Lecture Notes in Networks and Systems 617

Devendra Kumar Sharma
Sheng-Lung Peng
Rohit Sharma
Gwanggil Jeon *Editors*

Micro-Electronics and Telecommunication Engineering

Proceedings of 6th ICMETE 2022

Springer

Lecture Notes in Networks and Systems

Volume 617

The series "Lecture Notes in Networks and Systems" publishes the latest developments in Networks and Systems—quickly, informally and with high quality. Original research reported in proceedings and post-proceedings represents the core of LNNS.

Volumes published in LNNS embrace all aspects and subfields of, as well as new challenges in, Networks and Systems.

The series contains proceedings and edited volumes in systems and networks, spanning the areas of Cyber-Physical Systems, Autonomous Systems, Sensor Networks, Control Systems, Energy Systems, Automotive Systems, Biological Systems, Vehicular Networking and Connected Vehicles, Aerospace Systems, Automation, Manufacturing, Smart Grids, Nonlinear Systems, Power Systems, Robotics, Social Systems, Economic Systems and other. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution and exposure which enable both a wide and rapid dissemination of research output.

The series covers the theory, applications, and perspectives on the state of the art and future developments relevant to systems and networks, decision making, control, complex processes and related areas, as embedded in the fields of interdisciplinary and applied sciences, engineering, computer science, physics, economics, social, and life sciences, as well as the paradigms and methodologies behind them.

Indexed by SCOPUS, INSPEC, WTI Frankfurt eG, zbMATH, SCImago.

All books published in the series are submitted for consideration in Web of Science.

For proposals from Asia please contact Aninda Bose (aninda.bose@springer.com).

Devendra Kumar Sharma · Sheng-Lung Peng ·
Rohit Sharma · Gwanggil Jeon
Editors

Micro-Electronics and Telecommunication Engineering

Proceedings of 6th ICMETE 2022

Springer

Editors
Devendra Kumar Sharma
Department of Electronics
and Communication Engineering
SRM Institute of Science and Technology
Ghaziabad, Uttar Pradesh, India

Rohit Sharma
Department of Electronics
and Communication Engineering
SRM Institute of Science and Technology
Ghaziabad, Uttar Pradesh, India

Sheng-Lung Peng
National Taipei University of Business
Hualien, Taiwan

Gwanggil Jeon
Department of Embedded Systems
Engineering
College of Information Technology
Incheon National University
Incheon, Korea (Republic of)

ISSN 2367-3370 ISSN 2367-3389 (electronic)
Lecture Notes in Networks and Systems
ISBN 978-981-19-9511-8 ISBN 978-981-19-9512-5 (eBook)
https://doi.org/10.1007/978-981-19-9512-5

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The book presents high-quality papers from the Fourth International Conference on Microelectronics and Telecommunication Engineering (ICMETE 2022). It discusses the latest technological trends and advances in major research areas such as microelectronics, wireless communications, optical communication, signal processing, image processing, big data, cloud computing, artificial intelligence, and sensor network applications. This book includes the contributions of national/international scientists, researchers, and engineers from both academia and the industry. The contents of this volume will be useful to researchers, professionals, and students alike.

Ghaziabad, India — Devendra Kumar Sharma
Hualien, Taiwan — Sheng-Lung Peng
Ghaziabad, India — Rohit Sharma
Incheon, Korea (Republic of) — Gwanggil Jeon

Contents

Analysis of Various Smart Security Systems 1
Harsh Rawat, Jayant Singh, Garvita Wadhwa, Arushi Gupta, and Sugandh Gupta

Towards Prediction of Students Educational Accomplishments Using Data Mining 11
Mini Agarwal and Bharat Bhushan Agarwal

"Bow Tie Slot Fed Circularly Polarised Hybrid (Cone Over Cylinder) Shaped DRA Antenna" 27
Richa Gupta

Handwritten Character Recognition from Image Using CNN 37
Partha Chakraborty, Shanta Roy, Sadia Nowshin Sumaiya, and Aditi Sarker

Traffic Scenarios and Vision Used Cases for the Visually Impaired Clients 49
Bhoopesh Chaudhary, Vipin Rawat, Prateek Kumar, and Manisha Vashisht

Statistical Analysis in Indian Banking Industry 61
Himani Bansal, Ritu Agarwal, Tanupriya Choudhury, Bikram Pratim Bhuyan, Ravi Tomar, and Gaurica Puri

Smart Home Based on IoT by Using Machine Learning 73
K. Lavanya and K. S. Archana

Develop Model for Malicious Traffic Detection Using Deep Learning . . . 83
Kaushal Kishor, Prabhjeet Singh, and Rhea Vashishta

Mine Safety Monitoring System Based on WSN 93
Avni Sharma, Arpit Kumar, Yamini Gupta, Aaradhya Nain, Rachit Patel, and Ahmed Alkhayyat

Comparative Analysis of Dual Metal Gate Fully Depleted SOI FET With/Without δ-Doped Insulated Layer for AF Application 103
Jay Prakash Narayan Verma and Prashant Mani

Investigating Graph-Based Recommendations Systems and Graph Traversal Algorithms 115
Gaurica Puri, Abhiram Varanasi, Gagandeep Singh, Harshit Agarwal, Ravi Tomar, and Tanupriya Choudhury

Movie Rating Prediction and Viewers' Sentiment Trend Analysis Using YouTube Trailer Comments 127
Sandipan Sahu, Raghvendra Kumar, and Pathan Mohd Shafi

Performance Evaluation of Hybrid FSO/RF Link Under NRZ Modulation Format 143
Shakshi and Himanshi Saini

An Adaptive Opposition Learning-Improved Slime Mould Algorithm-Based Optimization Routing for Guaranteeing Reliable Data Dissemination in FANETs 153
J. Sengathir, M. Deva Priya, A. Christy Jeba Malar, and Suma Sira Jacob

COVID-19 Diagnosis Based on Deep Features Using Transfer Learning 167
P. Anantha Prabha, M. Deva Priya, R. Kiruthick, M. Nishith, and Prajish

Honey Badger Optimization Algorithm-Based RSU Deployment for Improving Network Coverage in VANETs 179
J. Sengathir, M. Deva Priya, A. Christy Jeba Malar, and S. Sam Peter

Map Drawing Approach for Airport Connectivity Using Coloring Algorithm 195
Neha Singh and Jyoti Srivastava

L2 Teachers' Strategies and Students' Engagement in Virtual Classrooms: A Multidimensional Perspective 205
Hung Phu Bui

A Performance Comparison of State-of-the-Art Imputation and Classification Strategies on Insurance Fraud Detection 215
M. Shanthini and Bhuvana Sanmugam

Autonomous Health Care Robot 227
K. Umapathy, S. Omkumar, D. Muthukumaran, S. Chandramohan, and M. Sivakumar

ThingSpeak-Based Garbage Monitoring and Collecting System 235
K. Umapathy, S. Omkumar, D. Muthukumaran, S. Chandramohan, and M. Sivakumar

Technology-Assisted Teaching during the COVID-19 Pandemic: L2 Teachers' Strategies and Encountered Challenges 243
Mai Khanh Chau and Hung Phu Bui

The Application of Artificial Intelligence Technologies in Social Media to Detect Fake News: A Systematic Review 251
Pham Chien Thang and Ta Thi Nguyet Trang

Design and Optimization of Compact RFID Antenna Tag for Biomedical Applications 263
M. Sivakumar, I. Manju, K. Umapathy, K. S. Srinivasan, and D. Muthukumaran

Low-power High-speed Approximate Multiplier Design Using Compression Techniques 273
Shayanki and C. Paramasivam

Design of Bio-inspired Maple Leaf-Shaped Textile Antenna for Wireless Application 287
R. Jothi Chitra, M. Sivarathinabala, S. Vathana Sree, S. Akshaya, and S. Rajarajeshuwari

Undergraduate College Admission Prediction System Using Decision Tree Classifier 297
Roshani Raut, Jayant Abnave, Sushil Dikondwar, Shivani Pandita, and Atharva Marudwar

Early Detection of Heart Disease Using Multilayer Perceptron 309
Priyanka Gupta and D. D. Seth

Task Scheduling Algorithm Using Improved PSO in Dew Computing ... 317
B. Gomathi, S. Lokesh, and J. Antony Vijay

A Review Analysis on Measuring the Soil Characteristic in Agriculture Using Artificial Intelligence and IOT 325
Sapna Dewari, Meenu Gupta, Rakesh Kumar, Ahmed J. Obaid, and Mazin R. AL-Hameed

5G as a New Phase of Wireless Network Technology 335
Saima Naaz, Hamnah Rao, Parul Aggarwal, and Ahmed J. Obaid

Machine Learning-Based Comparative Analysis of COVID-19 Infected Cases with GDP and World Happiness Report 345
Meenu Gupta, Rakesh Kumar, Shanon Sharma, Mitashi Bansal, and Ahmed J. Obaid

Enhancing the Protection of Information in Digital Voting Using Application of Block Chain Technology 357
K. Saikumar, Faiza Iram, A. Sampath Dakshina Murthy, Ahmed Kareem Alzeyadi, and Sarah A. Al-Ameedee

A Novel Approach to Avoid Road Traffic Accidents and Develop Safety Rules for Traffic Using Crash Prediction Model Technique 367
Sk Hasane Ahammad, M. Sukesh, Mekala Narender, Sajjad Ali Ettyem, Kadhum Al-Majdi, and K. Saikumar

Intrusion Detection in the IoT-Fog Adopting the GRU and CNN: A Deep Learning-Based Approach 379
Zahraa Majeed Al-Khuzaie, Salah A. K. Albermany, and Mohammed Ahmed AbdlNibe

Design, Optimization and Characterization of Optical Imaging Systems for Complex Temperature Environment 391
T. S. Srinivasan, Vivek Maik, and Samiappan Dhanalakshmi

Decentralized Smart Irrigation with Remote Data Visualization 401
Sanjeev Kumar and Vivek Sharma

Comparative Study of Optical Character Recognition Using Different Techniques on Scanned Handwritten Images 411
Anshika Singh and Sharvan Kumar Garg

Deep Learning Models in EEG Signals: Comparative Analysis 421
Awwab Mohammad, Farheen Siddiqui, and M. Afshar Alam

Analytical Analysis on LS, MMSE and Modified Entropy-Based LS Channel Estimation Techniques for 5G Massive MIMO Systems 431
Shaik Nilofer, Praveen Kumar Malik, P. Manju, and Sumit Agarwal

A Study and Design of Flexible Planar Antenna with Different Substrates for Long-Range Applications 447
Sneha, Praveen Kumar Malik, and Joan Lu

Sustainable Development, Renewable Energy and Environment 455
Pooja Malik, Praveen Kumar Malik, Rajesh Singh, and Anita Gehlot

An Insight to Textile Substrates for Wearable Antenna 465
Safina Shokeen, Harbinder Singh, and Anurag Sharma

Artificial Intelligence in Formulation and Product Design of BCS Class I and II Drugs 481
Jayant Singh Goud, Sanjay Kumar Elisetti, Navneet Kaur, Ranjit Singh, Kamaljit Singh Saini, and Vimal Arora

Blockchain Technology for Better Security by Using Two-Way Authentication Process 495
Ayasha Malik, Jaya Srivastava, Bharat Bhushan, Veena Parihar, V. S. Anoop, and Ahmed Alkhayyat

A Survey of Human Emotion Recognition Using Speech Signals: Current Trends and Future Perspectives 509
Radhika Subramanian and Prasanth Aruchamy

Artificial Intelligence-Based React Application (Powered by Conversational ALAN-AI Voice Assistance) 519
Ayasha Malik, Veena Parihar, Bharat Bhushan, Jaya Srivastava, and Lamia Karim

Comparative Analysis of Three Waves of COVID-19 in India: A Deep Study of Three Waves Based on Selected Parameters 531
Ayasha Malik, Veena Parihar, Bharat Bhushan, Jaya Srivastava, and Rohit Sharma

Genetic Algorithm: An Approach for Software Testing Based on a Given Source Code 543
Jaya Srivastava, Ayasha Malik, Bharat Bhushan, Veena Parihar, and Shyam Nair

Crop and Weed Detection From Images Using YOLOv5 Family 555
Katakam Koushik and S. Venkata Suryanarayana

