

An electrocardiogram (ECG) is a vital analytical tool for the assessment of arrhythmia situations by taking signals from patient's body and then categorizing patient's ECG into related arrhythmia conditions. The defined tool called electrocardiogram signal is used to identify heart rhythms (Keshavamurthy & Eshwarappa, 2017).

The reliable discovery and analysis of arrhythmia set up a challenge not only in detecting and controlling patients in CCU, but also it will be vital at the time of electric shock while emergency notification.

Irregular rhythm of a human heart could results not the same types of arrhythmias, which might be directly fatal or reason irremediable damage to the heart nonstop over long periods of time. Thus, heart rhythm conditions in the ECG waveform are marks of basic cardiovascular difficulties, such as arrhythmias (Joshi et al., 2014). The capability to over and over again detect arrhythmias from ECG records is vital for clinical analysis and treatment. In this paper, we have used machine learning schemes. The objective of the study is to automatically categorize cardiac arrhythmias and to point out the performance of machine learning algorithms and try to define an effective model for categorizing arrhythmia for the proposed patients, which utilizing SVM and K-NN for model training Salehi et al., 2020a), and a developed correctness amount is achieved using a combination of F-score and sequential forward search (SFS) for selection of features.

We are trying to describe an efficient approach in this article, which will be able to categorize ECG records into

R. Saboori
Faculty of Computer Science, Rana University, Kabul, Afghanistan

R. Saboori · A. W. Salehi · P. Vaidya · G. Gupta (✉)
Yogananda School of AI, Shoolini University, Solan, Himachal Pradesh 173229, India

Fig. 1 Human ECG pattern

related classes, and the main goal is to distinguish between ARR, CHF, and NSR and how to categorize human electrocardiogram (ECG) signals via wavelet-based feature extraction and a SVM classifier. For implementation of this method, the ECG data should be acquired from three collections of patients with cardiac arrhythmia, peoples with congestive heart failure, and peoples with normal sinus rhythms. Figure 1 shows the arrhythmia rhythms, congestive heart insufficiency, and normal sinus rhythm (Table 1).

2 Materials and Methods

2.1 Arrhythmia Dataset

We can get the ECG signals from MIT-BIH library. Three forms of ECG data obtained from three types of people with cardiac arrhythmias (ARR), congestive heart failure (CHF), and regular sinus rhythms (NSR) have been obtained and used. Classification of arrhythmia, along with the efficient usage of ECGs and to extract its signal wavelet features used those structures to categorize ECG signals into three types. It distinguishes between the ARR, CHF, and NSR classes. Figure 2 shows steps that are used for computation.

2.2 ECG Signals

As far as, we are giving input to the CNN model the jpg image format. An electrocardiogram (ECG) is a vital methodical tool for the assessment of arrhythmia situations by taking signals from patient's body and then categorizing patient's ECG into related arrhythmia situations without creation any surgical cut or a wound. The electrical action of

Table 1 Various techniques used for arrhythmia detection

| References	Technique	Data source	Accuracy (%)
Bhardwaj et al. (2012)	SVM, LibSVM3.1	MIT-BIH database	95.21
Zacharia et al. (2016)	QRS, ECG	Marian Hospital, Pala, Kerala and St. Gregorios Cardiac Centre, Parumala, Kerala, India	96.88
Clayton et al. (1994)	TCI ACF VF-filter	Coronary Care Unit (CCU), Department of Academic Cardiology Freeman Hospital, Newcastle upon Tyne, UK	75
Chiu et al. (2005)	QRS, ECG	MIT-BIH arrhythmia database	99.3
Isin and Ozdalili (2017)	CNNs, RNNs, DBNs	MIT-BIH arrhythmia (MITDB) CUDB AFDB	96.1
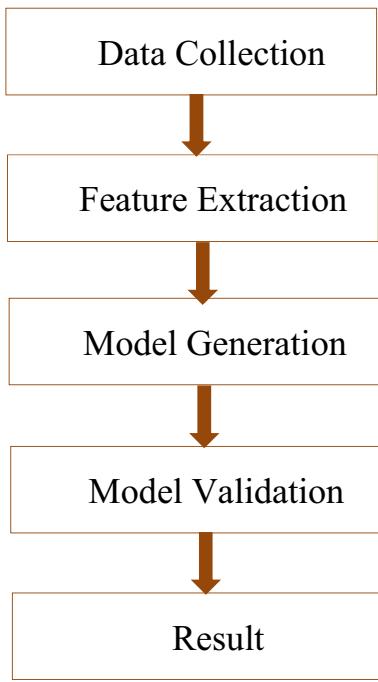
Fig. 2 Flowchart

the heart is reported or recorded by an electrocardiogram (ECG). The heart generates small electrical impulses that expand to establish the heart contract through the heart muscle (Joshi et al., 2014) (Fig. 3).

2.3 ECG Test

An electrocardiogram is a diagnostic examination used for cardiac activity detection by evaluating the electrical movement produced by the heart. Usually, regular healthy ECG signals have *P*, *Q*, *R*, *S*, and *T* waves with normal measurement values, and these could be not the same in terms of features or characteristics for irregular ECG signals (Amani 2011). An electrocardiogram (ECG) system makes available signals covering useful information to doctors. Several cardiac arrhythmias could be easily recognized when abnormalities of ECG signals are detected (Fig. 4).

We utilize the different physical appearance that arrhythmias display to become aware of the abnormal ECG

waveform. We must find the position of every QRS complex as the locations of QRS complex have the extreme variant in the slopes. By using the mentioned calculation, we are able to find the slope.

$$\text{Slope}(n) = -2x(n-2) - x(n-1) + (n+1) + 2x(n+2) \tag{1}$$

The slope threshold is computed using equation.

$$\text{Slop}_{\text{threshold}} = \frac{\text{threshold}_{\text{param}}}{16} * \max i \tag{2}$$

As each ECG beat covers *P* wave, *QRS* complex, and *T* wave, every peak (*P*, *Q*, *R*, *S*, *T*, and *U*), intervals (*PR*, *RR*, *QRS*, *ST*, and *QT*), and segments (*PR* and *ST*) of ECG signals have their standard duration values. These peaks, intervals, and segments are called ECG features (Jambukia et al., 2015). In addition to their definition and length, Fig. 5 explains ECG features.
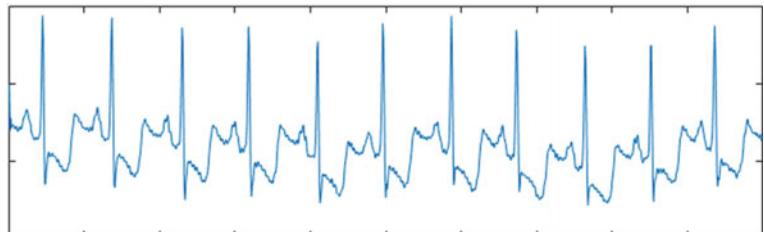
ECG signals are achieved to support doctor for diagnosing cardiac problems by:

- Calculating the structure and work of the chambers of the heart, valves, scale, and flow of blood.
- Calculating the consequence of coronary artery syndrome, such as incomplete flow of blood to the heart muscle and scarring after a heart attack within the heart muscle.
- Scheduling a patient's action for cardiovascular disorders.
- Observing the development of certain syndromes over time.
- Calculating influence of surgical modifications, especially in patients with congenital heart disease.
- Calculation in children and adults with congenital heart disease of the anatomy of the heart and blood vessels (Fig. 6).

3 Arrhythmia Classification Models

Considering the importance of heart diseases, numerous computational procedures have been created for prediction of arrhythmia using ECG, and these different methods have

Fig. 3 ECG signal
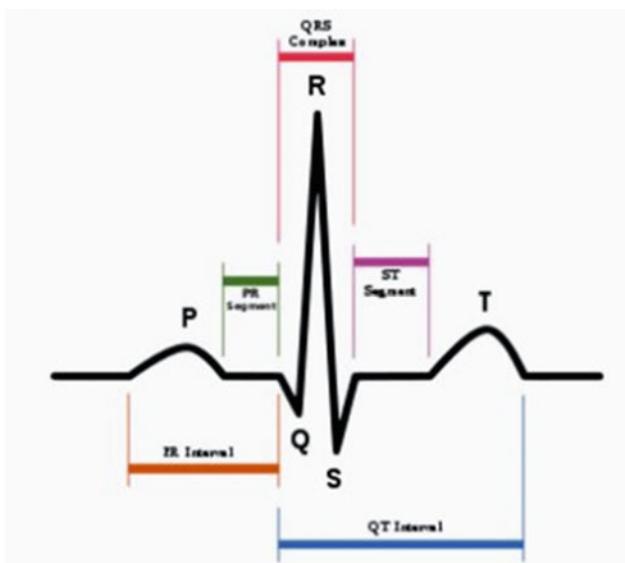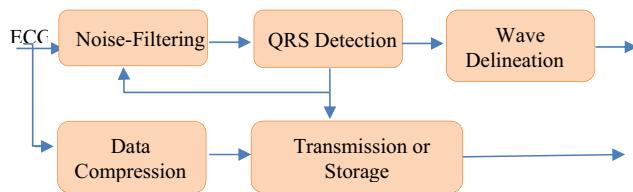
Fig. 4 ECS signal (Zacharia et al., 2016)

been suggested to develop automated recognition and classification of ECG. Self-organizing maps (SOM), SVM, decision trees, nearest neighbors, clustering, hidden Markov models, multilayer perceptron (MLP), Markov models, fuzzy or neuro-fuzzy systems, and combinations of different approaches have been projected to increase performance (Mitra & Samanta, 2013; Salehi et al., 2020b). These are the methods of classifying the top classifier from the each unlabeled and labeled information, and via unlabeled information, it transfers the high performance of classification (Shailaja et al., 2018). The phase of randomized trials is often with disappointing results, so that over the last three decades, only a few of the active antiarrhythmic drugs that were developed and investigated were actually put on the market and then not always in all countries (Jordaens, 2018).

Moreover, in current technology, the doctor is able to control patients remotely which can call U-Healthcare services. For collection of related features from ECG dataset, it selects feature subsets from the dataset, and at that point,

Fig. 5 ECG features

| Feature	Description	Duration
RR	interval between R wave and the next R wave	0.6-1.2 s
P	first short upward movement of the ECG	80ms
PR	measured from the beginning of the P wave to the beginning of the QRS complex	120-200 ms
QRS	normally begins with a downward deflection Q, a larger upwards deflection R and ends with a downward S wave	80-120 ms
PR	connects the P wave and the QRS complex	50-120 ms
J-point	The point at which the QRS complex finishes and the ST segment begins is called J-point	Not applicable
ST	connects the QRS complex and the T wave	80-120 ms
T	normally a modest upward waveform	160 ms
ST	measured from the J point to the end of the T wave	320 ms
QT	measured from the beginning of the QRS complex to the end of the T wave	420 ms
U	normally has low amplitude and often it is completely absent	Not mentioned

Fig. 6 ECG processing

classifiers are trained on each subset. Collaborative techniques are useful via a common voting method, which is computational and measured approaches in medicine. Arrhythmia and heart problems are one of the main health difficulties in whole world which leads to various other severe complications, for example, heart attack (Fig. 7).

U-Healthcare

The U-Healthcare definition is intended to provide the ability for using and interconnection of devices in U-Healthcare. This technology will proceed the key role to provide U-Healthcare to people in remote locations and observe the system that is responsible for a continuous stream of correct data for improved healthcare results (Sharma et al., 2016). As the technology for gathering, analyzing and spreading data, which are focused to develop healthcare applications, systems networking and environments of intranet, extranet, and Internet that are supported by technologies such as cloud computing (Salehi et al., 2019), SaaS, and SOA created based on regulated data formats and communication criteria. The captured information may be put in storage on the device or referred to a gathering center that makes available a complete one-to-one care, for both health professionals and patients (Zanjal & Talmale, 2016). Ubiquitous health care is a developing technology by which possibilities increase in efficiency, reliability, and accessibility of medical management.

U-Healthcare system is to make available suitable healthcare service to both doctors and patients and to make it easy to analyze patient's health condition. People can control their health without meeting the doctor. General computing has ended the communication between humans and computational devices, so user can acquire the desired data in transparent method (Singh et al., 2019a). The newly developed devices like mobile phone, laptops and PDAs made it possible. This method develops the quality of care through continuously caring and lower cost of care by reducing the need for caregiver to dynamically participate in data collection and analysis. It may be late or expensive to treat when a person rushes for emergency treatment with external symptoms, whereas it can be preventive and less complicated when internal heart condition abnormality is timely detected and immediate medical supervision is taken (Puri et al., 2016). Low-power standard communication is usually used for communication between several devices regarding to different location and distance of clients.

3.1 SVM Algorithm

Support vector machine is a supervised learning technique used for classification and regression which can lead to high performance in practical applications and is considered one of the most efficient families of algorithm in machine learning (Fig. 8).

3.2 Naïve Bayes

This algorithm works on the bases of applying Bayes' theorem with strong (naïve) independence assumptions between
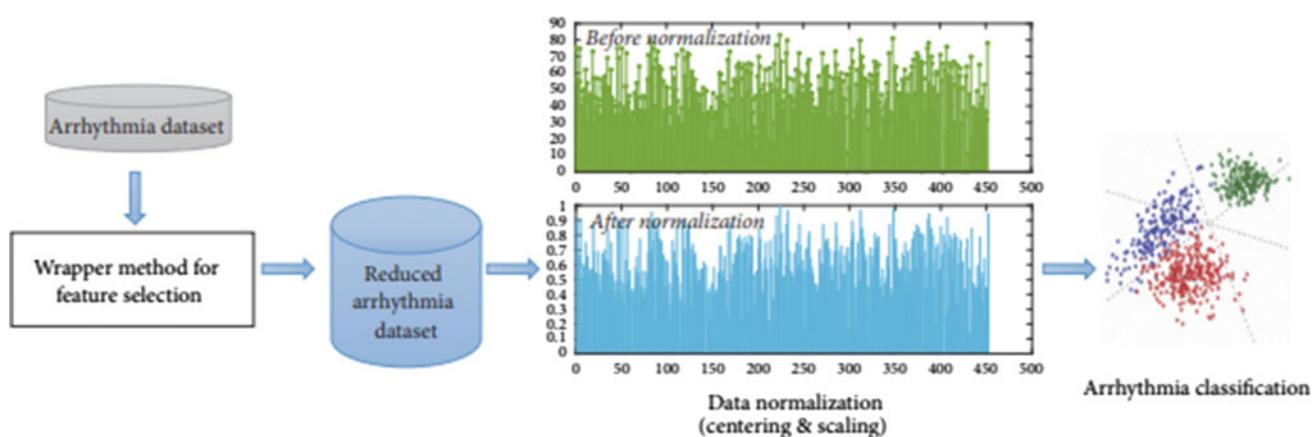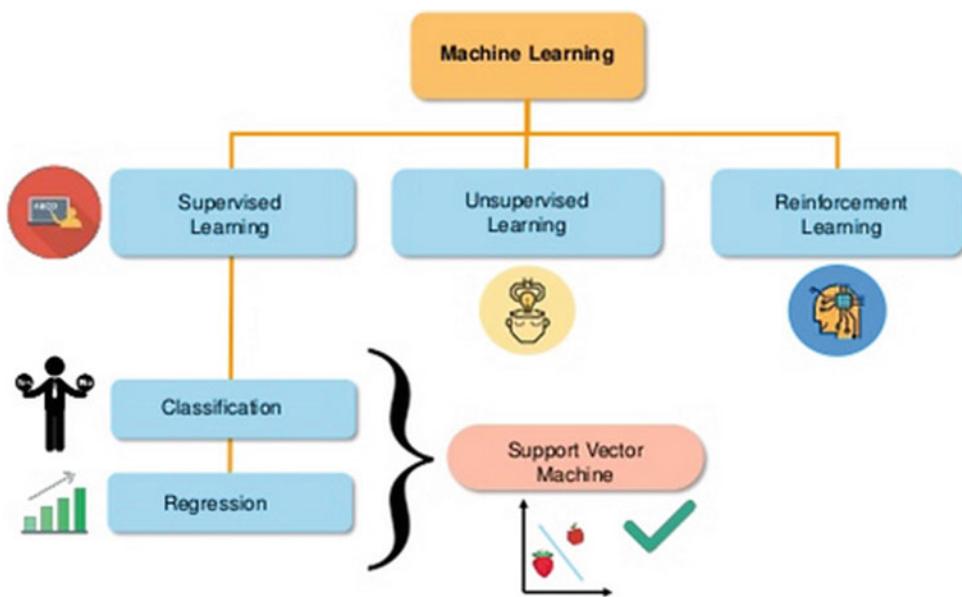
Fig. 7 Classification model

Fig. 8 Support vector machine

the features. Naïve Bayes classifier algorithm included a number of parameters in the number of predictors in a learning problem. It represented by a vector $X = (X1…Xn)$ representing some n features.

3.3 K-NN

The k-nearest neighbor algorithm is a non-parametric approach consisting of the k-closest training examples in the space of the function. The output is determined by whether k-NN is used for classification or regression and that is $C_n^{1nn(x)} = Y_{(1)}$.

3.4 ANN

Artificial neural network algorithm is designed to simulate associative memory; however, the input layer displays the data that we feed the ANN (Sethi et al., 2017; Singh et al., 2019b). The output layer is where the results of the algorithm are showed for us to observe.

According to a survey between many researchers, we can compare the accuracy among them. Table 2 talks about the accuracies of Naive Bayes, K-NN, ANN, and SVM with stratified tenfold dataset. The margin classification, while confirming that there are as few unlabeled observations near the margin as possible. These methods have trouble extending to large amounts of unlabeled data, and effective optimization in this setting is still an open problem (Kingma et al., 2014).

In a simple way, we can describe which prediction accuracy can be increased by using more patient's data, and this approach can be extended for development of a software that will be GUI which helps doctors to predict diseases; moreover, similar tool and methods may be developed for other complex diseases of heart.

The accuracy evaluation describes that support vector machine with PSO search feature selection is meliorated than the others, that is, 70.70%. In classification performance term with a fixed feature vector, the SVM model is produced for classification of heartbeats inputted in the algorithmic flow, in real time (Azariadi et al., 2016). Although over the years a large number of prediction tools are present, the researchers always keep trying to develop an efficient method to provide a tool that will allow researchers, doctors, and clinicians to get prediction of diseases on the bases of ECG signal. This prediction tool should be a user-friendly and free available resource tool which provides predictions on arrhythmia disease. There is hope that the availability of this tool would save time and effort of specialists involved in the field and thus will facilitate the doctors and clinicians for heart disease diagnosis, treatment, and prevention. After capturing the dataset based on three groups of people which are 'ARR,' 'CHF,' and 'NSR,' features are extracted from these ECG signals, and then, training and testing parts are done. After testing, it gives accuracies of prediction. This tool helps doctors and radiologist to make prediction in an easy way. As this tool is designed for clinicians, researchers, and doctors who are working in different locations, it is important to provide an easy, open source way to diagnose disease. Thus, a tool which gives prediction of disease is the best solution.

Table 2 Comparison of result with three different epoch sizes

Feature selection	Accuracy (%)			
	Naïve Bayes	*K*-NN	ANN	SVM
Original	17.44	60.00	68.84	62.56
GA search	53.02	63.26	70.00	67.21
PSO search	63.02	64.42	71.86	70.70

4 Conclusion

The key point of this review paper is to discuss about classification of arrhythmia, along with the efficient usage of ECGs to extract wavelet features from ECG signals and use those structures to categorize ECG signals into three types. It also shows the difference between the ARR, CHF, and NSR classes. It has confirmed by the cross-validation results and the execution of the SVM classifier on the test set for utilizing and providing a method for the evaluation of arrhythmia conditions by capturing signals from patient's body and then classifying to the related categories.

This paper endeavors to emphasize on a medicinal services framework for better treatment of arrhythmia patients; it is not only focused about health care but also try to describe and provide better healthcare services which is able to provide such a system to increase their flexibility, cost efficiency, optimization capability, availability, and scalability for the purpose of decreasing mistakes.

References

Alfaras, M., Soriano, M. C., & Ortín, S. (2019). A fast machine learning model for ECG-based heartbeat classification and arrhythmia detection. *Frontiers in Physics, 7,* 103.

Amani, T., et al. (2011). A review of ECG peaks detection and classification. In *5th Kuala Lumpur International Conference on Biomedical Engineering*. Springer.

Azariadi, D., et al. (2016). ECG signal analysis and arrhythmia detection on IoT wearable medical devices. In *2016 5th International Conference on Modern Circuits and Systems Technologies (MOCAST)*. IEEE.

Baglat, P., Salehi, A. W., Gupta, A., & Gupta, G. (2020, December). Multiple machine learning models for detection of Alzheimer's disease using OASIS dataset. In *International Working Conference on Transfer and Diffusion of IT* (pp. 614–622). Springer, Cham.

Bhardwaj, P., Choudhary, R. R., & Dayama, R. (2012). Analysis and classification of cardiac arrhythmia using ECG signals. *International Journal of Computer Applications, 38*(1), 37–40.

Chiu, C.-C., Lin, T.-H., & Liau, B.-Y. (2005). Using correlation coefficient in ECG waveform for arrhythmia detection. *Biomedical Engineering: Applications, Basis and Communications, 17*(03), 147–152.

Clayton, R., Murray, A., & Campbell, R. (1994). Recognition of ventricular fibrillation using neural networks. *Medical and Biological Engineering and Computing, 32*(2), 217–220.

Isin, A., & Ozdalili, S. (2017). Cardiac arrhythmia detection using deep learning. *Procedia Computer Science, 120,* 268–275.

Jambukia, S. H., Dabhi, V. K., & Prajapati, H. B. (2015). Classification of ECG signals using machine learning techniques: A survey. In *2015 International Conference on Advances in Computer Engineering and Applications*. IEEE.

Jordaens, L. (2018). A clinical approach to arrhythmias revisited in 2018. *Netherlands Heart Journal, 26*(4), 182–189.

Joshi, A. K., Tomar, A., & Tomar, M. (2014). A review paper on analysis of electrocardiograph (ECG) signal for the detection of arrhythmia abnormalities. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 3*(10), 12466–12475.

Keshavamurthy, T., & Eshwarappa, M. (2017). Review paper on denoising of ECG signal. In *2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT)*. IEEE.

Kingma, D. P., et al. (2014). Semi-supervised learning with deep generative models. In *Advances in neural information processing systems*.

Mitra, M., & Samanta, R. (2013). Cardiac arrhythmia classification using neural networks with selected features. *Procedia Technology, 10,* 76–84.

Puri, C., et al. (2016). iCarMa: Inexpensive cardiac arrhythmia management—An IoT healthcare analytics solution. In *Proceedings of the First Workshop on IoT-Enabled Healthcare and Wellness Technologies and Systems*.

Saboori, R., Sharma, B. B., Kumar, N., & Gupta, G. (2020). IoT-based healthcare support services for arrhythmia: A review. *Journal of Xi'an University of Architecture & Technology, 12,* 1035–1039.

Salehi, A. W., Noori, F., & Saboori, R. (2019). *Cloud computing security challenges and its potential solution.*

Salehi, A.W., Baglat, P., & Gupta, G. (2020a). *Alzheimer's disease diagnosis using deep learning techniques.*

Salehi, A. W., Baglat, P., & Gupta, G. (2020b). Review on machine and deep learning models for the detection and prediction of Coronavirus. *Materials Today: Proceedings*.

Salehi, A. W., Baglat, P., Sharma, B. B., Gupta, G., & Upadhya, A. (2020, September). A CNN Model: Earlier Diagnosis and Classification of Alzheimer Disease using MRI. In *2020 International Conference on Smart Electronics and Communication (ICOSEC)* (pp. 156–161). IEEE.

Sethi, K., et al. (2019). Comparative analysis of machine learning algorithms on different datasets. In *Circulation in Computer Science International Conference on Innovations in Computing (ICIC 2017)* (p. 87).

Shailaja, K., Seetharamulu, B., & Jabbar, M. (2018). Machine learning in healthcare: A review. In *2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA)*. IEEE.

Sharma, P., & Gupta, G. (2016a). Proficient techniques and protocols for the identification of attacks in WSN: A review. *Indian Journal of Science and Technology, 9,* 42.

Sharma, P., & Gupta, G. (2016b). Security problems in sensor network. *Int'l J. Info. Sec. & Cybercrime, 5,* 67.

Sharma, L., Gupta, G., & Jaiswal, V. (2016). Classification and development of tool for heart diseases (MRI images) using machine

learning. In *2016 Fourth International Conference on Parallel, Distributed and Grid Computing* (*PDGC*). IEEE.

Singh, P. K., et al. (2019a). *Proceedings of ICETIT 2019: Emerging trends in information technology* (Vol. 605). Springer Nature.

Singh, P. K., et al. (2019b). *Proceedings of ICRIC 2019: Recent innovations in computing* (Vol. 597). Springer Nature.

Zacharia, A. M., Shyjila, P., & Kizhakkethottam, J. J. (2016). Cardiac arrhythmia classification using atrial activity signal. *Procedia Technology, 24,* 1406–1414.