Fuzzy DEMATEL Approach to Identify the Modifiable Risk Factors of Cardiovascular Disease 567
M. Stephen and A. Felix

Bipolar Trapezoidal Fuzzy ARAS Method to Identify the Tuberculosis Comorbidities 577
N. Ezhilarasan and A. Felix

Intuitionistic Fuzzy PROMETHEE Method for Medical Ventilator Selection 587
S. Aicevarya Devi and A. Felix

Dynamic Bandwidth Allocation Using Linear Regression Model in IOT with Machine Learning Techniques 597
Shekhar, Gaurav Bhandari, and Sudhanshu Tyagi

An Open CV-Based Social Distance Violation Identification Using a Deep Learning Technique 611
Syam Sundar Pillalamarri, K. Saikumar, Sarah A. Al-Ameedee, Sahar R. Abdul Kadeem, and Mohammed J. Hussein

Fuzzy Net for Image Processing Applications: Image Segmentation 621
Huda A. Alameen, Noor Riyadh Kareem, and Sundus Q. Habeeb

A Reliable Transmission and Extraction of Textual Information Using Keyless Encryption, Steganography, and Deep Algorithm with Cuckoo Optimization 629
Binay Kumar Pandey, Digvijay Pandey, Mohammed Ayad Alkhafaji, Muhammet Tahir Güneşer, and Cihat Şeker

Smart Autonomous Breaking System for Vehicles to Improve Road Safety in India 637
Praveen Kumar Malik, Abdul Rahim, and Dac-Nhuong Le

An Intelligent Framework for Movie Recommendation Through Online Social Media 645
Gaurav Agarwal, Shail Kumar Dinkar, and Ajay Agarwal

Application of Artificial Intelligence in Software Development Life Cycle: A Systematic Mapping Study 655
Shilpi Singh and Saurabh Sambhav

CNN-based Recognition of Skin Cancer Using Contrast Limited Adaptive Histogram Equalization 667
Ayushi Jain, Neha Mittal, and Shubham Nain

Correction to: A Novel Approach to Avoid Road Traffic Accidents and Develop Safety Rules for Traffic Using Crash Prediction Model Technique C1
Sk Hasane Ahammad, M. Sukesh, Mekala Narender, Sajjad Ali Ettyem, Kadhum Al-Majdi, and K. Saikumar

Author Index 679

Editors and Contributors

About the Editors

Devendra Kumar Sharma received his B.E. degree in Electronics Engineering from Motilal Nehru National Institute of Technology, Allahabad in 1989, M.E. degree from Indian Institute of Technology Roorkee, Roorkee in 1992 and Ph.D. degree from National Institute of Technology, Kurukshetra, India in 2016. He served PSU in different positions for more than 8 years in QA and Testing/R&D departments. Dr. Sharma joined the department of Electronics and Communication Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh, India in October 2000 as Senior Lecturer and worked there till April 2018 at different capacities of Assistant Professor, Associate Professor, Professor and Dean Academics. He is currently working a Professor and Dean of SRM Institute of Science and Technology, Delhi-NCR Campus, Ghaziabad, India. Dr. Sharma has authored many papers in several international journals and conferences of repute. His research interests include VLSI interconnects, Electronic Circuits, Digital Design, Testing and Signal Processing. He is a reviewer of many international journals belonging to various publication houses such as IEEE, Elsevier, Emerald, World Scientific, and Springer. Dr. Sharma has participated in many International and National conferences as Session Chair, and member of Steering, Advisory and Technical Program Committees. He has been the Editor for several books/conference proceedings and has been the Organizing Chair for several international conferences. He is life member of ISTE, Fellow of IETE and Senior Member of IEEE.

Sheng-Lung Peng is a Professor of the Department of Creative Technologies and Product Design in National Taipei University of Business Taiwan, Honorary Professor in Beijing Information Science and Technology University, and Visiting Professor in Ningxia Institute of Science and Technology, China. He received a BS degree in Mathematics from National Tsing Hua University, and the MS and Ph.D. degrees in Computer Science from the National Chung Cheng University and National Tsing Hua University, Taiwan, respectively. He is an honorary Professor

of Beijing Information Science and Technology University, China, and a visiting Professor of the Ningxia Institute of Science and Technology, China. He is also an adjunct Professor at Mandsaur University, India. He serves as the secretary-general of the ACM-ICPC Contest Council for Taiwan and the regional director of the ICPC AsiaTaipei-Hsinchu site. He is a director of the Institute of Information and Computing Machinery, of Information Service Association of Chinese Colleges and Taiwan Association of Cloud Computing. He is also a supervisor of the Chinese Information Literacy Association, of Association of Algorithms and Computation Theory. Dr. Peng has edited several special issues at journals, such as *Soft Computing*, *Journal of Internet Technology*, *Journal of Real-Time Image Processing*, *International Journal of Knowledge and System Science*, *MDPI Algorithms*, and so on. He is also a reviewer for more than 10 journals such as *IEEE Access and Transactions on Emerging Topics in Computing*, *IEEE/ACM Transactions on Networking, Theoretical Computer Science*, *Journal of Computer and System Sciences*, *Journal of Combinatorial Optimization*, *Journal of Modelling in Management, Soft Computing*, *Information Processing Letters*, *Discrete Mathematics*, *Discrete Applied Mathematics*, *Discussiones Mathematicae Graph Theory*, and so on. His research interests are in designing and analyzing algorithms for Bioinformatics, Combinatorics, Data Mining, and Networks areas in which he has published over 100 research papers.

Rohit Sharma is currently acting as an Associate Professor and Head in the Department of Electronics and Communication Engineering, SRM Institute of Science and Technology, Delhi NCR Campus Ghaziabad, India. He is an active member of ISTE, IEEE, ICS, IAENG, and IACSIT. He is an editorial board member and reviewer of more than 12 international journals and conferences, including the topmost journal *IEEE Access* and *IEEE Internet of Things Journal*. He serves as a Book Editor for 16 different titles to be published by CRC Press, Taylor & Francis Group, USA and Apple Academic Press, CRC Press, Taylor & Francis Group, USA, Springer, etc. He has received the Young Researcher Award in "2nd Global Outreach Research and Education Summit and Awards 2019" hosted by Global Outreach Research and Education Association (GOREA). He is serving as Guest Editor in various SCI journals such as *Elsevier*, *CEE*, *COMNET*, *IET Communications Willey*, *Expert Systems Wiley* etc. He has actively been an organizing end of various reputed International conferences. He is serving as an Editor and Organizing Chair to 3rd Springer International Conference on Microelectronics and Telecommunication (2019), and have served as the Editor and Organizing Chair to 2nd IEEE International Conference on Microelectronics and Telecommunication (2018), Editor and Organizing Chair to IEEE International Conference on Microelectronics and Telecommunication (ICMETE-2016) held in India, Technical Committee member in "CSMA2017, Wuhan, Hubei, China", "EEWC 2017, Tianjin, China" IWMSE2017 "Guangzhou, Guangdong, China", "ICG2016, Guangzhou, Guangdong, China" "ICCEIS2016 Dalian Liaoning Province, China".

Prof. Gwanggil Jeon received the B.S., M.S., and Ph.D. (summa cum laude) degrees from the Department of Electronics and Computer Engineering, Hanyang University, Seoul, Korea, in 2003, 2005, and 2008, respectively. From 2009.09 to 2011.08, he was with the School of Information Technology and Engineering, University of Ottawa, Ottawa, ON, Canada, as a Post-Doctoral Fellow. From 2011.09 to 2012.02, he was with the Graduate School of Science and Technology, Niigata University, Niigata, Japan, as an Assistant Professor. From 2014.12 to 2015.02 and 2015.06 to 2015.07, he was a Visiting Scholar at Centre de Mathématiques et Leurs Applications (CMLA), École Normale Supérieure Paris-Saclay (ENS-Cachan), France. From 2019 to 2020, he was a Prestigious Visiting Professor at Dipartimento di Informatica, Università degli Studi di Milano Statale, Italy. He is currently a Full Professor at Incheon National University, Incheon, Korea. He was a Visiting Professor at Sichuan University, China, Universitat Pompeu Fabra, Barcelona, Spain, Xinjiang University, China, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, and University of Burgundy, Dijon, France. Dr. Jeon is an IEEE Senior Member, an Associate Editor of *Sustainable Cities and Society*, *IEEE Access*, *Real-Time Image Processing*, *Journal of System Architecture*, and *MDPI Remote Sensing*. Dr. Jeon was a recipient of the IEEE Chester Sall Award in 2007, the ETRI Journal Paper Award in 2008, and Industry-Academic Merit Award by Ministry of SMEs and Startups of Korea Minister in 2020.

Contributors

Mohammed Ahmed AbdlNibe Department of Electronics and Communication Engineering, Faculty of Engineering, University of Kufa, Kufa, Iraq

Sahar R. Abdul Kadeem National University of Science and Technology, Nasiriyah, Iraq

Jayant Abnave Department of Information Technology, Pimpri Chinchwad College of Engineering, Pune, India

M. Afshar Alam Department of Computer Science and Engineering, Jamia Hamdard, New Delhi, India

Ajay Agarwal Department of Information Technology, Krishna Institute of Engineering and Technology, Muradnagar, Ghaziabad, U.P., India

Gaurav Agarwal Department of Computer Science and Engineering, Veer Madho Singh Bhandari Uttarakhand Technical University, Dehradun, Uttarakhand, India

Harshit Agarwal School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand, India

Mini Agarwal Research Scholar, IFTM University, Moradabad, India

Ritu Agarwal Raj Kumar Goel Institute of Technology, Ghaziabad, Uttar Pradesh, India

Sumit Agarwal Pennsylvania State University, State College, Pennsylvania, US

Parul Aggarwal Jamia Hamdard, New Delhi, India

Sk Hasane Ahammad Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Guntur, India

S. Aicevarya Devi Mathematics Division, School of Advanced Sciences, Vellore Institute of Technology, Chennai, India

S. Akshaya Department of Electronics and Communication Engineering, Velammal Institute of Technology, Chennai, India

Sarah A. Al-Ameedee Department of Computer Technical, Al-Mustaqbal University College, Hillah, Iraq

Mazin R. AL-Hameed National University of Science and Technology, Nasiriyah, Iraq

Zahraa Majeed Al-Khuzaie Computer Science Department, University of Kufa, Najaf, Iraq

Kadhum Al-Majdi Ashur University College, Baghdad, Iraq

Huda A. Alameen Department of Computer Science, Faculty of Computer Science and Mathematics, University of Kufa, Najaf, Iraq

Salah A. K. Albermany Computer Science Department, University of Kufa, Najaf, Iraq

Mohammed Ayad Alkhafaji National University of Science and Technology, Dhi Qar, Iraq

Ahmed Alkhayyat College of Technical Engineering, The Islamic University, Najaf, Iraq

Ahmed Kareem Alzeyadi National University of Science and Technology, Nasiriyah, Iraq

P. Anantha Prabha Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

V. S. Anoop Kerala University of Digital Sciences, Innovation and Technology, Thiruvananthapuram, Kerala, India

J. Antony Vijay Hindusthan College of Engineering and Technology, Coimbatore, India

K. S. Archana Department of Data Science and Business Systems, School of Computing, SRM Institute of Science and Technology, Kattankulathur, Chennai, India

Vimal Arora University Institute of Pharma Sciences (UIPS), Chandigarh University Gharuan, Mohali, Punjab, India

Prasanth Aruchamy Department of Electronics and Communication Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

Himani Bansal Informatics Cluster, School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand, India

Mitashi Bansal Amity School of Engineering and Technology, Noida, India

Gaurav Bhandari ICFAI Tech School, The ICFAI University, Dehradun, India

Bharat Bhushan School of Engineering and Technology (SET), Sharda University, Greater Noida, India

Bharat Bhushan Agarwal Associate Professor, CSE Department, IFTM University, Moradabad, India

Bikram Pratim Bhuyan LISV Laboratory, University of Paris Saclay, Velizy, France;
School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand, India

Hung Phu Bui University of Economics Ho Chi Minh City (UEH), Ho Chi Minh City, Viet Nam

Partha Chakraborty Department of Computer Science and Engineering, Comilla University, Cumilla, Bangladesh

S. Chandramohan SCSVMV Deemed University, Kanchipuram, India

Mai Khanh Chau Tra Vinh University, Tra Vinh, Viet Nam

Bhoopesh Chaudhary Manav Rachna International Institute of Research and Studies, Faridabad, India

Tanupriya Choudhury Senior Associate Professor, Informatics Cluster, School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttarakhand, India;
Adjunct Professor, Graphic Era Hill University, Dehradun, Uttarakhand, India

A. Christy Jeba Malar Department of Information Technology, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

M. Deva Priya Department of Computer Science and Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamil Nadu, India

Sapna Dewari Department of Computer Science and Engineering, Chandigarh University, Chandigarh, Punjab, India

Samiappan Dhanalakshmi Department of Electronics and Communication Engineering, College of Engineering and Technology, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Kanchipuram, Chennai, TN, India

Sushil Dikondwar Department of Information Technology, Pimpri Chinchwad College of Engineering, Pune, India

Shail Kumar Dinkar Department of Computer Science and Applications, Govind Ballabh Pant Institute of Engineering and Technology, Garhwal, Uttarakhand, India

Sanjay Kumar Elisetti University Institute of Pharma Sciences (UIPS), Chandigarh University Gharuan, Mohali, Punjab, India

Sajjad Ali Ettyem National University of Science and Technology, Dhi Qar, Iraq

N. Ezhilarasan Mathematics Division, School of Advanced Science, Vellore Institute of Technology, Chennai, India

A. Felix Mathematics Division, School of Advanced Sciences, Vellore Institute of Technology, Chennai, TN, India

Sharvan Kumar Garg Department of Computer Science and Engineering, Subharti Institute of Technology and Engineering, Swami Vivekan and Subharti University, Meerut, India

Anita Gehlot Department of Electronics and Communication Engineering, Uttaranchal University, Dehradun, Uttarakhand, India

B. Gomathi PSG Institute of Technology and Applied Research, Coimbatore, India

Jayant Singh Goud University Institute of Pharma Sciences (UIPS), Chandigarh University Gharuan, Mohali, Punjab, India

Arushi Gupta ABES Institute of Technology, Ghaziabad, India

Meenu Gupta Department of Computer Science and Engineering, Chandigarh University, Mohali, Chandigarh, Punjab, India

Priyanka Gupta SRM Institute of Science and Technology, Ghaziabad, India

Richa Gupta Maharaja Surajmal Institute of Technology, New Delhi, India

Sugandh Gupta ABES Institute of Technology, Ghaziabad, India

Yamini Gupta Electronics and Communication Engineering, ABES Institute of Technology, Ghaziabad, India

Muhammet Tahir Güneşer Karabuk University, Karabuk, Turkey

Sundus Q. Habeeb Faculty of Medicine, Jabir Ibn Hayyan Medical University, Najaf, Iraq

Mohammed J. Hussein Al-Esraa University College, Baghdad, Iraq

Faiza Iram Department of Computer Science and Engineering, JNTUH College of Engineering, Sangareddy, Telangana, India

Suma Sira Jacob Department of Information Technology, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

Ayushi Jain Department of Electronics and Communication Engineering, Meerut Institute of Engineering and Technology, Meerut, UP, India

R. Jothi Chitra Department of Electronics and Communication Engineering, Velammal Institute of Technology, Chennai, India

Noor Riyadh Kareem Department of Computer Science, Faculty of Computer Science and Mathematics, University of Kufa, Najaf, Iraq

Lamia Karim Hassan 1st University, National School of Applied Sciences of Berrechid (ENSA), Berrechid, Morocco

Navneet Kaur University Institute of Computer Sciences and Engineering Chandigarh University Gharuan, Mohali, Punjab, India

R. Kiruthick Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

Kaushal Kishor Department of Information Technology, ABES Institute of Technology, Ghaziabad, Uttar Pradesh, India

Katakam Koushik IT Department, CVR College of Engineering, Hyderabad, India

Arpit Kumar Electronics and Communication Engineering, ABES Institute of Technology, Ghaziabad, India

Prateek Kumar Manav Rachna International Institute of Research and Studies, Faridabad, India

Raghvendra Kumar Department of Computer Science and Engineering, GIET University, Gunupur, India

Rakesh Kumar Department of Computer Science and Engineering, Chandigarh University, Mohali, Chandigarh, Punjab, India

Sanjeev Kumar Department of Computer Science and Engineering, Technocrats Institute of Technology, Bhopal, India

K. Lavanya CSE, Vels Institute of Science, Technology & Advanced Studies, Chennai, India

Dac-Nhuong Le Haiphong University, Haiphong, Vietnam

S. Lokesh PSG Institute of Technology and Applied Research, Coimbatore, India

Joan Lu Lovely Professional University, Phagwara, Punjab, India;
Department of Computer Science, University of Huddersfield, Huddersfield, West Yorkshire, UK

Vivek Maik Department of Electrical Engineering, Indian Institute of Technology Madras, Chennai, TN, India

Ayasha Malik Delhi Technical Campus (DTC), GGSIPU, Greater Noida, India

Pooja Malik Department of Electronics and Communication, Lovely Professional University, Phagwara, Punjab, India

Praveen Kumar Malik School of Electronics and Electrical Engineering Department, Lovely Professional University, Phagwara, Punjab, India;
Department of Computer Science, University of Huddersfield, Huddersfield, West Yorkshire, UK

Prashant Mani SRM-IST NCR Campus, Modinagar, Ghaziabad, India

I. Manju Mohamed Sathak AJ College of Engineering, Chennai, India

P. Manju BVRIT HYDERABAD College of Engineering for Women, Hyderabad, India

Atharva Marudwar Department of Information Technology, Pimpri Chinchwad College of Engineering, Pune, India

Neha Mittal Department of Electronics and Communication Engineering, Meerut Institute of Engineering and Technology, Meerut, UP, India

Awwab Mohammad Department of Computer Science and Engineering, Jamia Hamdard, New Delhi, India

D. Muthukumaran SCSVMV Deemed University, Kanchipuram, India

Saima Naaz Jamia Hamdard, New Delhi, India

Aaradhya Nain Electronics and Communication Engineering, ABES Institute of Technology, Ghaziabad, India

Shubham Nain Department of Electronics and Communication Engineering, Meerut Institute of Engineering and Technology, Meerut, UP, India

Shyam Nair School of Graduate Studies, Bluecrest University College, Monrovia, Liberia

Mekala Narender Department of Computer Science and Engineering, Jayamukhi Institute of Technological Sciences, Narsampet, Warangal, India

Shaik Nilofer Lovely Professional University, Paghwara, Punjab, India;
BVRIT HYDERABAD College of Engineering for Women, Hyderabad, India

M. Nishith Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

Ahmed J. Obaid Faculty of Computer Science and Mathematics, University of Kufa, Kufa, Iraq

S. Omkumar SCSVMV Deemed University, Kanchipuram, India

Binay Kumar Pandey Department of Information Technology, College of Technology, Govind Ballabh Pant University of Agriculture and Technology Pantnagar, Pantnagar, Uttarakhand, India

Digvijay Pandey Department of Technical Education, IET, Dr. A.P.J. Abdul Kalam Technical University, Lucknow, Uttar Pradesh, India

Shivani Pandita Department of Information Technology, Pimpri Chinchwad College of Engineering, Pune, India

C. Paramasivam Department of Electronics and Communication Engineering, Amrita Vishwa Vidyapeetham, Bengaluru, India

Veena Parihar KIET Group of Institutions, Delhi-NCR, Ghaziabad, India

Rachit Patel Electronics and Communication Engineering, ABES Institute of Technology, Ghaziabad, India

Syam Sundar Pillalamarri Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Prajish Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India

Gaurica Puri Informatics Cluster, School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand, India

Abdul Rahim Malla Reddy Engineering College for Women, Hyderabed, India

S. Rajarajeshuwari Department of Electronics and Communication Engineering, Velammal Institute of Technology, Chennai, India

Hamnah Rao Jamia Hamdard, New Delhi, India

Roshani Raut Department of Information Technology, Pimpri Chinchwad College of Engineering, Pune, India

Harsh Rawat ABES Institute of Technology, Ghaziabad, India

Vipin Rawat Manav Rachna International Institute of Research and Studies, Faridabad, India

Shanta Roy Department of Computer Science and Engineering, Comilla University, Cumilla, Bangladesh

Sandipan Sahu Department of Computer Science and Engineering, GIET University, Gunupur, India

K. Saikumar School of Engineering, Department of AI-ML, Malla Reddy University, Hyderabad, Telangana, India;
Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India;

School of Engineering, Department of CSE, Malla Reddy University, Hyderabad, India

Himanshi Saini Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India

Kamaljit Singh Saini University Institute of Computer Sciences and Engineering Chandigarh University Gharuan, Mohali, Punjab, India

S. Sam Peter Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India

Saurabh Sambhav Amity University Patna, Patna, India

A. Sampath Dakshina Murthy Department of ECE, Vignan's Institute of Information Technology (A), Visakhapatnam, Andhra Pradesh, India

Bhuvana Sanmugam PSG Institute of Technology and Applied Research, Coimbatore, India

Aditi Sarker Department of Computer Science and Engineering, Comilla University, Cumilla, Bangladesh

Cihat Şeker Karabuk University, Karabuk, Turkey

J. Sengathir Department of Information Technology, CVR College of Engineering, Hyderabad, Telangana, India

D. D. Seth SRM Institute of Science and Technology, Ghaziabad, India

Pathan Mohd Shafi Department of Computer Science and Engineering, MITADT University, Loni Kalbhor, India

Shakshi Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India

M. Shanthini PSG Institute of Technology and Applied Research, Coimbatore, India

Anurag Sharma Department of Electronics and Communication Engineering, Indraprastha University, Delhi, India

Avni Sharma Electronics and Communication Engineering, ABES Institute of Technology, Ghaziabad, India

Rohit Sharma SRM Institute of Science and Technology, Ghaziabad, India

Shanon Sharma Chandigarh University, Mohali, India

Vivek Sharma Department of Computer Science and Engineering, Technocrats Institute of Technology, Bhopal, India

Shayanki Department of Electronics and Communication Engineering, Amrita Vishwa Vidyapeetham, Bengaluru, India

Shekhar ICFAI Tech School, The ICFAI University, Dehradun, India

Safina Shokeen Department of Electronics and Communication Engineering, Chandigarh University, Mohali, India

Farheen Siddiqui Department of Computer Science and Engineering, Jamia Hamdard, New Delhi, India

Anshika Singh Department of Computer Science, Shaheed Rajguru College of Applied Sciences for Women, University of Delhi, Delhi, India

Gagandeep Singh School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand, India

Harbinder Singh Department of Electronics and Communication Engineering, Chandigarh University, Mohali, India

Jayant Singh ABES Institute of Technology, Ghaziabad, India

Neha Singh Madan Mohan Malviya University of Technology, Gorakhpur, India

Prabhjeet Singh Department of Information Technology, ABES Institute of Technology, Ghaziabad, Uttar Pradesh, India

Rajesh Singh Division of Research and Innovation, Uttaranchal University, Dehradun, Uttarakhand, India

Ranjit Singh University Institute of Computer Sciences and Engineering Chandigarh University Gharuan, Mohali, Punjab, India

Shilpi Singh Amity University Patna, Patna, India

M. Sivakumar Mohamed Sathak AJ College of Engineering, Chennai, India;
AJ College of Engineering, Chennai, India

M. Sivarathinabala Department of Electronics and Communication Engineering, Velammal Institute of Technology, Chennai, India

Sneha Lovely Professional University, Phagwara, Punjab, India;
Department of Computer Science, University of Huddersfield, Huddersfield, West Yorkshire, UK

K. S. Srinivasan Mohamed Sathak AJ College of Engineering, Chennai, India

T. S. Srinivasan Department of Electronics and Communication Engineering, College of Engineering and Technology, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Kanchipuram, Chennai, TN, India

Jaya Srivastava ABES Engineering College, Ghaziabad, India;
Noida Institute of Engineering Technology (NIET), Greater Noida, India

Jyoti Srivastava Madan Mohan Malviya University of Technology, Gorakhpur, India

M. Stephen Mathematics Division, School of Advanced Sciences, Vellore Institute of Technology, Chennai, TN, India

Radhika Subramanian Department of Electronics and Communication Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

M. Sukesh Department of Computer Science and Engineering, Vaagdevi College of Engineering, Warangal, Telangana, India

Sadia Nowshin Sumaiya Department of Computer Science and Engineering, Comilla University, Cumilla, Bangladesh