Zanjal, S. V., & Talmale, G. R. (2016). Medicine reminder and monitoring system for secure health using IOT. *Procedia Computer Science, 78*(3), 471–476.

An Approach for Documents Clustering Using *K*-Means Algorithm

Naveen Kumar, Sanjay Kumar Yadav, and Divakar Singh Yadav

Abstract

Clustering is a process to form the same group as per the similarity values. Document clustering has given importance to the information retrieval and data mining process. This proposed work gives the improvement in efficiency and accuracy of the document clustering. This paper proposed a work which following phase: preprocessing, term document matrix and applying clustering algorithm. Initially, it shows flowchart and later calculates the TF, IDF and TF-IDF values. Later on, *K*-means clustering takes place to form the multiple clusters as per similarity measures. As per TF values of given keywords that show the 2D and 3D graphically representation.

Keywords

Document clustering • *K*-means • TF-IDF • Similarity measures

1 Introduction

In many fields, the document clustering has played the significant role, these fields are data mining, information retrieval, and many more area can be there. So, many problems with document clustering or text clustering are there such as volume size is high, complexity of semantics and also the dimension of the data present in the document (Wahyu et al., 2018). The aim of document clustering is to squeeze the intra-cluster distance between documents Tagarelli (2011).

The challenges of document clustering are as follows Tagarelli (2011):

- For clustering usage, selection of appropriate features of documents should be considered.
- Appropriate clustering method should also be there.
- The selection of similarity measures between documents.
- Implement the optimized clustering algorithms.
- Best utilization of similarity measures of documents for information retrieval.

With the help of document clustering, similar documents can be grouped together. The basic means of the document clustering are as per similarity measure cluster will be formed. Many approaches have been invented for the classification of document or text clustering (Arivarasan & Karthikeyan, 2019) like as Naïve Bayes, support vector machines, DBSCAN and *K*-medoids. Users need to find out the related results as per the input keyword. These keywords can also proceed to retrieve the valuable information. This document clustering is beneficial for the searching mechanism and information retrieval also. Before implementing, the mechanism needs to preprocess the input text as per the target format. This process applies some formats like lower case, stop words and many more. Later on make a term document matrix which maintains the frequency of a text into the documents (Lydia & Govindasamy, 2018). To form the cluster, each document is defined by a vector that depicts the weight of each word in document. To find out the weight of each word needs to work with TF-IDF (term frequency-inverse document frequency) (Patil & Atique, 2013). There are so many clustering algorithms named as flat, *K*-means, hierarchical and fuzzy clustering (Gurung & Wagh, 2017).

N. Kumar (✉) · S. K. Yadav
Department of Computer Science and Information Technology, Sam Higginbottom University of Agriculture, Technology and Science, Allahabad, Uttar Pradesh, India

D. S. Yadav
Department of Computer Science and Engineering, Institute of Engineering of Technology, Lucknow, Uttar Pradesh, India
e-mail: dsyadav@ietlucknow.ac.in

2 Literature View

Document clustering (Ma et al., 2014; Odukoya et al., 2010) is the backbone for the information retrieval mechanism. Many researchers work on clustering approaches on documents for different types of information system. In this section, considered some published paper for literature point of view.

Rangrej (2011) explained the comparative study on different clustering techniques like as *K*-means, SVD-based method and graph-based technique and also gave the performance evaluation on Twitter text data and defined the cluster error for given cluster techniques. Deokar (2013) proposed a unstructured text documents clustering with the usage of *K*-means algorithm. This paper explained the *K*-means, residual sum of squares, termination condition, bad choice of initial seed and then further TF-IDF calculation for corresponding documents. This approach is implemented in Java. Roul (2014) examined Web document clustering and ranking using term frequency and inverse document frequency based on Apriori method. Just prepare the rank of the document as per TF-IDF value. This technique is valuable for the information retrieval as based on the similarity measurement and also gave the comparison with traditional Apriori approach that showed the better result.

Al-Anazi et al. (2016) focused on different clustering techniques which are as follows. *K*-means, *K*-means fast and *K*-medoids and further dataset tested on similarity measures cosine similarity, Jaccard similarity and correlation coefficient. Combination of *K*-means/*K*-medoids and cosine similarity gives the better result in case of performance. Gurung and Wagh (2017) presented application of cluster analysis of document collection of small as well as big documents. This paper focused on the topic identification of various documents. Text clustering and topic identifications both are playing vital role in information retrieval system. Lydia and Govindasamy (2018) produced a process of document clustering based on *K*-means algorithm for partitioned and also the centroid similarity and cluster similarity. Arivarasan and Karthikeyan (2019) proposed a two-steps text clustering approach by *K*-means, first step for preprocessing whereas second step is for clustering task. In case of preprocessing step, some token-based approach takes place and find out the word occurrences and tf-idf whereas in *k*-means clustering, step vector is clustered. Alexandre Ribeiro Afonso,

Afonso and Duque (2014) focus on the automated text clustering which is based on the newspaper text and scientific text also. This work provides a method of computational to create cluster based on the input texts. This proposed method works on following four sections namely corpus, class, filter and clustering. The outcome of this proposed

work, clustering consistency depends on the input texts and topics. Buatoom et al. (2020) give a approach to use term statistics and focus on the three types of standard deviation SD, ACSD and CSD. This proposed work calculates the TF-IDF and distribution term weight.

3 Methods for Preprocessing and Clustering

A. Preprocessing of text

This approach is used for filtering the text and makes the text identification easy. In this process of document clustering, different types of preprocessing techniques commonly implemented. The main aim of preprocessing task trains the document in form of vectors so that clustering can be implemented easily. To represent the documents, follow the different ways which are TF-IDF, vector model, graphical-model word count of keyword (Arivarasan & Karthikeyan, 2019). The refinement process clears the content text by text and removes the duplicity from the document. Many steps are there come under preprocessing (Jacob & John, 2016) which are follows:

1. Filtering: In the process of filtering, all the punctuation which has no meaning should also be removed from the text for example in Web content removes the tag from text for smooth working.
2. Tokenization: This process splits the whole string into collection of tokens.
3. Lower case: It is just converting the whole text into lower case.
4. Stop words: Removing the all words like as I/we/you, a/an, of, for, in, etc.
5. Stemming: Identifying the base of the words and reduces to the correspond for easy use of preprocessing for example the word "mailing" and "mailed" can be reduced to the base word "mail".

B. Term document matrix

To mine large collection of documents, it is necessary to preprocess them. As most of the text mining algorithms work on numbers, we used the bucket of terms representation in our job to preprocess the text wherein the documents are modeled as the bucket of exclusive terms along with a count of total occurrences of these words also called vector of words/term. The order and structure of words are completely discarded. All the documents get converted into a *n*-dimensional matrix where each row corresponds to a word

and each column represents a document vector. This indicates the occurrence of word existence in an exacting text. There is not very complex to observe that the matrix would be a sparse one, and we will make utilize of this information for the duration of clustering. The occurrence of each word as its weight which is represent of our assumption that an elevated frequency word is extra expressive of the text. So this though requires a small revision which is bringing in the representation of inverse document frequency (IDF) value.

Consider the documents list where D indicates documents collection set and individual documents named as d_1, d_2, d_3, till d_n, where n is number of documents and term represented by T which has a series of terms like t_1, t_2, t_3, till t_m, where m is exclusive terms. After this task, document can be expressed as: $t_d = t_{f1}$, t_{f2}, t_{f3}, till t_{fm}, where m is dimensional vector. It is important that document preprocessing task is required in which we take out high appearance of stop words in all documents like an, for, in, is/are/am, etc. We also specify the weight values of words to terms not simply based on their frequencies but on TF-IDF weight values. TF-IDF weights discount the frequency of terms based on their significance to specific text in the complete text put in concern.

This is explained as follows:

$$\text{TF-IDF}(d, t) = \text{TF}(d, t) \times \log\left(\frac{|D|}{DF(t)}\right)$$

In TF-IDF, the term frequency (TF) is the frequency of the term in the current document and found out by following formula:

$$\text{TF} = \frac{\text{Number of times of appearance of term in a document}}{\text{Total number of terms in the document}}$$

In the inverse document frequency, term weighting the higher weights is assigned to these more discriminative words. The total number of documents in a collection by N and n_i is the number of documents where term i appears, the inverse document frequency of a term t is defined as by fraction of N and n_i by following formula:

$$\text{IDF} = \log\frac{N}{n_i}$$

The final calculation of TF-IDF is collective process which is represented as following formula:

$$\text{TF-IDF} = \text{Tf} * \text{IDF}$$

C. Document representation in vector space model

Vector space model also called as term vector model or vector processing model represents both document and query by term set and compares similarities between them. This vector space model (VSM), (Roul, 2014) a standard technique in information retrieval, is a way of representing documents through the words they contain. In this, each document is *N*-dimensional vector where *N* is the number of distinct terms over all the documents. The weight related with every keyword/term find outs the significance of the giving keyword in any document. Therefore, a text in vector type can be shown as $Dj = [w1j, w2j, w3j, w4j, ..., wnj]$ and *wij* is represented as weight of keyword *i* in text *j*.

D. Apply *K*-means cluster algorithm

For every later experiment, *K*-means clustering algorithm is used for the clusters forming. The *K*-means is a partitioning clustering algorithm. Its process intends to minimize the least square error principle (Jacob & John, 2016). The partitioning algorithms handled large amount of document datasets than hierarchical clustering, as earlier told, this algorithm is best suited because of few computational needed (Arivarasan & Karthikeyan, 2019; Gurung & Wagh, 2017).

The process of standard *K*-means algorithm is as follows. There are used two values as input, one is set of data vector named "*D*", and another one is "*k*" number of optimal cluster. Each clusters has centroid and then the residual objects assign to the cluster represent by the most related or nearest centroid. Again recomputed new centroid for each cluster and based on new centroid re-assigned the all document (Deokar, 2013; Roul, 2014). This process repeated again and again until find out a fixed solution, where all data object remains in the similar cluster after update of centroid. Steps are following:

Input data:

D   It is a collection of set of "*n*" data vectors
k   It is a number of clusters that randomly selected.

Output:

Obtain a set of data that contain "*k*" clusters

Steps:

- Randomly picked "k" data vector from n dataset after that calculate first cluster center and assign to *cj* $(1 \leq j \leq k)$
- Determining the distance of all data vectors in "*D*" from every clusters center in "*C*"
- Now that data vector has minimum distance, i.e., most similar data vector is put into the cluster
- Again find out the updating cluster center by calculating the average of data vector assigned to a cluster

• Repeat step 2–4 until get same mean and stop.

4   Proposed Work

This flowchart in Fig. 1 shows the different phases of proposed work. As initially unstructured documents are available, applying the data preprocessing to filter these documents into token format then needs to apply the different preprocessing process which has lower case conversion, stemming and stop words. Later on, count each word occurrences in the sentences of each document which is known as count vectorizer. After completion of preprocessing phase, calculate the TF, IDF and then TF-IDF and create vectors. After calculating the TF-IDF values, apply the *K*-means clustering algorithm and proceed to the next phase of proposed work which is creating clusters based on the Euclidean distance similarity measures.
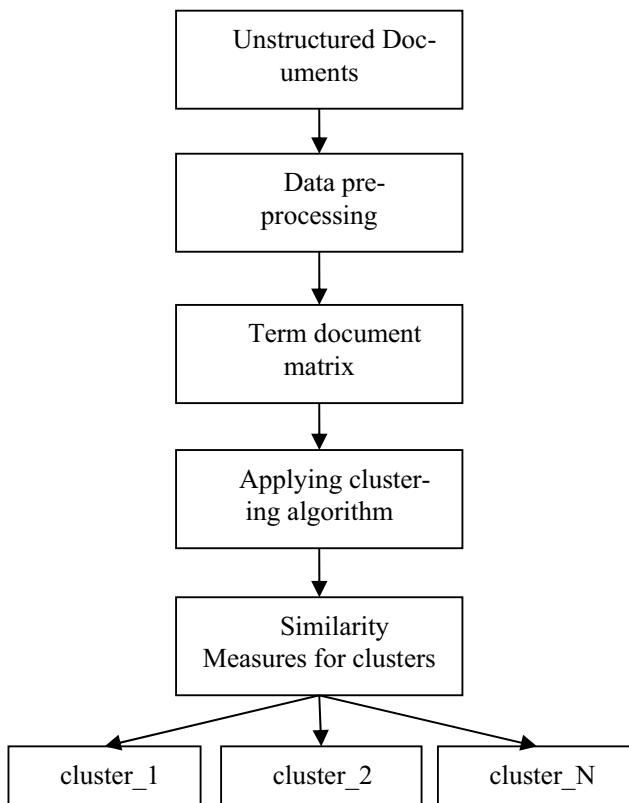

Fig. 1 Flowchart of document clustering

5   Simulation and Result Analysis

This proposed work coding section is completely implemented in Python. For this experiment, the proposed work collected the agriculture dataset which has multiple documents, and each document has multiple sentences. As proposed work simulation calculates the TF-IDF values of the considered document. For the process of text mining or information retrieval, calculate the weights of terms. Later on, distance is taken into the consideration to implement the clustering algorithm.

A. Dataset

Indian agriculture dataset used to implement the proposed work. This is very standard dataset used for distinguishing text-based application, mining techniques and many more application. This dataset has multiple dataset where multiple sentences are in each document.

B. Cluster formation using *K*-means clustering algorithm

Here, the distance similarity measures of terms of each document form the cluster using *K*-means algorithm. If consider the cluster size is two then forms the top terns per cluster shown in Table 1.

And sentences those are coming under the clusters are also shown in Table 2. As per the terms, each line of document belongs to specific cluster. As in Table 2, line no: 5, 6, 7 are in cluster 0 (first cluster), whereas line 1, 2, 3, 4, 8, 9, 10 are in cluster 1 (second cluster).

If consider the cluster size is three then forms the top terns per cluster shown in Table 3.

And sentences those are coming under which cluster are also shown in Table 4. As per the terms, each line of document belongs to specific cluster. As in Table 4, line no: 2, 8, 9, 10 are in cluster 0 (first cluster), line no: 1, 3, 4 are in cluster 1 (second cluster), whereas line no: 4, 5, 6 are in cluster 2 (third cluster).

Figure 2 shows the Tf values between agriculture and breeding words of the dataset. For line number 1, the "agriculture" TF value is 0.1, and the "breeding" TF value is 0.0, for line number 2, the "agriculture" TF value is 0.07143, and the "breeding" TF value is 0.07143, for line number 3, the "agriculture" TF value is 0.09091, and the "breeding" TF value is 0.0, for line number 4, the "agriculture" TF value is 0.1111, and the "breeding" TF value is 0.0, for line number

Table 1 Top terms per cluster two

Cluster 0	Agricultural drainage irrigation conservation sanitary
Cluster 1	Science breeding genetics agriculture livestock

Table 2 Two clusters with sentences

| Line No.	Document lines	Cluster No.
1.	Agriculture is art, science and industry of managing the growth of plants and animals for human use	1
2.	In a broad sense, agriculture includes cultivation of the soil and growing and harvesting crops and breeding and raising livestock and dairying and forestry	1
3.	Regional and national agriculture are covered in more detail in individual continent, country, state and Canadian province articles	1
4.	Modern agriculture depends heavily on engineering and technology and on the biological and physical sciences	1
5.	Each of irrigation and drainage and conservation and sanitary engineering is important in successful farming	0
6.	Irrigation and drainage and conservation and sanitary engineering are some of the fields requiring the specialized knowledge of agricultural engineers	0
7.	Agricultural chemistry deals with other vital farming concerns, such as the application of fertilizer and insecticides and fungicides and soil makeup and analysis of agricultural products and nutritional needs of farm animals	0
8.	Plant breeding and genetics contribute immeasurably to farm productivity	1
9.	Genetics has also made a science of livestock breeding	1
10.	Hydroponics is a method of soilless gardening	1
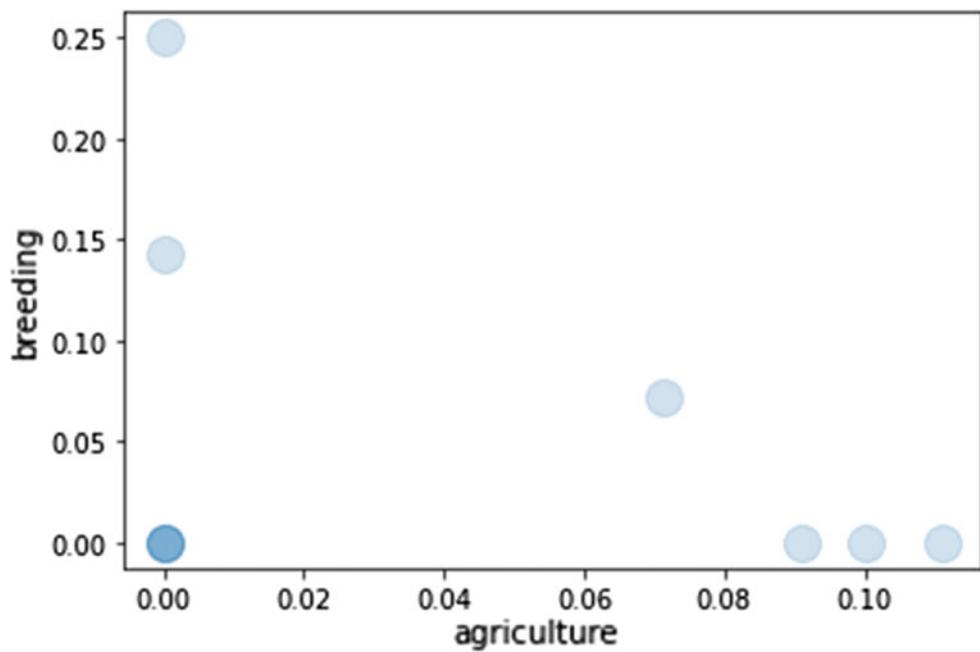
Table 3 Top terms per cluster three

Cluster 0	Breeding genetics livestock method gardening
Cluster 1	Agriculture science heavily depends physical
Cluster 2	Agricultural drainage irrigation conservation sanitary

Table 4 Three clusters with sentences

Line No.	Document lines	Cluster No.
1.	Agriculture is art, science and industry of managing the growth of plants and animals for human use	1
2.	In a broad sense, agriculture includes cultivation of the soil and growing and harvesting crops and breeding and raising livestock and dairying and forestry	0
3.	Regional and national agriculture are covered in more detail in individual continent, country, state and Canadian province articles	1
4.	Modern agriculture depends heavily on engineering and technology and on the biological and physical sciences	1
5.	Each of irrigation and drainage and conservation and sanitary engineering is important in successful farming	2
6.	Irrigation and drainage and conservation and sanitary engineering are some of the fields requiring the specialized knowledge of agricultural engineers	2
7.	Agricultural chemistry deals with other vital farming concerns, such as the application of fertilizer and insecticides and fungicides and soil makeup and analysis of agricultural products and nutritional needs of farm animals	2
8.	Plant breeding and genetics contribute immeasurably to farm productivity	0
9.	Genetics has also made a science of livestock breeding	0
10.	Hydroponics is a method of soilless gardening	0

Fig. 2 Plotting points as per TF values

5, the "agriculture" TF value is 0.0, and the "breeding" TF value is 0.0, for line number 6, the "agriculture" TF value is 0.0, and the "breeding" TF value is 0.0, for line number 7, the "agriculture" TF value is 0.0, and the "breeding" TF value is 0.0, for line number 8, the "agriculture" TF value is 0.0, and the "breeding" TF value is 0.14286, for line number

9, the "agriculture" TF value is 0.1, and the "breeding" TF value is 0.25, for line number 1, the "agriculture" TF value is 0.0, and the "breeding" TF value is 0.0.

Figure 3 shows the three-dimensional representation of three keywords named as: agriculture, breeding and agricultural. This shows the TF values in all three axis.
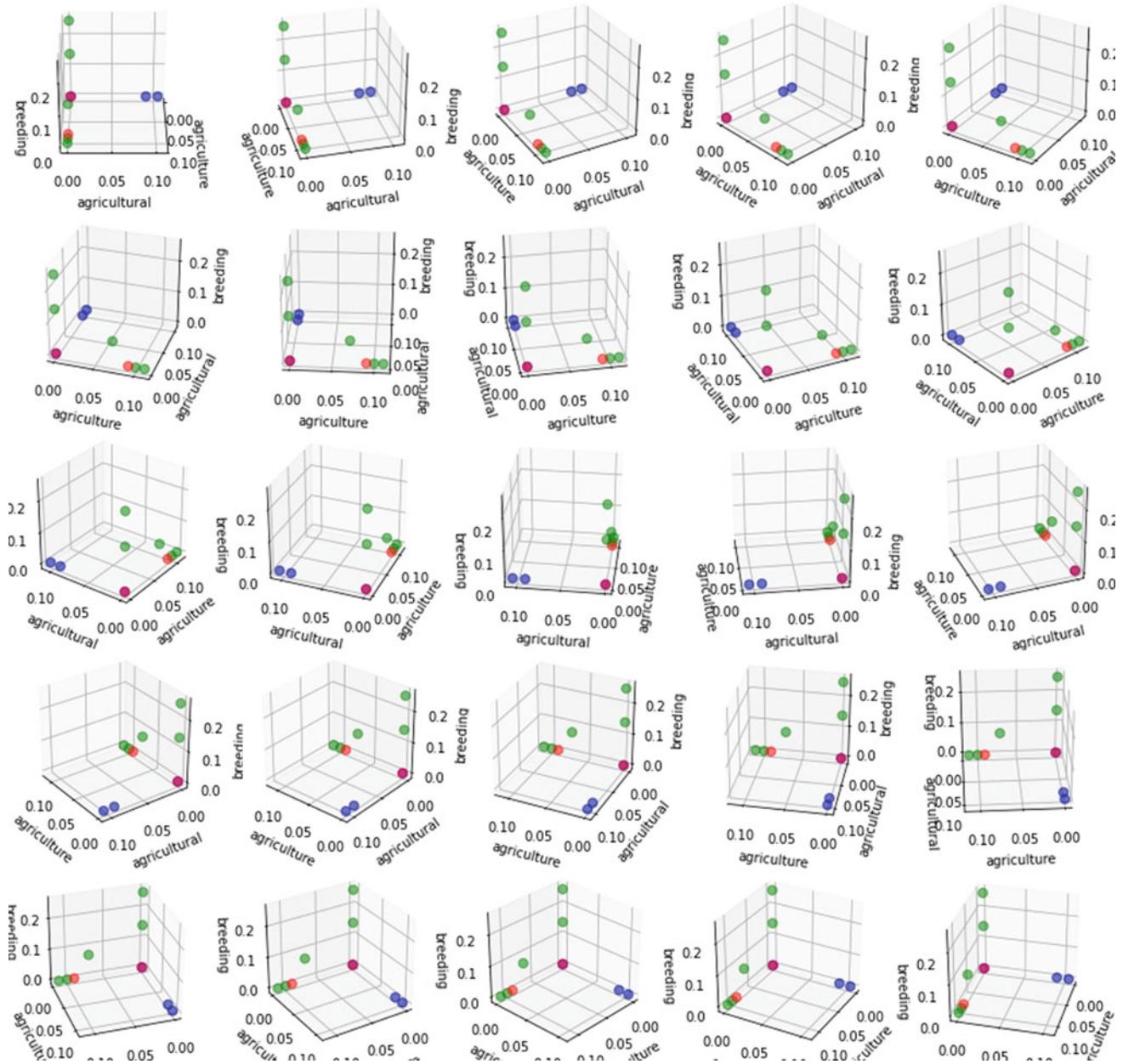
Fig. 3 3D graph representation for agriculture, breeding and agricultural keywords

6 Conclusion

Use of *K*-means clustering algorithm in document clustering is best to form the cluster on the basis of similarity measures. Topic uniqueness and text clustering these are the two main concepts of information retrieval. This paper worked for TF, IDF and TF-IDF values to find out the importance of the document. On the behalf of these values form the clusters. This work is capable to form the cluster with best quality also in fast way. This also reduced the execution time in the cluster process. This proposed work used business application, search engines and marketing. This work can further be extended by considering those documents which are not parts of the initial clusters formed by the proposed approach because of strong association rule, to make either new clusters or part of the existing clusters which may be of user interest.

References

Afonso, A. R., & Duque, C. G. (2014). Automated text clustering of newspaper and scientific texts in Brazilian Portuguese: Analysis and comparison of methods. *Journal Information System and Technology Management (JISTM), 11*(2), 415–436.

Al-Anazi, S., Almahmoud, H., & Al-Turaiki, I. (2016). Finding similar documents using different clustering techniques. *Procedia Computer Science, 82,* 28–34.

Arivarasan, A., & Karthikeyan, M. (2019). Data mining *K*-means document clustering using TFIDF and word frequency count. *International Journal of Recent Technology and Engineering, 2,* 2542–2549.

Buatoom, U., Kongprawechnon, W., & Theeramunkong, T. (2020). Document clustering using *K*-means with term weighting as similarity-based constraints. *Symmetry (Basel), 12*(6), 1–25.