Pham Chien Thang Thai Nguyen University of Sciences, Thai Nguyen, Vietnam

Ravi Tomar Senior Architect, Persistent Systems, Pune, India

Ta Thi Nguyet Trang International School, Thai Nguyen University, Thai Nguyen, Vietnam

Sudhanshu Tyagi Thapar Institute of Engineering and Technology, Patiala, India

K. Umapathy SCSVMV Deemed University, Kanchipuram, India

Abhiram Varanasi School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand, India

Manisha Vashisht Manav Rachna International Institute of Research and Studies, Faridabad, India

Rhea Vashishta Department of Information Technology, ABES Institute of Technology, Ghaziabad, Uttar Pradesh, India

S. Vathana Sree Department of Electronics and Communication Engineering, Velammal Institute of Technology, Chennai, India

S. Venkata Suryanarayana IT Department, CVR College of Engineering, Hyderabad, India

Jay Prakash Narayan Verma SRM-IST NCR Campus, Modinagar, Ghaziabad, India

Garvita Wadhwa ABES Institute of Technology, Ghaziabad, India

Analysis of Various Smart Security Systems

Harsh Rawat, Jayant Singh, Garvita Wadhwa, Arushi Gupta, and Sugandh Gupta

Abstract The traditional locking systems consisting of mechanical locks and keys were effective to keep things secure in earlier times. But with the advancement in technology, these systems have become outdated. Hence, enhancing and improving security systems becomes an important aspect too. In the present paper, we have tried to analyze various approaches and systems invented to enhance security. This document will include different locking systems or vehicles using different technologies like RFID systems, fingerprint modules, GPS-GSM modules, and more. It also takes into consideration door locking systems using data encryption technology, wireless and IoT technology, and various other approaches. The objective of all these systems is to enhance security features that contribute to a safer society. We think it is important to know about all possible security systems so that we can choose the best suitable system as per our needs. It will also help us to come up with smarter and more efficient hybrid systems and work on the cons of existing technology.

Keywords Security · RFID module · Door locking · Arduino · GPS-GSM · Fingerprint scanner

1 Introduction

Humans have always worked on technology that is capable of easing their lives. As technology is evolving, security threats have become much more common as well. Thus, it becomes important for us to pay attention to the security aspects involved with the things that we are creating or the environment that we are in. Vehicles are also becoming better and faster, and our dependency on them has increased tenfold. They have become independent smart machines that are no longer just a transport medium. Hence, their security becomes an important aspect too. Considering how the car makers are putting great effort into enhancing the driving experience, the anti-social elements of our society are not too far behind. Thus, we need to keep up

H. Rawat · J. Singh (✉) · G. Wadhwa · A. Gupta · S. Gupta
ABES Institute of Technology, Ghaziabad, India
e-mail: jayantsingh254@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_1

and come up with more reliable, personalized, and efficient locking systems for both modern homes and vehicles.

Each of the systems included in this paper talks about how we can limit the access to our environment or vehicles that we are trying to protect. The content that we have analyzed talks about security systems of different domains, and by the means of this paper, we are trying to summarize and compare the basic working features and technologies used in all individual systems.

2 Literature Review

Mathew and Divya [1] proposed a door locking system with RFID technology that ensures two-factor authentication. This system integrates an Android app with the real-time implementation of RFID technology. Nath et al. [2] proposed a system for door unlocking system with the use of a database. This system operates at a large scale and makes it easy to operate multiple doors. When we researched vehicle security systems, we landed on a system proposed by Ali et al. [3]. A two-way authentication method is with an additional feature of only giving access to registered drivers only. This system not only helps to enhance the security of vehicles but helps to make the driving experience safer by making sure that laws are abode by the people. A similar anti-theft system for vehicles was proposed by Noman et al. [4] that not only sends an alert to the vehicle owner but also has sensors to detect more than one way in which a burglar can break into your vehicle. Tamilselvan et al. [5] brought the concept of biometrics into vehicle security. This system is precisely for two-wheelers and makes the ignition process personal.

The introduction of facial recognition technology was discussed by Khalimov et al. [6] in a low-cost door locking system. The system process works on face detection, feature extraction, and face recognition. Thus, the process of face recognition becomes smooth and fast without any physical contact. Tseng et al. [7] in their paper discussed a wrist-worn sensor for monitoring door opening activity. The system works by assessing the body movements of a person during everyday activities. Park et al. [8] coined a smart digital lock system for home automation. They made the use of digital information such as secret codes, semi-conductors, smart cards, and fingerprints as the method for authentication. Yu [9] proposed a digital door lock system that can also work in the case of power failure. The door lock system plays an important role in home automation. Prajeesha et al. [10] proposed a project where they aim to develop a fingerprint authentication mechanism that is made mandatory to access vehicle ignition. The system involves the use of biometrics as well as a government-issued license being involved. Shafin et al. [11] developed a RFID-based access control system. This system consists of a digital door lock that can be unlocked in real time, and the entire system is connected with a central client–server sub-system that maintains the overall integrity of the system. Devi et al. [12] with their work present a fingerprint-based system to verify the driving license of the

driver. As a secondary feature, ignition access is also given when the fingerprints match.

Aziz et al. [13] worked toward solving theft problems for vehicles by introducing a multi-layer security system consisting of various features like theft-alerting feature, owner speed-limiting system, and emergency monitoring vehicle feature. The use of the GSM-GPS module makes this system much more appreciable and effective. Jabeen et al. [14] came up with a three-layer authentication system to start a car. These layers consist of facial recognition, fingerprint authentication, and alcohol detection, respectively, which all need to be authenticated correctly for the purpose of starting the engine of the car. Sowmya et al. [15] talk about smart doors to assist people in gaining control and access to their doors.

3 Analysis of Existing Technology

Meera Mathew and Divya developed a secure door locking system with RFID technology. This system includes two-factor authentication and multiple encryptions for enhancing system security. It makes this system more reliable and efficient than a single-factor authentication system. The multiple encryption schemes are implemented using Java. The whole system consists of two vital features which are key matching and an encryption scheme. This system uses an Android app named "Secure Wallet" that stores the unique key set for encryption. The user can then view the encryption keys at each entry and can edit or update the keys. The user has to log in to this app with an ID and a password that leads to the generation of an OTP. RFID technology is also included in this system, to make it more reliable. The door is unlocked only when the right RFID tag is brought close to the reader module. The role of this module is to read the information associated with the tag, and it then encrypts the information using the secret key. The obtained data is compared with the stored data to find a match. Another OTP is generated and sent on the smartphone of the user when the data matches. OTP generation takes place with the help of the central server. When this OTP is entered in the keypad installed and verified by the server, a control signal is generated by the system instructing the parallel ports to unlock or lock the door. The record of independent entry and exit is kept with other valid user information. The technology used to send and receive OTP is ZigBee. The encryption method used is block encryption which encrypts the RFID tag information [1] (Fig. 1).

Naskarand et al. [2] designed a door unlocking system that works by giving access for opening doors of multiple rooms in a certain zone. Implementation of this system can be done in laboratory or library. This system has a central server connected to one central database which contains information about the authorized personnel. Here, the use of RFID technology is made to identify the user. Hardware components used in this system are an RFID reader, passive RFID tags, a real-time wireless transmitter, and a receiver. An Arduino Uno microcontroller is also used. All the users are assigned a unique serial number which is encrypted into their RFID

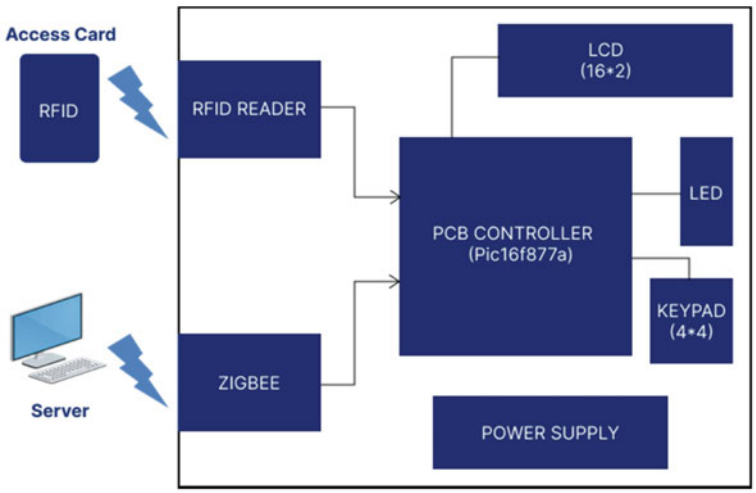


Fig.1 Hardware module of the door lock [1]

tags that can be read by the reader when the user wants to open the door. All the relevant information about the user is stored on the central server. There is a default time for which the door remains unlocked before it is locked again. This system also provides manual buttons for opening and closing the server terminal for safety reasons. To monitor the activities of all system units, an online monitoring system is also present. Transmitters and receivers are used for communication between the door and the server (Fig. 2).

Ali et al. [3] made a system that gives a two-way authentication method that allows the use of vehicles by registered drivers only. It talks about a single system that comprises of driver's license (DL), radio frequency identification reader (RFID), global system for mobile communication modem (GSM), Arduino microcontroller, and fingerprint module (FP). This system not only prevents car theft but also solves the problem associated with inexperienced drivers which becomes a major problem for road safety. It also notifies the driver about the license validity and sends an SMS to the holder to renew DL before expiration. A new concept of electronic driving license is implemented here that gives advanced document design integrating which integrates a microprocessor. The new EDL has advantages over the traditional DL and RFID tag with additional ease of usage. This system gives two-factor authentication and allows the driver to access vehicle ignition only when both conditions are satisfied. For the first step, the DL information is read by the reader module. After the information is matched to the pre-fed information, the second feature comes into play. The driver is asked to give a registered fingerprint that is taken as input via a fingerprint module. If an unreliable driver's license is entered twice, an SMS will be sent via the GSM module to the vehicle owner notifying them about the attempted theft. As an additional feature, the GSM module can also send an SMS to remind

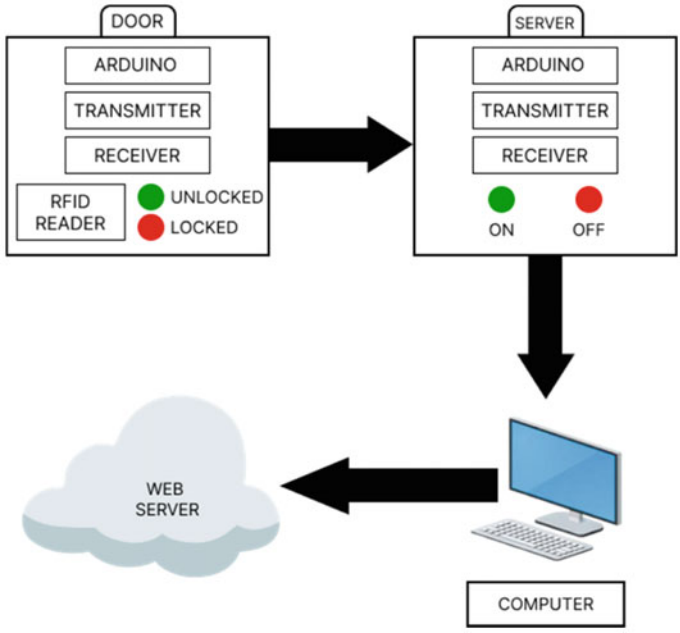


Fig. 2 Block diagram of the door unlocking system [2]

the driver's license holder of the remaining time to renew their license before its expiration deadline (Fig. 3).

Noman et al. [4] created an anti-theft system consisting of a PIC16F876A microcontroller and fingerprint, RFID, GPS-GSM modules, and a tilt sensor. Their system is for cars and works toward enhancing the safety feature and gives updates about vehicle security breaches. The system takes input at the door in the form of an RFID tag or password. If the correct input is provided, vehicle access is granted. In case wrong input is detected, the security system activates and an SMS is sent to the owner. Further, there are tilt sensors installed in this system that ring an alarm if car windows are smashed in case of forced entry. GPS module in the system actively sends the vehicle location to the vehicle owner whenever the tilt sensors detect an input. PIC16F876A microcontroller is used to take action in this system (Fig. 4).