Deokar, S. T. (2013). Text documents clustering using *K* means algorithm. *International Research Journal of Engineering and Technology (IRJET), 1,* 282–286.

Gurung, P., & Wagh, R. (2017). A study on topic identification using *K* means clustering algorithm: Big vs. small documents. *Advances in Computational Sciences and Technology, 10*(2), 221–233.

Jacob, M., & John, A. (2016). Improved clustering of documents using *K*-means algorithm. *International Journal of Engineering Research and Technology (IJERT), 5*(07), 378–382.

Lydia, L., & Govindasamy, P. (2018). *Document clustering based on text mining K-means algorithm using Euclidean distance similarity,* April, 2018.

Ma, Y., Wang, Y., & Jin, B. (2014). A three-phase approach to document clustering based on topic significance degree. *Expert Systems with Applications, 41,* 8203–8210.

Odukoya, O., Aderounmu, G. A., & Adagunodo, E. R. (2010). *An improved data clustering algorithm for mining web documents.* IEEE.

Patil, L. H., & Atique, M. (2013). A novel approach for feature selection method TF-IDF in document clustering. In *IEEE International Advance Computing Conference*

Rangrej, A. (2011). *Comparative study of clustering techniques for short text documents* (pp. 10–12), January, 2011.

Roul, R. K. (2014). *Web document clustering and ranking using Tf-Idf based apriori approach,* November, 2014.

Tagarelli, A. (2011). XML document clustering. In *Handbook of research on innovations in database technologies and applications: Current and future trends* (pp. 665–673).

Wahyu, R. B., Vito, A., & Panjaitan, E. (2018). Documents clustering using *K*-means algorithm. *IT for Society, 03*(02), 62–66.

Edge Intelligence: A Robust Reinforcement of Edge Computing and Artificial Intelligence

Brinda Parekh and Kiran Amin

Abstract

Due to the development of faster and improved modes of communication, technologies, as well as customers, get benefited. The world is moving rapidly toward digitization, and connectivity has been placed under tremendous pressure. The development and implementation of IoT devices benefit all industry sectors, stimulating more areas in terms of convenience, productivity, and communication. But such a huge amount of data generated by IoT devices could result in a breakdown of IT infrastructure. To reach to the desired destination, this massive data travels via some intermediator. When the so-called intermediator that is cloud database is based in a remote location, the data can experience some kind of delay before it reaches the cloud for processing. So in recent years, the IT industry is attracted tremendous attention to improving communication between these technologies. And this is what the aim of edge computing (EC) is. Meanwhile also artificial intelligence (AI) algorithms and models have made breakthrough progress to accelerate the successful deployment of intelligence in the cloud services. By and large, AI services are executed in cloud for dealing with demands, because of the way that most AI models are intricate and difficult to process their induction results in favor of resource-limited devices. Nonetheless, such sort of 'end–cloud' architecture cannot address the issues of real-time AI services such as real-time analytics and smart manufacturing. Accordingly, deploying AI applications on the edge can widen the application situations of AI especially as for the low-latency characteristic. Combining the above two-mentioned paradigms, i.e., EC and AI can give rise to a new outlook: Edge Intelligence (EI). This paper provides insights into this new outlook by discussing core definitions, concepts, components, and frameworks. It also describes some necessary background in future research areas and challenges.

1 Introduction

Due to the advancement of artificial intelligence (AI) in the IT industry, applications and services based on AI are developing rapidly nowadays. With such a breakthrough, a massive amount of data processing demands the development of many powerful AI technologies, for mining insights ranging from facial recognition, natural language processing, computer vision, traffic prediction, and so on that lead to better decisions and strategic business moves. For example, smart homes have enormously improved the nature of our lives at the expense of high computational and memory requirements. Cloud computing has been utilized as a likely answer to lessen the computation from the device to a remote computing infrastructure that has the essential processing power (Plastiras et al., 2018). Yet, using the cloud as a centralized processing server could bring about an increment of to and fro exchange of data between the user/client devices and the distantly located data centers. Many applications require real-time information that needs computer devices and AI services to be closer to them otherwise for exchanging vital information, could arise delay and latency which may turn up extremely dangerous. A connected car generates tones of megabytes of information every second including information with respect to its portability (e.g., directions), its working conditions, images from its cameras,

B. Parekh (✉) · K. Amin
Faculty of Engineering and Technology, Ganpat University, Mehsana, India
e-mail: brin.prkh@gmail.com

K. Amin
e-mail: kiran.amin@ganpatuniversity.ac.in

and information that depict its surrounding conditions (Chiang & Zhang, 2016).

1.1 Need for Edge Intelligence

Just as this could be a restriction for some applications processing private data, for example, wearable biomedical devices, and wearable cameras (Esterle et al., 2017). Processing such private data on the cloud could bring about the dangers of numerous sorts on the security of such information. Hence, there arises a need for computing/processing such data as close as possible to the origin point of the data. This new paradigm could be considered as edge computing that helps close the distance between connected devices and the cloud.

To better demonstrate the difference among cloud and edge-based systems, we represent the case of different applications that require real-time information to be shared and exchanged for processing and getting the desired result in Fig. 1. In the cloud-based systems, various smart devices like smartphones or smartwatches, etc., need data to be transferred to the remote infrastructure for processing. When the so-called remote infrastructure that is cloud database is based in a remote location, it can take a while before the data even reaches the cloud for sorting or processing/computing. Even it could arise many security threats on private data. In the edge-based systems, all the previously mentioned processing is done on some device/edge which is as close as conceivable to the source point of data and just transfers the actual data and metadata information. Immediately, it is apparent that the transmission capacity necessities are diminished altogether and private information is not communicated which reduces protection issues. The principle challenge is on undertaking the entire processing well on such an edge device.

Moving knowledge/intelligence from the cloud to the edge is the main objective of edge intelligence (EI). By implementing this kind of intelligence, we can improve the

Table 1 Summary of notations

Abbreviation	Description
AI	Artificial intelligence
EC	Edge computing
IoT	Internet of things
EI	Edge intelligence

quality and rapidity of information handling, by thinking about the security of information. Therefore, we discuss that EI is estimated to ascend in the future years as well as we can explore its reach into almost every domain. In this paper, we first identify various definitions and concepts of EI. This paper also describes and discusses the components and framework of EI. Along with that, we attempt to provide an overview of the challenges and opportunities it has to offer.

1.2 Organization of Paper

The remainder of this paper is composed as follows:
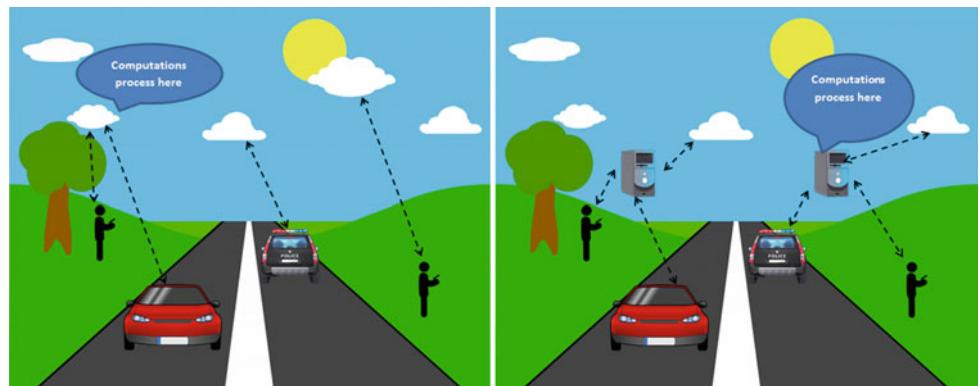
Section 2 discusses the core definitions and concepts of edge intelligence. Section 3 describes components of EI along with its key problems. Section 4 briefly identifies some of the opportunities, benefits, and challenges of EI. Finally, Sect. 5 concludes the work (Table 1).

2 Concepts of Edge Intelligence and Core Definitions

2.1 Concept of EI

In the context of the Internet, 'The Edge' is where it meets the physical world to implement the Internet of things (IoT) happen. Every IoT application has such components that can be used to achieve effective outcomes to improve the user experience. When AI is used to develop prediction

Fig. 1 Cloud computing versus edge computing

machines that enable businesses to make decisions under uncertainty and increase productivity in many applications, likewise this kind of infrastructure such as IoT edge will become intelligent if it can be able to reconfigure or adapt to changing needs of real-time information.

As previously said, IoT applications generate a massive amount of data which may result in a heavy load on networks. To support such kind of applications, using only cloud computing technology may not be efficient enough. Moreover, existing intelligent applications generally adopt a centralized cloud data-center that expects clients to transfer their data to the central data-center (Xu et al., 2020). Uploading/processing such a massive amount of data to the centralized data centers can ingest huge bandwidth resources, resulting in delay and latency for users. As well as it can arise various concerns about privacy issues of data also.

From Cloud Computing Toward Edge Computing

In the post-cloud period, edge computing has emerged as a new technology where data is produced and processed at the edge of the network. Edge computing alludes to the empowering innovations permitting calculation to be performed at the edge of the network, on downstream data on behalf of cloud services and upstream data on behalf of IoT services (Shi et al., 2016). Here, the author characterizes 'edge' as any computing and network resources along the path between data sources and cloud data centers (Shi et al., 2016). The principal points of interest of the edge computing paradigm could be summed up into three viewpoints (Xu et al., 2020).

- Ultra-low latency: Calculation ordinarily happens in the vicinity of the source data, which spares considerable measures of time on data transmission. Edge servers provide nearly real-time responses to end devices.
- Saving energy for end devices: Since end devices could offload processing undertakings to edge servers, the energy consumption on end devices would fundamentally

recoil. Accordingly, the battery life of end devices would be extended.
- Scalability: cloud computing is as yet accessible if there is not sufficient asset on edge devices or edge servers.

As discussed in the previous section although intelligent AI-based applications give remarkable results, in any case, it is at the expense of high calculation and memory necessities. Meanwhile, the benefits of edge computing could be advantageous for the drawbacks of AI-based applications; it is a promising answer for consolidate edge computing and AI together offering to ascend to new paradigm edge intelligence (EI).

### Key Ingredients for Building IoT intelligent

For IoT, things are 'smart', 'connected', 'programmable', and 'adaptable'. But the main question arises on how to make them 'intelligent'. Intelligence needs to be implemented at the system level so that it performs predictions and decisions to achieve better outcomes.

For successfully deploying intelligence in edge, i.e., in smart devices or things, following mechanism needs to exist in them (Sonal, 2020) (Fig. 2).

- Connectivity—Smart devices must be connected to the network which makes data exchange possible.
- Computing—Internal computing resources such as chips must be installed in such devices for computation of real-time data.
- Controllability—Such devices must be able to communicate with central databases for taking decision regarding controlling devices, making modifications, and instigating actions through the network.
- Autonomy—Devices must be autonomous so that it will not require any kind of help while monitoring, managing, transferring the data.

Therefore, building a solution with edge intelligence will require these key ingredients (Nelson, 2019):
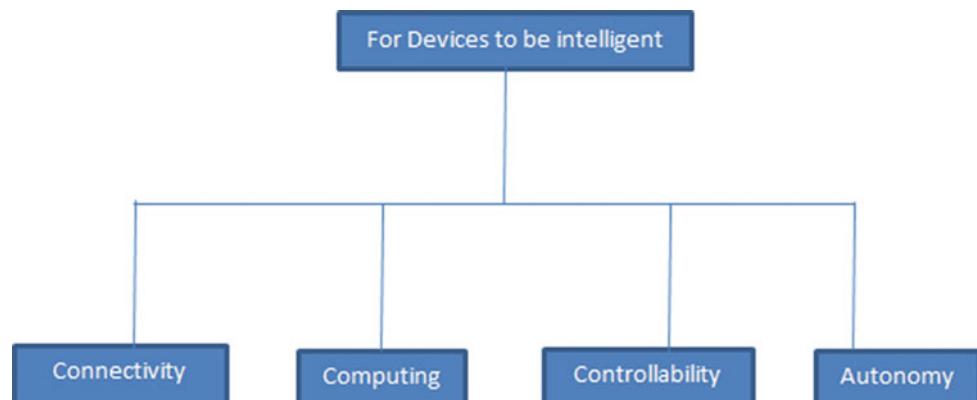
Fig. 2 Mechanism needed for intelligent edge (Sonal, 2020)

- Hardware with partitioned Edge Compute: To make up IoT stack delivers the desired levels of connectivity, sensing, data aggregation.
- Cloud Connectivity: Systems should be associated with the cloud to leverage storage and compute resources on edge.
- Remote Device Management: Needed for security, management automation, edge intelligence, and API integration.
- Virtualization tools—Python, Java, Docker, Kubernetes.
- Microservices: It will provide the full cloud knowledge context like protocol, data structure translations, network adaptions, etc., to the edge dynamically.

2.2 Core Definitions

State-of-the-art researches have given diverse edge intelligence definitions; Table 2 records a few key definitions:

3 Components of EI

Let us initially portray quickly about end devices and edge devices (Sagar, 2020).

- End devices: End devices or edge servers could be IoT gateways, routers, or micro data centers in mobile network base stations, or on automobiles.

- Edge devices: Mobile phones, IoT devices, and embedded devices that request services from edge servers are called edge devices.

Unlike traditional methods, in EI, data processing is done on device/edge which is as close as possible to the origin point of data instead of transmitting all data onto the cloud.

Thus in general, EI can be referred to as a set of connected systems and devices which gathers the information, reserves it, measures it, and do the examination on the spot which as close as conceivable to the source of information.

As we say, we need edge devices to be intelligent, like other intelligent real-time systems, it also has components like data collection, training, and inference.

Edge Intelligence can be identified in four components, which are briefly described in Table 3.

In general, edge Intelligence can be identified in four components (Xu et al., 2020):

A. Edge Caching—Collects and stores the data generated by edge devices.
B. Edge Training—It usually occurs on edge servers or edge devices. The optimal values are found out dependent on the training set accumulated at the edge.
C. Edge Inference—Usually, a trained algorithm deduces the testing instance.
D. Edge Offloading—Provides computing services for all the above three components.

Table 2 Edge intelligence definitions

Papers	Definition: edge intelligence
Plastiras et al. (2018)	Is perceived as the future for empowering artificial intelligence on embedded edge devices at mass. It can possibly offer expanded security and decreased expenses while keeping up the performance compared to processing on the cloud and can possibly empower new capacities for industry and consumers alike
Xu et al. (2020)	Alludes to a lot of connected systems and devices for data collection, caching, processing, and analysis in a spot near where information is caught, to upgrade the quality and speed of information handling and to ensure the protection and security of information
Keshavarzi and Hoek (2019)	The ability to analyze data at the purpose of data collection as opposed to sending it to the cloud for investigation will be a key empowering influence to understand a universe of a trillion hyper-connected smart IoT devices
The Edge Intelligence Project Team (2017)	The process of when the data is acquired is stored and processed with machine learning algorithms at the network edge. EI permits bringing data (pre-) processing and decision-making closer to the data source, which decreases delays in communication. In addition, such (pre-) processing makes it conceivable to amass and gather information before sending it to IoT core services in the cloud or storing it, which consummately coordinates the limits offered by the upcoming fifth-generation wireless technology (5G) networks providing localized throughput and delay enhancements

Table 3 EI components

Component	Meaning	Key problems	Example
Edge caching	Refers to a distributed data system, which gathers and stores the information produced by edge devices and surrounding environments, and the information got from the Internet to help to support intelligent applications for users at the edge (Xu et al., 2020)	Three key problems need to be addressed (Xu et al., 2020): (i) What to cache (ii) Where to cache (iii) How to cache	• The video captured by cameras could be reserved on vehicles for supported driving (Xu et al., 2017) • Even the base station can cache the user's interest or preferences based on his/her past activities while communicating with the Internet. This kind of data can be used from recommendations
Edge training	Alludes to a distributed learning method that learns the ideal qualities for all the weights and bias, or the hidden patterns based on the training set accumulated at the edge (Xu et al., 2020)	Four key problems should be considered for edge training (Xu et al., 2020): (i) How to train (the training architecture) (ii) How to make the training faster (acceleration) (iii) How to optimize the training procedure (optimization) (iv) How to estimate the uncertainty of the model output (uncertainty estimates)	• Google builds up an intelligent input application, named G board, which learns the user's input habits with the user's input history and gives a more exact expectation on the user's next input (McMahan & Ramage, 2017)
Edge inference	Alludes to the phase where a trained model/algorithm is utilized to gather the testing occurrence by a forward pass to compute the output on edge devices and servers (Xu et al., 2020)	Two key problems of employing edge inference are (Xu et al., 2020): (i) How to make models applicable for their deployment on edge devices or servers (design new models or compress existing models) (ii) How to accelerate edge	• Developers have designed a face verification application-based DL
Edge offloading	Refers to a distributed computing paradigm, which offers computing service for edge caching, edge training, and edge inference (Xu et al., 2020)	In edge offloading, the offloading strategy is of utmost importance, which should give full play to the accessible resources in the edge environment (Xu et al., 2020)	• If a solitary edge device needs more resources for a specific edge intelligence application, it could offload application undertakings to edge servers (Device to Edge Server; D2E) or other edge devices (Device to Device; D2D). For example, in smart home scenarios, where IoT devices, smartwatches, and smartphones together perform training/inference tasks

4 Some Promising Application Areas of EI

With more AI procedures are all around implanted in such emerged applications, the presented processing delay and extra calculation cost make the cloud gaming architecture battle to meet the latency necessities. Edge computing architectures, close to clients, can be utilized with the cloud to frame a crossover gaming design. Additionally, intelligent driving involves speech recognition, image recognition, intelligent decision-making, etc. Various AI applications in intelligent driving, such as collision

warning, require edge computing platforms to ensure millisecond-level interaction delay, traffic environment around the vehicle, etc.

Alongside all these application regions, it can likewise be utilized in the military field by vision sharing. At the point when the equipped perform hostile to psychological warfare activities or extraordinary assignments, because of hindrances and their restricted vision, the degree they can see is restricted, which likewise builds the risk and accidentalness. Edge computing and deep learning can take care of this issue quite well. By wearing AR glasses with cameras for each combatant, the edge device can gather and join the visual field data from all workforces, gather other picture data from drones, and utilize deep learning algorithms to show immensely significant data in the whole scene in the AR glasses of every soldier. What is more, it improves the effectiveness and security of battle in mission execution (Wang, 2020).

5   Vision, Benefits, and Challenges of EI

The advantages of edge knowledge are self-evident—it prepares for the last mile of AI and to give high-proficient intelligent services for individuals, which altogether diminishes the reliance on central cloud servers, and can successfully ensure information protection.

5.1   Benefits of EI

Some key benefits of EI can be (Raima, 2020):

- Reduce dependency on network performance
- Reduce threats through a holistic security approach
- Data management at the edge
- Single identity management
- Improve reliability through consistent app development across cloud and edge
- Increase bottom lines by reducing overhead expenses
- Edge intelligence can provide predictive risk assessments for healthcare professionals and promote better health awareness
- Edge intelligence is helping organizations to oversee and break down information anyplace—with reactions to inquiries in a flash
- There is no limit as to the benefits the intelligent edge can provide, not even the cloud.

Table 4 Benefits of EI in terms of specific parameters

Parameters	Maximize(↑)/Minimize(↓)
Latency	↓
Bandwidth	↓
Cost	↓
Security threat	↓
Data duplication	↓
Data reliability	↑
Policy compliance	↑

In general, some important benefits of EI over the following parameters can be listed as follows (Table 4):

5.2   Challenges of EI

On the off chance that AI and edge are very much incorporated, they can offer incredible potential for the advancement of imaginative applications. There are as yet numerous zones to be investigated to give operators, suppliers, and third parties with new business opportunities and revenue streams.

It merits recapping that there are still some unsolved open difficulties in acknowledging edge intelligence. Some significant difficulties can be recognized as (Xu et al., 2020):

- data shortage at the edge,
- data consistency on edge devices,
- bad adaptability of the statically trained model,
- privacy and security issues,
- incentive mechanism.
- There is a critical requirement for improving the capacities not just of the figuring infrastructure and underlying processor architectures yet additionally the proficiency of the algorithms utilized for machine learning.

Other challenges and opportunities can be listed as follows (Table 5):

Consequently, all in all the main point of contention of stretching out AI from the cloud to the edge of the network is: under the numerous requirements of networking, communication, computing power, and energy consumption how to devise and create edge computing architecture to accomplish the best performance of AI training and inference. As the computing power of the edge increases, edge intelligence will become common, and intelligent edge will

Table 5 Other open challenges in EI

Challenges	Description
Programmability (Shi et al., 2016)	The function/computing can be relocated so that data computed can be as close as to the data source and transmission cost can likewise be decreased
Naming (Shi et al., 2016)	Due to a lot of applications running at top of edge nodes, the naming scheme needs to handle addressing, things identifications, movement of things, highly dynamic network topology, data communications, etc.
Data abstraction (Shi et al., 2016)	With IoT, there will be enormous data generators, so edge nodes should process/consume data in a proactive manner that processed data is sent to the upper level for computation after noise /low-quality data removal, privacy protection, and so on
Service management (Shi et al., 2016)	The edge of the network should support the following fundamental features for a reliable system like differentiation, extensibility, isolation, and reliability
Privacy and security (Shi et al., 2016)	At the edge, the usage privacy and data security should be provided. A few difficulties stay open for this like 1. Awareness of privacy and security 2. Possession of data collected from things at the edge 3. Missing of effective tools for the protection of data privacy and security
Optimization metrics (Shi et al., 2016)	As EI will have numerous layers with various computation ability, the remaining burden allotment will turn into a major issue. We have to choose which layer registers the outstanding task at hand, how many tasks should be assigned. Several metrics should be handled as follows: 1. Latency 2. Bandwidth 3. Energy 4. Cost
Model establishment (Deng et al., 2020)	On the off chance that we need to utilize AI techniques, the numerical models must be restricted, and the figured optimization issue should be confined
Balance between optimality and efficacy (Deng et al., 2020)	The compromise among optimality and productivity ought to be acknowledged dependent on the qualities of powerfully changing prerequisites on QoE and the network resource structure
Computing power limitation (Zhang et al., 2019)	The edge is normally resource-constrained contrasted with the cloud data centers which are anything but a solid match for executing AI calculations as they require enormous capacity and computing power
Data sharing and collaborating (Zhang et al., 2019)	The temporal-spatial diversity of edge data makes hindrances for data sharing and collaborating

assume a significant supporting function to improve the exhibition of edge intelligence.

6 Conclusion

Artificial intelligence and edge computing are relied upon to profit one another. Edge intelligence has attracted many researchers and companies to develop and implement it in real-time intelligent applications. This paper attempts to provide some core concepts of EI so far investigated in the industry. Along with that, this paper also describes some key ingredients needed for the implementation of EI, and also,

we have identified four components of EI and their key problems. In the ending sections of the paper, we endeavored to give a few chances and difficulties in the developing field of edge intelligence. We hope that this paper can stimulate profitable conversations on potential future exploration headings for edge intelligence.

References

Chiang, M., & Zhang, T. (2016). Fog and IoT: An overview of research opportunities. *IEEE Internet of Things Journal, 3*(6), 854–864.

Deng, S., Zhao, H., Fang, W., Yin, J., Dustdar, S., & Zomaya, A. Y. (2020). Edge intelligence: The confluence of edge computing and

artificial intelligence. *IEEE Internet of Things Journal, 7*(8), 7457–7469.

Esterle, L., Lewis, P. R., McBride, R., & Yao, X. (2017, September). The future of camera networks: Staying smart in a chaotic world. In *Proceedings of the 11th International Conference on Distributed Smart Cameras* (pp. 163–168).

Keshavarzi, A., & van den Hoek, W. (2019). Edge intelligence—On the challenging road to a trillion smart connected IoT devices. *IEEE Design & Test, 36*(2), 41–64.

McMahan, B., & Ramage, D. (2017, April 6) *Federated learning: Collaborative machine learning without centralized training data*. https://ai.googleblog.com/2017/04/federated-learning-collaborative.html

Nelson, S. (2019, May 29) Five "Must Haves" For Edge Intelligence, https://aithority.com/guest-authors/five-must-haves-for-edge-intelligence/

Plastiras, G., Terzi, M., Kyrkou, C., & Theocharidcs, T. (2018, July). Edge intelligence: Challenges and opportunities of near-sensor machine learning applications. In *2018 IEEE 29th International Conference on Application-specific Systems, Architectures and Processors* (ASAP) (pp. 1–7). IEEE.

Raima. (2020). *The edge of intelligent: What is intelligent edge and how it can help you*. https://raima.com/the-edge-of-intelligent-what-is-intelligent-edge-and-how-it-can-help-you/

Sagar, R. (2020, April 2). *A beginner's guide to edge intelligence*. https://analyticsindiamag.com/edge-computing-machine-learning/

Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: Vision and challenges. *IEEE Internet of Things Journal, 3*(5), 637–646.