Tamilselvan et al. [5] introduced a system that concentrates on the application of biometrics for two-wheelers, especially motorbikes and scooters. Test results show that the developed system identifies the right person and only allows them to start the bike. There was a need to design a low-cost security system for the two-wheelers. Proper compatibility of the fingerprint unit with the microcontroller unit is carefully integrated into this system. The designed system uses a fingerprint module to verify the fingerprint of the authorized person, and OLED is used to display whether the fingerprint matches the data that is fed into the microcontroller. If the fingerprint

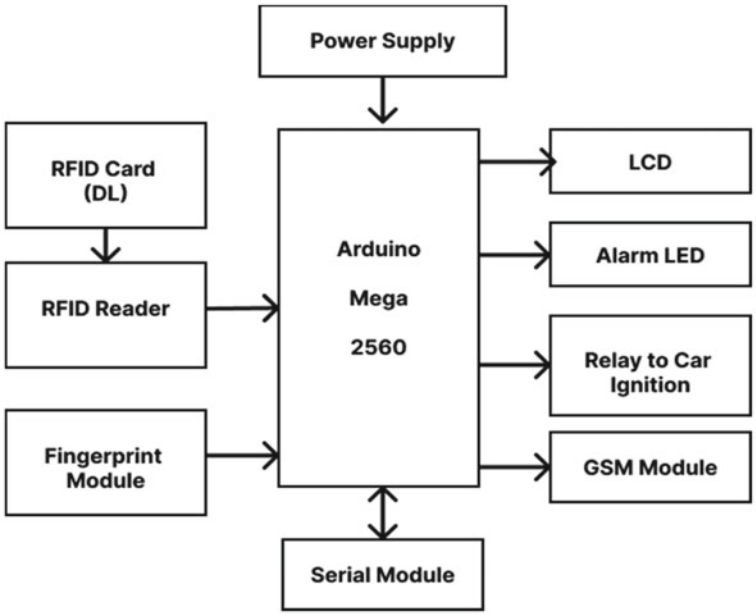


Fig. 3 Proposed system for two-way authentication method [3]

matches, Arduino, which is the microcontroller used in this system, will direct the relay to turn on the ignition system (Fig. 5).

As a result of reviewing several research papers that are using different techniques to increase security, we came up with a two-tier authentication system for automobiles since complete dependency on a single type of system makes any environment prone to attacks. Thus, when it comes to creating a secure and reliable system, one must use a combination of algorithms to enhance the security. Hence, we propose a solution to boost the security of any vehicle by giving the driver complete access to the individual features of the vehicle. The proposed combination integrates two different technologies and ensures two-way protection. These technologies are being utilized in two phases: first phase: RFID tag-based entry system; second phase: fingerprint-based ignition system. The first phase, which can also be classified as the door unlocking system, uses an RFID module for unlocking the car door. An RFID reader is attached to the door unlocking mechanism and can only be accessed with the right or authenticated unique RFID tag. After a simple tap of an authenticated RFID tag over this RFID reader, the door of the car will get unlocked. Then comes the second phase which is being used not only to enhance the security of the car but also to eliminate the age-old mechanical ignition switch. This system consists of a fingerprint scanner module that is attached to the car ignition system, and it allows the authenticated user to start the car only with a simple finger press on this module (Table 1).

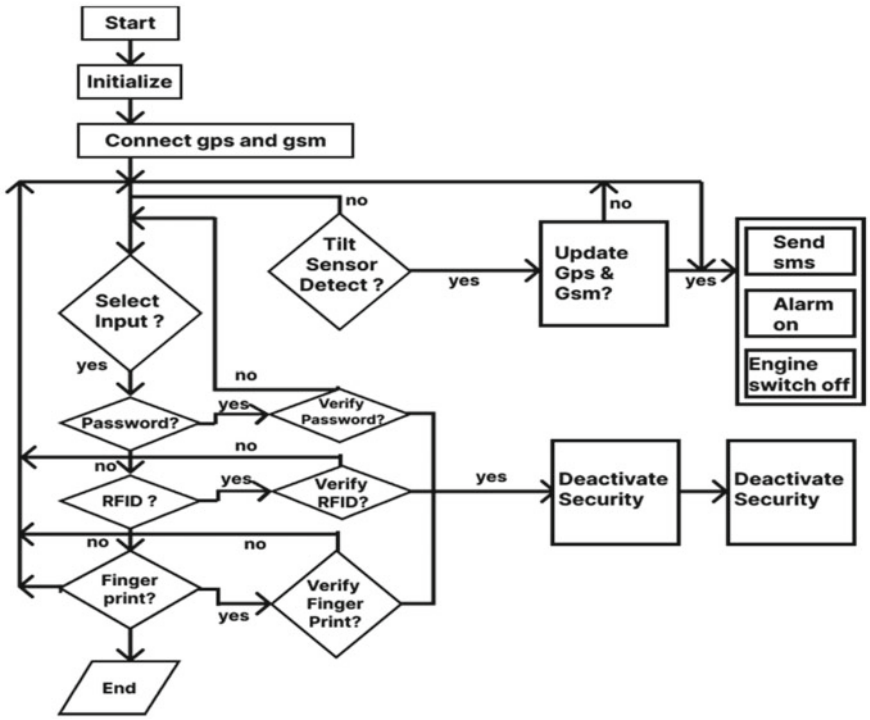


Fig. 4 Flowchart of anti-theft system [4]

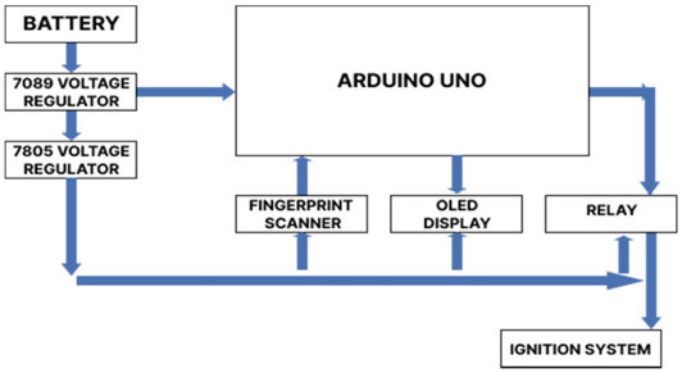


Fig. 5 Block diagram for the application of biometrics for two-wheelers [5]

Table 1 Comparison table of the reviewed papers

Parameters for comparison	Super-secure door lock system for critical zones [1]	Vehicle access and ignition control with EDL and fingerprint [3]	Arduino-based door unlocking system with control [2]	Vehicle security system using GPS, GSM, and RFID [4]	Biometric-based bike protection system [5]	Smart security system for automobiles using biometrics and RFID tags
System hardware components	ZigBee module, RFID module, LCD, PIC16F877A microcontroller	Fingerprint sensor, RFID module, GSM module, Arduino Mega 2560	Arduino Uno, Raspberry Pi, RFID module, wireless transmitter and receiver	Fingerprint sensor, RFID, GPS, GSM module, tilt sensor, PIC16F87A microcontroller	Fingerprint sensor, Arduino Uno microcontroller, OLED	Fingerprint sensor, Arduino Uno, RFID module, LCD, relay 5 V
System software components	Secure Wallet app, encryption scheme using Java	C language to upload data in the microcontroller	Internet of Things, programming language	C language to upload data in the microcontroller	C language to upload data to the microcontroller	Arduino IDE
Level of authentication	Three-factor authentication: Digital key OTP RFID tag	Two-factor authentication: 1)RFID tag 2) Fingerprint detection	Single- factor authentication using RFID tag	Multiple-factor authentication using RFID or password or fingerprint	Single-factor authentication using fingerprint	Two-factor authentication: RFID tag Fingerprint detection
Notification	No notification generated	SMS via GSM to the vehicle owner after 2 failed attempts	No notification generated	SMS via GSM and live location via GPS	No notification generated	No notification generated
Additional features	Use of encryption algorithms, central server for database management	Reminder via SMS before EDL expiry date to the driver	The server maintains entry and exit logs in the database	Car ignition is cut-off by the server if an unauthorized person is detected	No additional feature other than the primary feature	No additional feature other than the primary feature

4 Summary

This paper summarizes different approaches of enhancing and creating a secure environment. It gives a brief description and working of different models based on their respective technologies.

5 Future Scope

Better and smarter security systems for doors and vehicles can be compared and listed in the coming future. This paper can be used as a reference to know about existing systems and will help to compare the listed systems with the upcoming technologies.

6 Conclusion

This review paper concludes with the comparative analysis of different security systems for doors and vehicles that have been coined by all the respective authors along with their project concepts, research, and theory in their papers. We have made our observations based on system architecture, methodology used, and level of security delivered by the systems.

References

1. Mathew, M., & Divya, R. S. (2017). Super secure door lock system for critical zones. In *2017 International Conference on Networks & Advances in Computational Technologies (NetACT)*, Thiruvanthapuram.
2. Nath, S., Banerjee, P., Biswas, R. N., Mitra, S. K., & Naskar, M. K. (2016). Arduino based door unlocking system with real-time control. In *2016 2nd International Conference on Contemporary Computing and Informatics (IC3I)*, Noida.
3. Ali, A. M., Awad, H. M., & Abdalgader, I. K. (2020). Authenticated access control for vehicle ignition system by drivers license and fingerprint technology. In *2020 International Conference on Computer, Control, Electrical, and Electronics Engineering.*
4. Noman, A. T., Hossain, S., Islam, M. S., Islam, M. E., Ahmed, N., & Chowdhury, M. A. M. (2018). Design and implementation of microcontroller based anti-theft vehicle security system using GPS, GSM, and RFID. In: *2018 4th International Conference on Electrical Engineering and Information and Communication Technology (IEEE, ICT)*
5. Tamilselvan, K. S., Murugesan, G., & Sasikumar, S. (2018). Design and implementation of biometric based smart antitheft bike protection system. In: *2018 International Conference on Intelligent Computing and Communication for Smart World (I2C2SW).*
6. Khalimov, R., Rahimbayeva, Z., Shokayev, A., Kamalov, B., & Ali, M. H. (2020). Development of intelligent door locking system based on face recognition technology. In *2020 11th International Conference on Mechanical and Aerospace Engineering (ICMAE)*

7. Pannu, P., & Sharma, D. K. (2020). Miniaturize four-port UWB-MIMO antenna with tri-notched band characteristics. *Microwave Optical Technology Letters, Wiley Publication, 62*(12), 1–10. https://doi.org/10.1002/mop.32766
8. Pannu, P., & Sharma, D. K. (2020). A low profile quad-port ultra wide band-multiple input multiple output antenna using a defected ground structure with dual notch behaviour. In *International Journal of RF and Microwave Computer-Aided Engineering*, Wiley Publications, vol. 30, issue 9, Sept. 2020.
9. Yu, Y. (2018). A practical digital door lock for smart home. In *2018 IEEE International Conference on Consumer Electronics (ICCE)*, Las Vegas, NV.
10. Prajeesha, R. B. S., Nagabhushan, N., & Madhavi T. (2021). Fingerprint-based licensing for driving. In: 2021 6th International Conference for Convergence in Technology (I2CT)
11. Shafin, M. K., Kabir, K. L., & Hasan, N. (2015). Development of an RFID based access control system in the context of Bangladesh. In *IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems.*
12. Sharmila Devi, S. Surya Prakash, T., Vignesh, G., & Venkatesan, P. V. (2021). Ignition system based licensing using PIC microcontroller. In *2021 Second International Conference on Electronics and Sustainable Communication Systems (ICESC).*
13. Aziz, T., Faisal, T. M., Ryu, H.-G., & Hossain, M. N. (2021). Vehicle speed control and security system. In *2021 International Conference on Electronics, Information, and Communication (ICEIC).*
14. Jabeen, F., Rupanagudi, S. R., & Bhat, V. G. (2019). IoT based smart vehicle ignition and monitoring system. In *2019 International Conference on Advances in Computing, Communication and Control (ICAC3).*
15. Sowmya, G., Divya Jyothi, G., Shirisha, N., Navya, K., & Padmaja, B. (2018). IoT Based smart door lock system. *International Journal of Engineering and Technology.*

Towards Prediction of Students Educational Accomplishments Using Data Mining

Mini Agarwal and Bharat Bhushan Agarwal

Abstract Prediction outcomes help students and faculty learn new ideas for gaining the desired goals of institutes. The goal of this research is to study all the data mining techniques, algorithms, and factors that help in the prediction of the student's performance between the years 2010 and 2021. In this paper, we have reviewed and analysed more than 35 research papers based on seven aspects, i.e. (1) prediction of the student's performance outcomes related to the student grade, result, and knowledge, (2) models and software developed in performance prediction, (3) factors that helped in prediction, (4) algorithm that gave the most accurate result, (5) student posture in the classroom while taking the class, (6) subjective paper evaluation, and (7) feedback related to students and faculty.