Sonal, T. (2020 February 28). *What on earth is edge intelligence?* https://www.medianova.com/en-blog/2020/02/28/what-on-earth-is-edge-intelligence

The Edge Intelligence Project Team. (2017). *Edge intelligence, international electrotechnical commission* (*IEC*) [White Paper]. https://webstore.iec.ch/publication/60568

Wang, X. *Edge AI: Convergence of edge computing and artificial intelligence*. Springer Nature.

Xu, D., Li, T., Li, Y., Su, X., Tarkoma, S., & Hui, P. (2020). *A survey on edge intelligence*. arXiv preprint arXiv:2003.12172

Xu, M., Liu, X., Liu, Y., & Lin, F. X. (2017). *Accelerating convolutional neural networks for continuous mobile vision via cache reuse*. arXiv preprint arXiv:1712.01670

Zhang, X., Wang, Y., Lu, S., Liu, L., & Shi, W. (2019, July). OpenEI: An open framework for edge intelligence. In *2019 IEEE 39th International Conference on Distributed Computing Systems* (ICDCS) (pp. 1840–1851). IEEE.

An Efficient Image Watermarking Through BEMD and Discrete Cosine Domain Based on PSO

Laxmanika and Pradeep Kumar Singh

Abstract

This article presents a robust image watermarking founded on discrete cosine transform (DCT), bi-dimensional empirical mode decomposition (BEMD) and particle swarm optimization (PSO). In encoding process, DCT coefficient is implemented on original image, and also, the BEMD decomposition is applied to disintegrate the watermark image. For the optimization, PSO is used for complex and multidimensional search. The embedding and scaling factor is embedded through the help of security key. Such a procedure is accompanied by the reverse of IDCT as well as IBEMD. Recovery algorithm is employed to extract the watermark image. The outcome of this technique shows that the suggested technique is robust compared to various different attacks. Therefore, this proposed technique is feasible for the visible quality of watermark image and improves the imperceptibility compared to other techniques.

Keywords

BEMD • Digital watermarking • DCT • PSO • Robustness • PSNR and NC

1 Introduction

Currently, computer-based technology has eased the similarity, exploitation and dissemination of the digital facts which has feasible in the result for secure ownership of digital facts (Singh et al., 2014). Ownership protection and tempered region of cover image are secured by digital image watermarking technique. Image manipulation and ownership and copyright protection can be secured by the fragile watermarking as well as the robust watermarking, respectively (Ansari & Pant, 2017). Watermarking method has two basic processes: embedding process and extraction process. There are two types of image watermarking according to the embedding process: spatial domain and frequency domain. Both methods are simple to execute and use very less amount of computation resources. Frequency domain watermarking is better than spatial domain with respect to robustness (Singh et al., 2018). Watermark information can be embedded by the frequency domain into the transform domain of the host image like discrete cosine transform (DCT). Also, an image watermarking, a new transform domain algorithm such as bi-dimensional empirical mode decomposition to increase the robustness, is suggested. Further, BEMD transform is a separated frequency band from most robust to least fragile (Sinsha & Ranjith Ram, 2015). On the other hand, PSO is an optimization technique which is used for complex and multidimensional search (Ansari & Pant, 2016).

2 Related Work

A concise review of recent and associated watermarking techniques using SVD, DWT, BEMD, PSO and DCT to obtain the imperceptibility, security and robustness is introduced below:

In Makbol and Khoo (2014), a secured and strong watermarking system through integer wavelet transform (IWT) as well as singular value decomposition (SVD) is applied for the copyright protection. However, digital signature and Wilcoxon signed-rank test are embedded for the ownership authentication and effectiveness certification, respectively. IWT-SVD is employed to produce robustness

Laxmanika (✉)
Department of Computer Science and Engineering, JUIT, Solan, Himachal Pradesh, India

P. K. Singh
Department of Computer Science and Engineering, ABES Engineering College, Ghaziabad, Uttar Pradesh, India

compared with geometric and non-geometric attacks and used to insert the robust watermark.

A strong image watermarking found on DWT, DCT and SVD is given in Hu et al. (2012). In that procedure, host image is transformed into the gray-level image from the RGB color to YCbCr. However, SVD is employed to achieve the frequency module. Outcome of this technique shows the robustness in respect of various attacks such as cropping, rotation, Gaussian noise additions, histogram equalization, JPEG compression and JPEG2000 compression. A semi-fragile watermarking with SVD-IWT is developed in Gokhale and Joshi (2012). In this method, decomposition of hidden image into four sub-bands is done by the IWT technique, and SVD technique is used to each sub-bands to increase the robustness. However, chaos sequence produced by logistic mapping is used to improve the security of watermark by encryption technique. This outcome of this method represents that the PSNR value is about 50 dB except any attacks and obtained a trade-off between robustness and visual quality. A blind image watermarking technique is founded on DWT and SVD offered in Thakkar and Srivastava (2017). This approach using DWT and SVD is to obtain different frequency sub-bands of its wavelet decomposition and different singular metrics, respectively. Further, authentication is offered by watermark image, and identification is offered by text data which signifies electronic patient record (EPR). Moreover, use of Hamming error correcting code (ECC) on EPR text bits reduces the BER and thus provides better recovery of EPR. Experimental result shows that the PSNR and WPSNR values are more than 43 dB and 52 dB, respectively, and demonstrate good imperceptibility of watermarked image. A multipurpose image watermarking method through DWT as well as SVD for tamper localization, self-recovery and ownership verification was offered in Ansari and Pant (2017). DWT is used to convert the original into wavelet domain, and further, singular values of converted host are varied according to principal factor of watermark, and SVD includes the scrambled and deterministic average depiction of host itself based on tamper localization information. Therefore, ABC optimization is employed to improve the robustness of watermark for the insertion process. In Makbol and Khoo (2013), composite image watermarking techniques for robustness thorough IWT, SVD and Arnold transform for offering the robustness and imperceptibility with respect to numerous attacks was presented. In embedding and extraction process, combination of IWT-SVD is used for high robustness with respect to numerous attacks. Moreover, Arnold transform is used for both robustness and security. This result indicated that the suggested technique is extremely imperceptible and has good capacity. In Harish et al. (2013), the author presents composite robust watermarking techniques founded on SVD, DCT and DWT. Further, this method enhanced the PSNR and NC values, and this scheme is used to hide text message instead of hiding watermark image. This method can also be analyzed for audio watermarking or video watermarking.

In Singh et al. (2017), the author proposed a new hybrid technique of multiple watermarking for medical images using NSCT, DCT and MSVD. Further, security as well as visible quality of the examined image watermark is improved by MSVD, NSCT, DCT and Arnold transform. Moreover, this method uses multiple watermarks for a single cover image. The outcome of this technique represents that the process is highly robust against geometrical and non-geometrical. This proposed technique is evaluated with some other detailed techniques. Ansari et al. (2016) offered a watermarking method founded on DWT and SVD through PSO optimization. In this embedding process, SVD is implemented on the first-level group of DWT and modify the singular value of original image by the scaled principal constituent of watermark. This proposed technique stated that it presents the scheme free from false positive rate. The outcome of this technique represents that the suggested technique provides favorable robustness and good security and capacity of watermark embedding. In Ansari et al. (2018), the authors proposed a secured and robust watermarking scheme through IWT, SVD and artificial bee colony to make certain the high value of robustness, capacity and imperceptibility. In the encoding process, SVD is applied on the three levels of IWT and modify the singular values accordingly. Further, signature is inserted to make the technique free form the security errors. Experimental results show that it offers better performance in comparison with other techniques.

In this article, we suggested a robust image watermarking technique depending upon PSO, BEMD and DCT. The embedding and execution process of this technique is measured in the form of robustness, security and imperceptibility. There are some challenging issues to protect the authenticity, visual quality and security. It is important to produce robust and secure watermarking method to preserve the authenticity and security of data in comparison with unauthorized access. Therefore, this suggested technique can be probably productive to resolve the challenging issues of robustness, security and authenticity for the images.

3 Proposed Algorithm

The proposed algorithm is to improve the robustness and imperceptible through bi-empirical mode decomposition along with DCT based on particle swarm optimization (PSO).

Embedding Process

1. Cover image is broken into DCT block coefficient of 8×8 blocks of pixels.
2. BEMD is employed on the watermark image to decompose it into intrinsic mode functions (IMFs).
3. For the embedding process, PSO is implemented on the DCT block of the host image to elect the intensities.
4. Similarly, PSO is applied to residue of BEMD.
5. The output of this process is embedded and applies the inverse process to get the watermark image.

Extraction Process

1. DCT coefficient is employed on the watermarked image.
2. Further, BEMD is applied on the DCT block coefficient.
3. For the extraction process, PSO is employed to the DCT block of the watermarked image to elect the intensities.
4. The output of the process is extracted and applies the inverse process to obtain the recovered watermark.

4 Experimental Results

In this segment, the experiment analysis is performed on 512×512 Gy-scale original image and 256×256 Gy-scale watermark image. The performance of the experiment depends on the PSNR and NC values. Here, Figs. 1 and 2 define the process of encoding and recovery process briefly. Figure 3 is showing the novel image of (a) baboon (b) Lena (c) cameraman (d) Barbara (e) man (f) tank (g) baboon as watermarked image.

The experimental outcomes are presented in Tables 1 and 2. According to Table 1, the PSNR and NC values at distinct gain factor. Table 2 demonstrates the PSNR and NC value for the distinct host image at same gain factor.

According to Table 1, it is seen that maximum values of PSNR and NC are 49.4254 and 0.999 (gain factor = 0.001), respectively. Table 2 shows the PSNR and NC values for distinct host images at gain factor = 0.01. On the basis of Table 2, optimum PSNR value is 49.4254 for cameraman and optimum NC value is 0.9998 for both cameraman and tank image.

On the basis of Table 3, it represents the PSNR and NC value for different attacks, respectively. From the table, it


Fig. 1 Embedding process
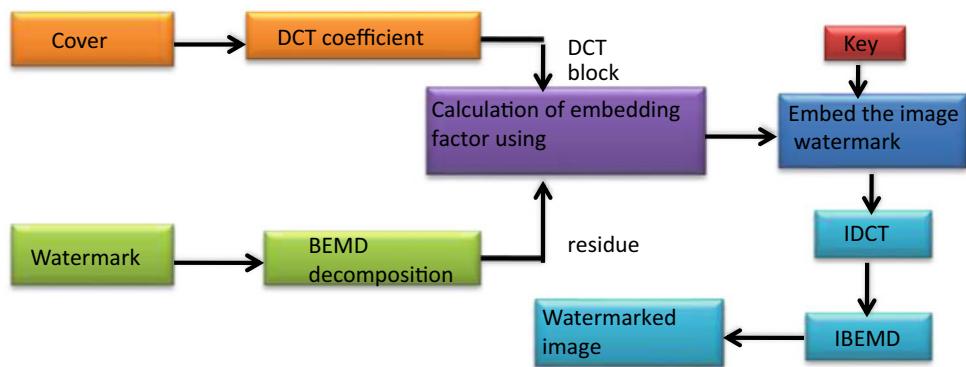

Fig. 2 Extraction process
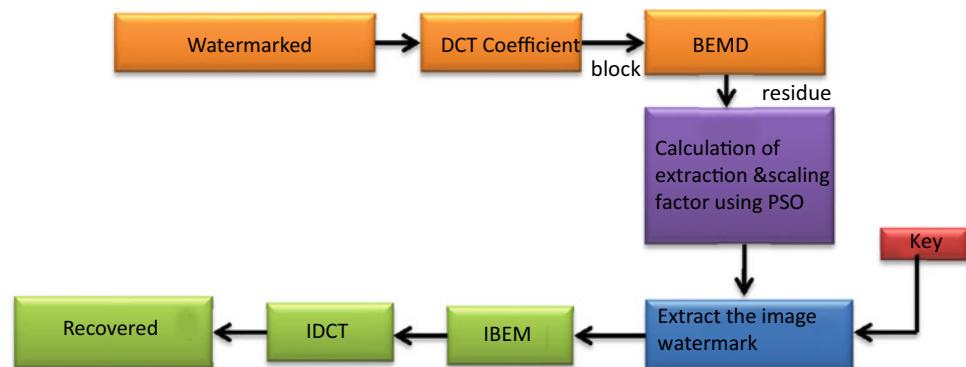
Fig. 3 Novel host image of **a** baboon **b** Lena **c** cameraman **d** Barbara **e** man **f** tank **g** the watermark image


(a)   (b)   (c)

(d)   (e)   (f)