Keywords Recognition · Educational data mining · Prediction · Machine learning · Review · Outcome

1 Introduction

Everything becomes online, i.e. shopping, playing, examination, education, banking, and business in this pandemic era. New technologies and ways have been developed using educational data mining and machine learning for making online education interesting and powerful. Cheating prevention is very less in online examinations, many students lack knowledge related to the subject and practical, but they get the full marks, due to this students do not get a placement and faculty cannot be able to measure the right performance of the students. In this technology era, more institutes, colleges, and universities are opened and all of them have high-level competition. Predicting the performance of the students becomes more challenging for a good

M. Agarwal (✉)
Research Scholar, IFTM University, Moradabad, India
e-mail: miniagarwal21@gmail.com

B. Bhushan Agarwal
Associate Professor, CSE Department, IFTM University, Moradabad, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_2

result database. The best ranking, institutes, and universities students have excellent performance because they provide the best teachers, methodology, and excellent learning system. These universities have excellent results and records of student performance. Students are big source of advertising and feedback of the institution all over the world therefore, students' satisfaction about the teaching process and course selection is very important. The country has different types of boards (like NAAC accreditation under UGC and NBA accreditation under AICTE), and they work on the quality enhancement of the institution like technical programmes, teaching methodology, laboratory equipment, placements, and years wise progress of the students. A lot of students aspire to become an engineer but only some students become successful engineers, some drop out the college in the middle of the course because they cannot bear the pressure of the various internal and external exams. Data mining techniques and machine learning play a vital role in prediction of student performance.

Data mining techniques light on important aspects from a database and expose important data that is not in limelight. Clustering in data mining analyses the data and clusters the same type of data that are similar in specific manner [1]. Academic mining discovers student understanding and chooses how teacher deliver the right lecture in changing academic standards [2].

Data mining is a procedure to draw out important data from data sets without error using machine learning algorithms or artificial intelligence. The process cycle of data mining is shown in Fig. 1. This combination of predicting the student performance and the outcome helps the faculty for improving and making interesting teaching methodology. In this paper, our objective is to review various techniques and algorithms, i.e.

- Analyse existing prediction models.
- Identify key findings of existing model.
- Analyse gaps in previous research.

Fig. 1 Data mining process cycle [3]

- To study subjective paper evaluation, student gesture in classroom.
- Analyse student and teacher feedback.

2 Research Methodology

The methodology is being used for finding the gaps, study research algorithms, study and analyse factors of existing or previous research, and develop a new research in the same field with different or same algorithm and factors. Through the research methodology getting the all answers related to the research questions that are helpful in outcome.

2.1 Research Questions

Research questions are very important part of overall literature review. Through thus researcher develops some questions related to research and finding out the answers that are being helpful in researcher research. Various frameworks have been developed for developing research questions. We are using PICO, finer, and QA. Tables 1, 2, and 3 show the research strategies.

Many questions had been developed using above research framework, and some questions are given below:-

- How many prediction algorithms have been used?
- What are the common factors?
- What are the results of different algorithms on common factor?
- What type of degree involve in research?

Table 1 PICO research strategy

PICO factors	Description
P: Population of interest	What type of population has been used for experiment/what type of population has do research on this/student performance
I: Intervention	How many and which type of factors and algorithms have been used
C: Comparison	Comparison among various algorithms and factors for finding best, study of case studies
O: Outcome	Deeply study of past research, find out best prediction algorithms and methods

Table 2 QA research strategy

QA factors	Description
Q:Quality	Quality of the past researches
A: Assessment	Assessment of various research results

Table 3 Finer research strategy

Finer factors	Description
F: Feasibility	Tools, time, algorithms, sample size, funding, methods, researchers, study design in previous research had been sufficient or not
I: Interesting	How research can be made interesting. Finding out the most interesting factors and algorithms
N: Novel	Finding the new research from the previous research
E: Ethical	Research should be ethical. All researchers should follow the rules and regulations
R: Relevant	Past research had been relevant. Do a new relevant research

- How prediction algorithm outcome worked on student performance?
- Which algorithm is best for prediction?
- What are the factors and attributes used in comparison with algorithm?
- What is the quality of previous research?
- How previous research helpful for finding new one?
- What is the sample size used in previous research?

3 Common Factors/Attributes Used in Prediction

Attributes are the most important part of predicting performance. Some research papers had the same attributes along with additional attributes. The most common attributes that have been used are parents and family background details (like parents occupation, parents education, family size, parents salary, language, etc.) because family and parents are ideal to everyone. Family and parents are the first teacher and motivators of their children [4–9]. Next, a most used attribute is gender (female/male) because female students are serious, hardworking, self-motivated, focused, and disciplined in comparison with boy's students [4, 8–11]. Most used attributes for internal assessment are attendance, internal marks, assignment, and presentation, i.e. shows how student serious to their studies [5, 6, 8, 9, 12–15]. Grade or external assessment is also most important attribute of student performance prediction in this 10th, 12th, and external marks are included [4–10, 12, 15]. Some important attributes that help in prediction, i.e. nationality, language, Internet access, entrance result, scholarship, community, and distance and these attributes are the least important, and some researchers used in their research because, i.e. not give the valid result [4, 5, 8, 10, 11]. In the above some attributes, researchers predict the student performance based on student school background, some researchers use family background, and some researchers used grade, internal assessment, and external assessment based on 10th, 12th, b.tech internal and external marks, and some researchers used assignment, language, extracurricular activities in prediction. Some attributes are work on the qualitative data and some on the quantitative data.

4 Key Findings and Gap Analysis in Previous Research

This paper contains the various sections, and each section has different information of research done in previous years in tabular form.

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
1	Prediction of student performance	S. Anupam Kumar & Dr. Vijayalakshmi M. N., 2011	Decision tree	Predicted the MCA students' final results using C4.5 algorithm and compare with ID3 algorithm	Build the system for predicting the placement, faculty feedback, student feedback, etc.
2		Osmanbegovic E., Suljic M., 2012	Naïve Bayes, MLP, and J48	Predicted the passed and failed result of students in which course they were involved	Extend the research with more attributes, algorithm and will finding the accurate result
3		Vamanan Ramesh et al., 2013	Naive Bayes, multilayer perception, SMO, J48, and REPTree algorithms	Identified the different higher predictive variables and construct algorithm for grading the higher secondary students	Modify the system for providing the online learning material and also find out the various factors that affected the student's performance
4		Elakia et al., 2014	Decision tree algorithms (C4.5 and CART)	Classification technique had been used for predicting carrier of high school students and also predicts the violation behaviour of students	Would examine different types of techniques and attributes for predicting more accurate result
5		A. M. Shahiria, W. Husaina, N. A L Rashida, 2015	Data mining algorithms	Studied the various predicting algorithms and find out best attributes that given the best result in prediction	Develop the model that predicts the students' performance using meta-analysis

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
6		P. Thakar, A. Mehta, Manisha, 2015	Data mining techniques	Analysed various types of educational tools and applications that help in performance prediction	Identify and apply various data mining techniques for predicting the more accurate result
7		Amjad Abu Saa, 2016	Decision tree algorithms and Naive Bayes model	Constructed the prediction model on the base of various attributes that depends on the personal, family, and social factors	Finding out the more patterns for improving the students' performance by applying the more data mining techniques on the students record
8		Annisa Uswatun Khasanah, Harwati, 2017	Feature selection method, Bayesian network, and decision tree algorithm	Analysed the different attributes that gave the accurate prediction. The study showed that first year attendance and GPA had the important attribute in accurate performance prediction	Using the more two attributes gender and origin in predicting the students' performance
9		Aysha Ashrafa, Sajid Anwerb, M. G. Khan, 2018	Various data mining algorithms, classifiers, classification algorithms, and use of neural network in data mining	Identified the best prediction method and algorithm that gave the accurate result on the basis of comparison and study	Finding out more efficient techniques for accuracy in result

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
10		Atta-Ur-Rahman, Kiran Sultan, Nahier Aldhafferi, Abdullah Alqahtani, 2018	Clustering, C-mean, and Apriori algorithm	Constructed the model on the basis of student interest and feasibility	Including the some attributes in the research like student is working or not, what could the time table and timing of class? How teachers will evaluate the marks
11		S. Urkude, K. Gupta, 2019	Decision tree, Naïve Bayes, and support vector machine	Calculate how many students complete their graduation and how much course rate achieved in which student enrolled	Same technology will applied on the large data set and develops more attributes related to first year progress
12		K. K. Lay, A. Cho, 2019	Naive Bayesian classifier	Classification model was used on previous result of IT students for predicting division	Applying the more classification algorithms and add the more attributes that will give the optimal result
13		Vairachilai S, Vamshidharreddy, Avvari Sai Saketh, Gnanajeyaraman R, 2020	Decision tree, support vector machine (SVM), and Naive Bayes	Identified the different dependent and independent factors and apply the various data mining algorithm in which Naive Bayes algorithm predicted the best grades	Applying and analyse the data set to identify the students' performance in systematic manner

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
14		R. Hasan, S. Palaniappan, S. Mahmood, A. Abbas, K. U. Sarker and M. U. Sattar, 2020	Classification tree, random forest, KNN, SVM, regression, Naïve Bayes, NN, and CN2 rule induction	Analysed various e-learning applications and apply various algorithms. Apply the genetic algorithm and various components to the result to reduce the features	Develop the dashboard would helpful for teachers to predict the student performance and find out the poor performers on the weekly basis. Students could also calculate their own performance
15		F. Afrin, M. S. Rahaman, M. Hamilton, 2020	SVM, multilayer perceptron, decision tree, random forest, decision table, and KNN	Predicted the satisfaction of the students in aspects of course outcome, professional outcome, course objective, and how to all learning things connect to the real world	Will add the more aspects for predicting the satisfaction of the students like teaching method, teacher knowledge related to subject, text books, syllabus, etc.
16		Ahajjam Tarika, Haidar Aissab, F. Yousef, 2021	Regression algorithm, decision tree, and random forest algorithm	Advised the students to take the preference of the subject by performance of first year and aptitude test and how will future grow with subject preference after bachelors and predicted the grades after deciding the subject	This model made for Moroccan students so after doing the some changes in the existing model and will work for Indian students

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
17		J. Dhilipan, N. Vijayalakshmi, S. Suriya, Arockiya Christopher, 2021	Binomial logical regression, decision tree, and entropy and KNN classifier	Students recognize the final grade and improve their academic performance	More attributes will add to the database for improving the accuracy of the result
18	Feedback	D. Shrivastava, S. Kesarwani, A. K. Kadam, A. Chhibber, N. kumar J. kumar, 2017	General sentiment analysis algorithm, multi-use sentiment analysis algorithm	This system calculates the overall feedback example course, subject teacher related and reduce the time and paper work	After modify the system. It will use in the hotels, hospitals, etc.
19		Rajvee Patel, Omkar Agrawal, Yash Gangani, Ashish Vishwakarma, 2018	HTML, CSS, j Query, My SQL,	Evaluated the feedback online to reduce the manpower and paperwork	Adding the module of student feedback in existing system
20		R. R. Kamble, V. V. Patil, P. R. Bhujange, P. M. Kolawale, N. A. Kamble, 2019	HTML, CSS, j Query, My SQL, Ajax with Xampp server, php	Through this module student easily modify the feedback anytime and faculty see his/her past feedbacks easily	Develop more modules for making feedback process easy
21		B. T. Agricola, F. J. Prins, and D. M. A. Sluijsmans, 2020	ANOVA F-ratios, MSLQ, FAPQ	In this research, researcher studied that verbal feedback is more accurate than the written feedback because it does not create misunderstandings	Will trained the students how to fill the properly feedback form

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
22	Subjective answer evaluation	S. M. Patil, S. Patil, 2017	NLP	Developer identify the important keyword, sentences in the answer and gave the weight according to the presence and then compare to the users answer and give the score according to the weight	Rebuild system will give the report to the students that how their answer will evaluate
23		P. Patil, S. Patil, V. Miniyar, A. Bandal, 2018	Nave Bayes, cosine similarity, machine learning	In this model, scanned sheet of answer has been taking and then tokenize the answer in to words and sentences and the match to already given answer on the basis of grammar, keywords, cosine similarity, etc., and gave the appropriate grade	Some add-ons done on the system that will give the more accurate result
24		Sakshi Berad, Pratiksha Jaybhaye, Sakshi Jawale, 2019	Natural language processing	In this admin insert a question and related answer and machine compared the user answer to the machine answer word by word and gave the marks according the answer	Develop the system for giving the marks to new words and sentences

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
25		R. S. Victoria D, V. G. Vinitha P, Sathya R, 2020	Optical character recognition, natural language processing, machine learning	In this model, handwritten answer extracted by OCR and then comparison done by the given answer that give the result on basis of sentence length, keyword match, and usage of words	Upgrade the software for evaluating the digits, broken characters, and images in the subjective answer
26		Vineet Sanjeev Khalkho, Shoyab Malik. S. K, S. Rama, 2021	NLP, regular expression, cosine factor, TF-IDF	In this system, developer converts the question and related answer in to regular expression and then generate the cosine factor and then same method done in user answer and then both results measure by the TF-IDF for accurate result	A system in which electronic invigilator and student help module will construct
27		A. Girkar, M. khambayat, A. Waghmare, S. Chaudhary, 2021	Natural language processing, Naive Bayes, decision tree classification	Evaluate the subjective answer by comparing the all these like keyword matching, cosine similarity, number of words and line in answer, cosine similarity, etc., to the faculty answer, i.e. given in the starting	Modify the system for giving the more accurate result
28	Posture recognition	J. Redmon, A. Farhadi	YOLOv3	In this user add the more attributes in YOLOv3 to clearing the computer vision more clearly	Doing the more research for clear computer vision

(continued)

(continued)

S. No.	Type	Author name and published year	Methodology	Key findings	Gap analysis
29		Quang Trung, Nguyen, Hoang Tieu Binh, The Duy, Bui, Phuong Dung, N. T, 2019	VGG16 AND VGG 19, adaptive learning	Through the postures and gestures of the student, the students were taking interest in class material and methodology or not. It helped the teacher to give a lecture more attractive to the learners	Developing the more modules of adaptive training system
30		Y. Zhang, T. Zhu, H. Ning, Z. Liu, 2021	SVM, high-resolution network, S&E networks	Recognizing the students was attentive in the class or not through the different poses. In this student pose was compare to the already stored poses of database. This model accuracy is 90.1%	Rebuild the recognition algorithm for adding new poses at different time and environments

5 Algorithms Used for Student Performance Prediction

Various classification and clustering algorithms have been used in student performance prediction like KNN, SVM, neural network, machine learning, binomial regression, random forest, Naive Bayes, multilayer perceptron, and Apriori algorithm.

- The decision tree is a simple and easy algorithm for large and small database sets. Its reasoning process has very easy to use, and it can be immediately transform in decision rules (if-else). Many researchers used a decision tree algorithm for prediction and some users got the best result. The paper used a decision tree and got the best prediction [6, 7, 12, 16, 17].
- A Naive Bayes algorithm is a collection of classification algorithms in one place. It has labelled training data sets for developing the database tables. The paper used Naive Bayes and got the best prediction [5, 6, 9, 10, 14].

- Support vector machine (SVM) acquires database and characterizes the hyperplane into two classes. The paper used SVM and got the best prediction [8, 11, 18].
- Neural networks have interconnected nodes. Input nodes take the input, middle layers process the input, and the output layer produces the result. The papers got the best prediction [4, 7, 13].
- Binomial regression is similar to binary regression response that comes from either success or failure. The papers got the best prediction [15, 19].
- Random forest is also a good prediction algorithm [20] that gave the best prediction result.

6 Other Areas

Faculty and student feedback is more important area in 2020, and Bas T. Agricola, Frans J. Prins, and Dominique M. A. Sluijsmans studied verbal feedback is more accurate than the subjective and multiple choice feedback (30). Through subjective answer evaluation calculates the accurate performance of students. In 2021, A. Girkar et al. developed the system using natural processing language that gave the accurate marks to the students in subjective answers [21]. Posture recognition recognizes that student is attentive or not in classroom and helps in invigilation. In 2021, author Yiwen Zhang et al. recognize the student gesture in classroom and analysed student is attentive in classroom or not [22].

7 Summary

All researchers have researched educational data mining that is very useful in the new era. Prediction through data mining has a vast area in the computer science field. Through this research, researchers made predictions on students' performance, results, feedback, poses, grade, career, and provide satisfaction related to course selection, job selection, and business selection. Finding out various sets like the weak students, students who are comfortable/uncomfortable with class timetables, class timings, students who have completed their graduation or not. Studied different types of attributes that are helpful in prediction like status, father occupation, previous results, attendance, interest in the subject, related family member's education, and other information. Through posture recognition, whether a student is interested in a lecture or not and feedback is a more important part for teachers that help in teacher self-improvement in various fields. In overall review process, Naive Bayes and decision tree gave the best result.

8 Future Scope

In education, everything relates to another thing like the result is dependent on the acquisitive power of student, interest area depends on how the subject and expertise on it that only come when the student learns the subjects taking the interest, placement depends on the result, good feedback depends on the teaching methodology, course objective, and the result and last but not the least, college ranking depends on the student result, placement, and the feedback. Now the challenge is improve and calculate the performance of college on the basis of improve the performance of weak students, to prepare the students for interview, aware the parents about placement, feedback, compute the college performance, and complete data analysis. Everyone related to institute will do the progress (management, student, teacher, attendants, and parents).

References

1. Govindasamy, K., & Velmurugan, T. (2018). Analysis of student academic performance using clustering techniques. *International Journal of Pure and Applied Mathematics, 119*(15), 309–323.
2. Majeed, I., & Naaz, S. (2018). Current state of art of academic data mining and future vision. *Indian Journal of Computer Science and Engineering (IJCSE)*, *09*(02). https://doi.org/10.21817/indjcse/2018/v9i2/180902026
3. Alapont, J., Bella-Sanjuán, A., Ferri, C., Hernández-Orallo, J., Llopis-Llopis, J., & Ramírez-Quintana, M. (2005). Specialised tools for automating data mining for hospital management. In *Proceedings of the First East European Conference on Health Care Modelling and Computation*, Craiova, Romania, 31 August–2 September 2005; pp. 7–19.
4. Ramesh, V., Parkavi, P., & Ramar, K. (2013). Predicting student performance: A statistical and data mining approach. *International Journal of Computer Applications 63*(8).
5. Abu Saa, A. (2016). Educational data mining and students' performance prediction. *International Journal of Advanced Computer Science and Applications 7*(5).
6. Khasanah, A. U., & Harwati. (2017). A comparative study to predict student's performance using educational data mining techniques. *IOP Conference Series Materials Science and Engineering 215*(1).
7. Ashrafa, A., Anwerb, S., & Gufran Khan, M. (2018). A comparative study of predicting student's performance by use of data mining techniques. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 44*(01), 122–136.
8. Urkude, S., & Gupta, K. (2019). *Student intervention system using machine learning techniques. International Journal of Engineering and Advanced Technology 8*(6S3), 2061–2065
9. Vamshidharreddy, V. S., Saketh, A. S., & Gnanajeyaraman, R. (2009). Student's academic performance prediction using machine learning approach. *International Journal of Advanced Science and Technology 29*(09), 6731–6737.
10. Osmanbegovic, E., & Suljic, M. (2012). Data mining approach for predicting student performance. *Economic Review Journal of Economics and Business,10*(1).
11. Rahman, A. U. Sultan, K., Aldhafferi, N., & Alqahtani, A. (2018). Educational data mining for enhanced teaching and learning. *Journal of Theoretical and Applied Information Technology, 96*(14), 4417–4427.
12. Kumar S. A. & Vijayalakshmi M. N. (2011). Efficiency of decision trees in predicting student's academic performance. In: First International Conference on Computer Science, Engineering and Applications, CS and IT 02 (pp. 335–343). Dubai.

13. Shahiria, A. M., Husaina, W., & Abdul Rashida, N. (2015). A review on predicting student's performance using data mining techniques. *Science Direct, The Third Information Systems International Conference, 72*, 414–422.
14. Lay, K. K., & Cho, A. (2019). Using Naive Bayesian classifier for predicting performance of a student. *International Journal of Trend in Scientific Research and Development (ijtsrd), 3*(05), 1387–1391.
15. Dhilipan, J., Vijayalakshmi, N., Suriya, S., & Christopher, A. (2021). Prediction of students performance using machine learning. *IOP Conference Series Materials Science and Engineering, 1055*(1), 012122.
16. Elakia, G., & Aarthi, N. J. (2014). Application of data mining in educational database for predicting behavioural patterns of the students. *International Journal of Computer Science and Information Technologies, (IJCSIT), 5*(3), 4649–4652 (2014)
17. Thakar, P., Mehta, A., & Manisha. (2015). Performance analysis and prediction in educational data mining: a research travelogue. *International Journal of Computer Applications 110*(15).
18. Afrin, F., Saiedur Rahaman, M., & Hamilton, M. (2020). Mining student responses to infer student satisfaction predictors. In *Seventh International Conference on Learning and Teaching in Computing and Engineering (LaTiCE'20).*
19. Tarika, A., Aissab, H., & Yousef, F. (2021). Artificial intelligence and machine learning to predict student performance during the COVID-19. In *The 3rd International workshop on Big Data and Business Intelligence (BDBI 2021)* March 23–26, 2021, ScienceDirect Available online at www.sciencedirect.com *Procedia Computer Science 184,* 835–840.
20. Hasan, R., Palaniappan, S., Mahmood, S., Abbas, A., Sarker, K. U., & Satta, M. U. (2020). Predicting student performance in higher educational institutions using video learning analytics and data mining techniques. *Advanced Techniques in the Analysis and Prediction of Students' Behaviour in Technology-Enhanced Learning Contexts 10*(11).
21. Girkar, A., Khambayat, M., Waghmare, A., & Chaudhary, S. (2021). Subjective answer evaluation using natural language processing and machine learning. *International Research Journal of Engineering and Technology (IRJET), 08*(04), 5040.
22. Zhu, Y. Z. T., Ning, H., & Liu, Z. (2021). Classroom student posture recognition based on an improved high-resolution network. *Research Square,02.*
23. Patil, S. M., & Patil, S. (2014). Evaluating student descriptive answers using natural language processing. *International Journal of Engineering Research & Technology(IJERT) 03*(3).
24. Sayana, T. S. (2015). Prediction of students academic performance using data mining: Analysis. *International Journal of Engineering Research & Technology (IJERT) Conference Proceedings.*
25. Agrawal, H., & Mavani, H. (2015). Student Performance Prediction Using Machine Learning. *International Journal Of Engineering Research and Technology (IJERT), 4*(03).
26. Bhogan, S., Sawant, K., Naik, P., Shaikh, R., Diukar, O., & Dessai, S. (2017). Predicting student performance based on clustering and classification. *IOSR Journal Of Computer Engineering (IOSR-JCE) 19*(03), 49–52.
27. Shrivastava, D., Kesarwani, S., Kadam, A.K., Chhibber, A., & Jayakumar, N. (2017). Online student feedback analysis system with sentiment analysis. *International Journal of Innovative Research in Science, Engineering and Technology, 6*(05).
28. Patel, R., Agrawal, O., Gangani, Y., & Vishwakarma, A. (2018). College feedback system. *International Research Journal of Engineering and Technology (IRJET), 05*(01), 1351.
29. Patil, P., Patil, S., V. Miniyar, A., & Bandal. (2018). Subjective answer evaluation using machine learning. *International Journal of Pure and Applied Mathematics, 118*(24).
30. Joseph, R., & Ali, F. (2018) YOLOv3: An incremental improvement. *Computer Vision and Pattern Recognition.*
31. Sya'iyah, K., Yuliansyah, H., & Arfiani, I. (2019). Clustering student data based on K-means algorithms. *International Journal Of Scientific & Technology Research 8*(08).
32. Kamble, R. R., Patil, V. V., Bhujange, P. R., Kolawale, P. M., & Kamble, N. A. (2019). Student feedback system. *International Research Journal of Engineering and Technology (IRJET), 06*(2), 550.