(g)
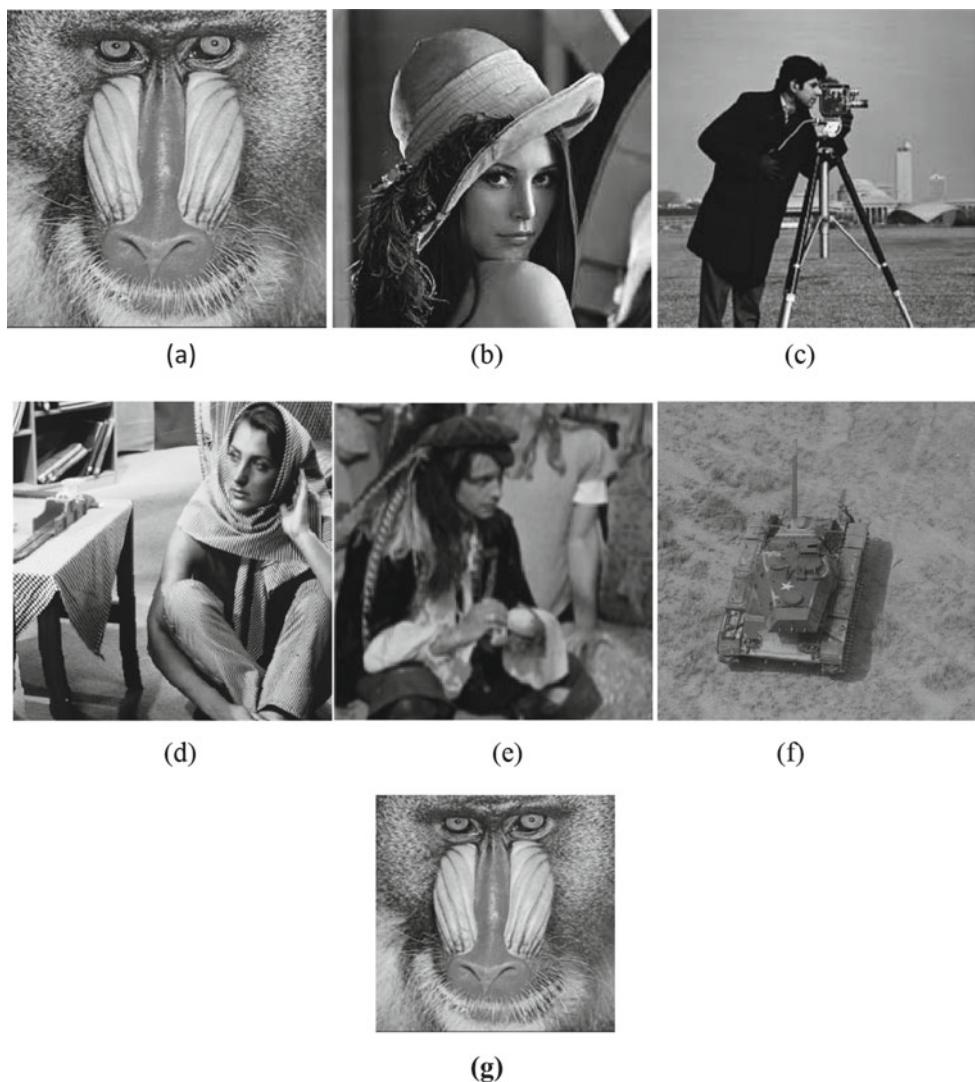
Table 1 PSNR and NC values obtained using the suggested technique at different gain factors

Gain factor	PSNR (in dB)	NC
0.001	49.4254	0.999
0.005	48.4754	0.998
0.01	44.6497	0.997
0.05	43.2497	0.996
0.1	42.7497	0.993

Table 2 PSNR and NC values obtained from offered method for distinct images

Image	PSNR (in dB)	NC
Baboon	44.6268	0.9997
Barbara	41.7053	0.9993
Cameraman	49.4254	0.9998
Lena	43.1863	0.9996
Man	43.4886	0.9994
Tank	45.3862	0.9998

Table 3 PSNR and NC value achieved under various attacks

Different attacks	Noise density	PSNR (in dB)	NC
Salt and pepper	0.0001	41.2915	0.9894
	0.0005	41.0871	0.9894
	0.01	40.2060	0.9897
	0.1	39.3139	0.9897
	0.5	39.0049	0.9898
Rotation	1°	39.7589	0.9850
	3°	39.2328	0.9861
	5°	39.8937	0.9749
Gaussian attack	0.0001	40.3916	0.9850
	0.01	40.3963	0.9850
	0.05	39.1709	0.9867
	0.1	38.4890	0.9867
Speckle		39.3916	0.9819

Table 4 Comparing PSNR values with other technique (Ansari & Pant, 2016)

Image	NC	PSNR (in dB) value (Ansari & Pant, 2016)	PSNR (in dB) value by the proposed method
Lena	0.9996	38.5334	43.1863
Man	0.9994	37.6545	43.4886
Baboon	0.9997	37.5343	44.6268

shows that the values of PSNR and NC are more than 38.4890 dB and 0.9819 (in most cases). However, these values demonstrate that the method is strong for different attacks. According to Table 3, optimum PSNR value is 41.2915 (gain factor=0.0001), and optimum NC value is 0.9898 (gain factor= 0.5) for salt and pepper attack. In Table 4, we have compared the performance of our method with PSO, DWT and SVD (Ansari & Pant, 2016).

Figure 4 demonstrates pictorial illustration for the PSNR values at distinct gain factor through DCT-PSO and BEMD method.

On the source of assessment from the offered method, it is determined that this method has maximum robustness contiguous to the major challenging attacks such as rotation, salt and pepper, Gaussian attack and speckle attacks of the image and another most widely used
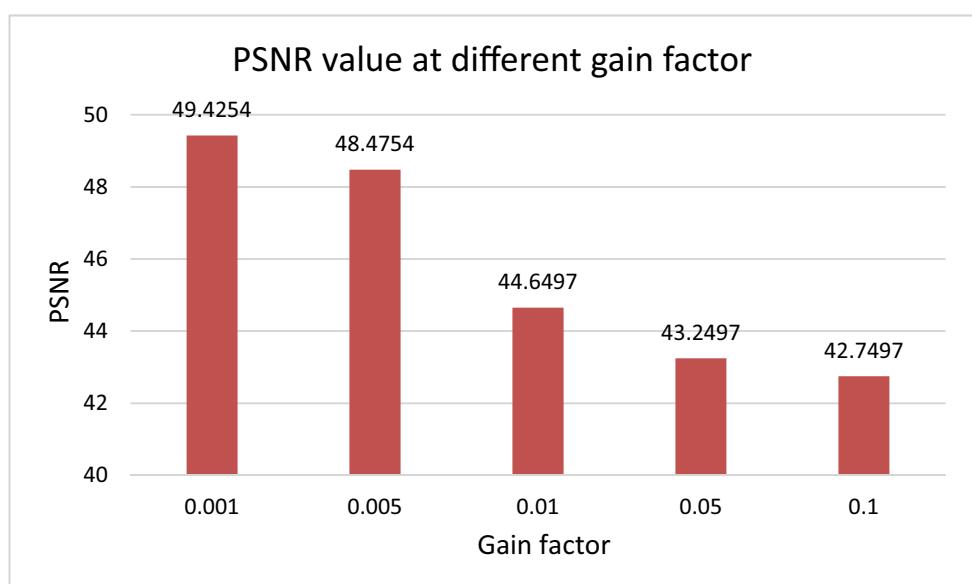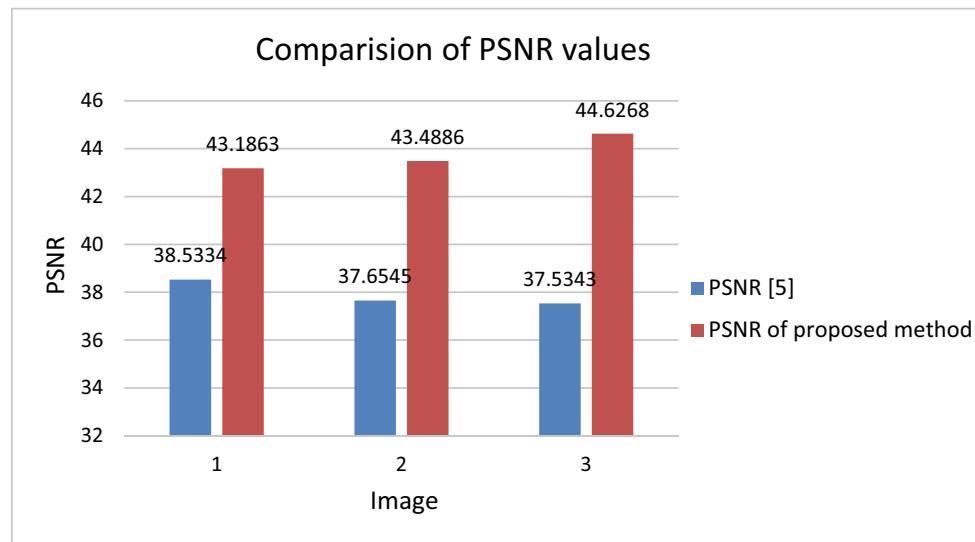
**Fig. 4** Graphic representation for the PSNR value at distinct gain factor

Fig. 5 Graph for the comparison
of PSNR value

operations in processing when associated to other pre-
senting techniques.

Figure 5 demonstrates the comparative value of PSNR
values between offered technique and exiting method
(Ansari & Pant, 2016).

5 Conclusion

A persistent image watermarking method using DCT,
BEMD and PSO was offered. However, DCT and BEMD
techniques were used for the watermarking process, and
PSO optimization is used for the improvement of robustness.
Moreover, the security of this process is increased through
cipher key with DCT-BEMD and PSO optimization. The
obtained PSNR and NC values are absolutely suitable under
deliberation. It shows good robustness against different
attacks. We have achieved the PSNR value which is equal or
higher than 40 dB except any attacks.

As a future perspective, it will likely be exciting to further
calculate the performance of this fundamental technique with
other comparison techniques. In future, this work can be used
for the medical image watermarking using new transform.

References

Ansari, I. A., & Pant, M. (2017). Multipurpose image watermarking in
the domain of DWT based on SVD and ABC. *Pattern Recognition
Letters, 94,* 228–236.

Ansari, I. A., Pant, M., & Ahn, C. W. (2016). PSO optimized and
secured watermarking scheme based on DWT and SVD. In
International conference on soft computing for problem solving
(pp. 411–424). Springer.

Ansari, I. A., Pant, M., & Ahn, C. W. (2018). Secured and optimized
robust image watermarking scheme. *Arabian Journal for Science
and Engineering, 43*(8), 4085–4104.

Gokhale, U. M., & Joshi, Y. V. (2012). A semi fragile watermarking
algorithm based on SVD-IWT for image authentication. *Interna-
tional Journal of Advanced Research in Computer and Communi-
cation Engineering, 1*(4), 217–222.

Harish, N. J., Kumar, B. B., & Kusagur, A. (2013). Hybrid robust
watermarking techniques based on DWT, DCT, and SVD. *Inter-
national Journal of Advanced Electrical and Electronics Engineer-
ing, 2*(5), 137–143.

Hu, W. C., Chen, W. H., & Yang, C. V. (2012). Robust image
watermarking based on discrete wavelet transform-discrete cosine
transform-singular value decomposition. *Journal of Electronic
Imaging, 21*(3), 033005.

Makbol, N. M., & Khoo, B. E. (2013). A hybrid robust image
watermarking scheme using integer wavelet transform, singular
value decomposition and Arnold transform. In *International visual
informatics conference* (pp. 36–47). Springer.

Makbol, N. M., & Khoo, B. E. (2014). A new robust and secure digital
image watermarking scheme based on the integer wavelet transform
and singular value decomposition. *Digital Signal Processing, 2014,*
134–147.

Singh, A. K., Dave, M., & Mohan, A. (2014). Hybrid technique for
robust and imperceptible image watermarking in DWT–DCT–SVD
domain. *National Academy Science Letter, 37*(4), 351–358.

Singh, S., Rathore, V. S., & Singh, R. (2017). Hybrid NSCT domain
multiple watermarking for medical images. *Multimedia Tools and
Applications, 76*(3), 3557–3575.

Singh, L., Singh, A. K., & Singh, P. K. (2018). Secure data hiding
techniques: A survey. *Multimedia Tools and Applications, 79,* 1–21.

Sinsha, P. P., & Ranjith Ram, A. (2015). Review on image
watermarking using bidimensional empirical mode decomposition.
International Journal of Engineering and Innovative Technology, 4
(11), 209–213.

Thakkar, F. N., & Srivastava, V. K. (2017). A blind medical image
watermarking: DWT-SVD based robust and secure approach for
telemedicine applications. *Multimedia Tools and Applications, 76*
(3), 3669–3697.