33. Berad, S., Jaybhaye, P., & Jawale, S. (2019). AI answer verifier. *International Research Journal of Engineering and Technology (IRJET), 06* (01).
34. Trung, Q., Nguyen, H. T. B., Duy, T., & Bui, P. D. (2019). N.T, Student postures and gestures recognition system for adaptive learning improvement. In *6th NAFOSTED Conference on Information and Computer Science (NICS) Conference.*
35. Rosy Salomi Victoria, D., Viola Grace Vinitha, P., & Sathya, R. (2020). Intelligent short answer assessment using machine learning. *International Journal of Engineering and Advanced Technology (IJEAT), 9*(04), 1111.
36. Agricola, B. T., Prins, F. J., Dominique M. & Sluijsmans, A. (2020). Impact of feedback request forms and verbal feedback on higher education students' feedback perception, self-efficacy, and motivation. *Assessment in education: Principles, Policy and Practice 27*(1).
37. Khalkho, V. S., Malik, S., S. K., & Rama, S. (2021). Automated subjective answer evaluation. *International Journal of Engineering Science and Computing (IJESC), 11*(05).
38. Aslam, S., & Emmanuel, P. (2010). Formulating a researchable question: A critical step for facilitating good clinical research. *Indian J Sex Transm Dis AIDS, 31*(1), 47–50.
39. Agarwal B. B., & Tayal, S. P. (Eds.). (2006). Book Data mining and data warehousing kindle (2006)
40. Agarwal, B. B. & Tayal S. P. (2007). Book data mining and data warehousing Kindle.

"Bow Tie Slot Fed Circularly Polarised Hybrid (Cone Over Cylinder) Shaped DRA Antenna"

Richa Gupta

Abstract The document depicts circularly polarised (CP) different geometries for dielectric resonator antenna (DRA) like cylindrical shaped, cone shaped, and cone over cylinder DRA using bow tie slots feeding technique and analysed for gigahertz (GHz) applications. A comparative analysis of all three geometries is presented and discussed. The proposed hybrid (cone over cylinder DRA) circularly polarised DRA with bow tie slots feeding technique provides the axial ratio bandwidth of (1.14–1.75 GHz) 40% and impedance bandwidth of (1–1.7 Ghz) 47.33% with highest gain of 6.63 dBi and 77.33% efficiency. The results have been verified using CST and HFSS.

Keywords Circularly polarised · Axial ratio · Bow tie · Hybrid

1 Introduction

Dielectric resonator antennas have gain popularity as they do not have metal parts, which become lossy at high frequencies, dissipating energy. So, these antennas can have reduced losses and be more efficient than metal antennas at high microwave and millimetre wave frequencies. The circularly polarised antennas have numerous benefits as compared to antennas employing linear polarisations and are becoming a crucial skill for different wireless systems such as satellite communications, mobile communications, global navigation satellite system, and wireless sensors. Dielectric material does offer losses at all frequency bands. There is no way to forestall dielectric losses neither are they negligible, but they can be managed by appropriate antenna design that can furnish elevated gain and efficiency.

A bow tie antenna is a common adaptation of the more general biconical antenna. It is a broad bandwidth antenna made from two triangular pieces of metal, each fed at its tip. The bow tie antenna is a natural extension of the dipole antenna and shares a similar radiation pattern and polarisation. The difference lies in that while

R. Gupta (✉)
Maharaja Surajmal Institute of Technology, New Delhi, India
e-mail: richagupta@msit.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_3

the resonant frequency of a dipole antenna is solely specified by its length, the bow tie antenna is specified by the angle between the two triangles. Since the variation in distance between the two edges of the bow ties will change as you move up or down the triangle, there exist many resonant frequencies for which the antenna can radiate. An infinite bow tie would have infinite bandwidth, since the antenna would look the same at any wavelength.

Numerous techniques like changing the shape of slot to enhance the AR bandwidth of CPDRAs were described like hybrid cross slot [1] and spiral slot [2] offering AR bandwidths of 24.6 and 25.5%, correspondingly. Circular polarisation is also achieved by certain models of the DRA, e.g. stair-shape [3], trapezoidal [4], and rotated stair [5]. Using RDRA's outer-fed square spiral strip excitation, a circular polarisation with a wide bandwidth of about 14% and an impedance-matching bandwidth of about 11% were achieved [6]. The other technique to enhance axial ratio bandwidth is to use multiple feeding technique. With single feeding, narrow axial ratio bandwidth of 20% is obtained [7, 8]. The low gain is achieved in most of the designs [9–11]. As per literature survey, much work needs to be done to enhance bandwidth and gain of CPDRA [4, 10, 12–16]. Also, design should be made in such a manner that gain remains almost stable for the desired band.

In this paper, a novel wideband circularly polarised DRA with different geometries like cylindrical shaped, cone shaped, and cone over cylinder with bow tie slot and multiple feeding technique is presented. Due to bow tie slot shape, wide axial ratio bandwidth with high gain is obtained.

2 Antenna Geometry

Figure 1a–c depicts different geometries for dielectric resonator antenna (DRA) like cylindrical shaped, cone shaped, and cone over cylinder DRA. Figure 1d presents bottom view of design with four bow tie slots and eight ports. Dimensions for the same have been portrayed in Table 1. All DRAs are fabricated using FR-4 epoxy substrate with a permittivity ε_r of 4.4 and alumina for the dielectric resonator on top submitting a permittivity of 10. The length of the bow tie slot is 36 mm. The antenna exhibits circular polarisation and wide axial ratio bandwidth due to a bow tie slots.

The operating frequency of cylindrical DRA is described as

$$f_0 = \frac{3 \times 10^8}{2\pi\sqrt{\varepsilon_r}}\sqrt{2\left(\frac{\pi}{a}\right)^2 + \frac{\pi^2}{2h}},$$

where a is the radius of cylinder, ε_r is the dielectric constant for substrate, h is the height of cylinder, and c is the speed of light.

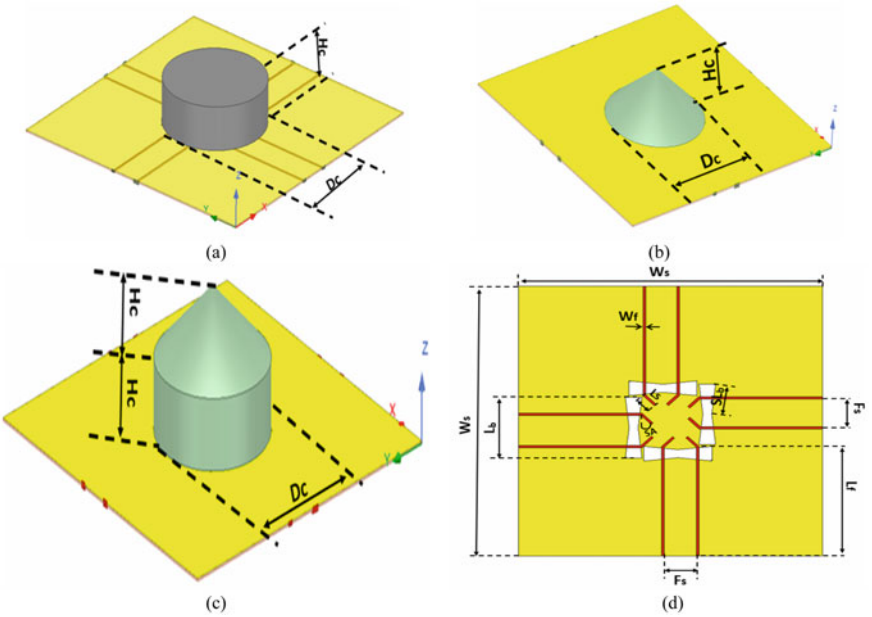


Fig. 1 Different geometries for dielectric resonator antenna (DRA); **a** cylindrical shaped, **b** cone shaped, **c** hybrid (cone over cylinder) DRA, and **d** bottom view of antenna (bow tie slots)

Table 1 Description of dimensions marked in Fig. 1

Name	Value	Unit	Description
Dc	63.5	mm	Diameter of cylinder
Fs	17.75	mm	Distance between feed
Hc	22	mm	Height of cylinder
Lb	36	mm	Length of bow tie
Lf	64.40	mm	Length of feed line
Ls	7.5	mm	Slant length of feed line
SA	45°	Deg	Tilt angle of feedline
SLb	18	mm	Slant length of bow tie
Wf	1.45	mm	Width of feed line
Ws	160	mm	Width of substrate

3 Simulated Results

The performance of each dielectric resonator antenna (DRA) like cylindrical shaped, cone shaped, cone over cylinder DRA, and bottom view of antenna with four bow tie slots and eight ports is analysed, and the impact of changing shape on antenna parameters like beamwidth, directivity, gain, impedance bandwidth, and axial ratio

bandwidth are investigated and discussed. The introduced 3D models are simulated using the finite element method (FEM)-based simulator, Ansys HFSS, and CST. All the designs are optimised to operate at 1.5 GHz. The S-parameter for distinct designs is offered in Fig. 2. Circular polarisation is observed in all three geometries by feeding the design through bow tie slots. The existence of circular polarisation in cylindrical geometry is captured in Fig. 3. The plot of axial ratio versus frequency for all three designs is shown in Fig. 3. The bow tie slot fed cone shape DRA provides highest axial ratio bandwidth of 43% and impedance bandwidth of 46% among the three geometries with a gain of 3.82 dBi only and low efficiency of 32% only. The hybrid DRA exhibits axial ratio bandwidth of 40% and impedance bandwidth of 47.33% with highest gain of 6.63 dBi and 77.33% efficiency. Figure 4a–c provides the gain, axial ratio, and efficiency of all three designs. The gain is nearly steady for the required frequency period.

The directivity pattern of various geometries displaying E and H plane 3 dB beamwidth is submitted in Fig. 5. All the three geometries, i.e. cylindrical shaped, cone shape, and cone over cylinder DRA exhibit same beamwidth in their E and H planes. The change in beamwidth is obtained with change in geometry of antenna. The cylindrical shaped, cone shaped, and cone over cylinder DRA provide E plane 3 dB beamwidth of 84.83°, 71.71°, 102.9°, respectively. The design provides same beamwidth in both E and H planes. It can be determined that beamwidth is improved with modification in the profile of the antenna. It has also been observed that

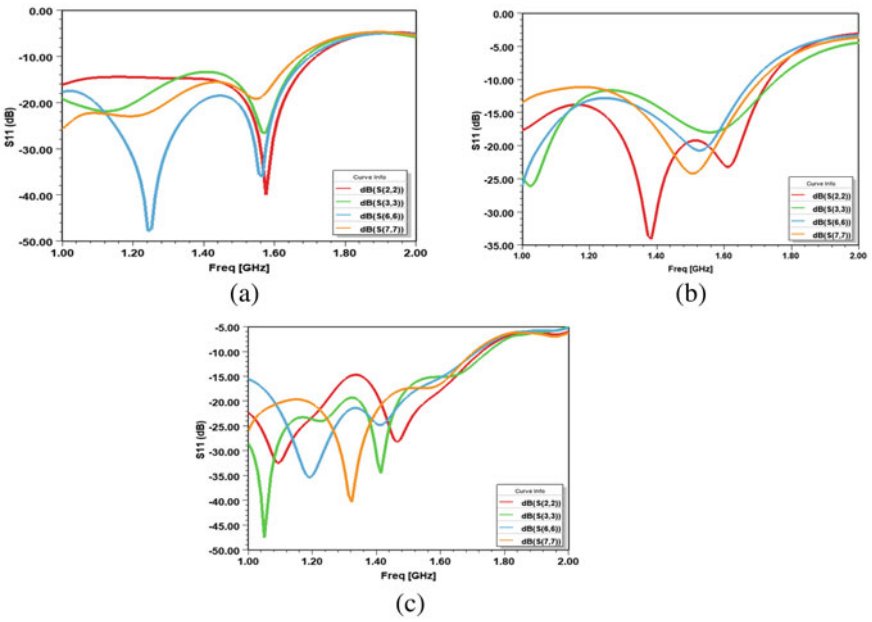


Fig. 2 S_{11} versus frequency for different geometries for dielectric resonator antenna (DRA); **a** cylindrical, **b** cone, and **c** hybrid (cone over cylinder)

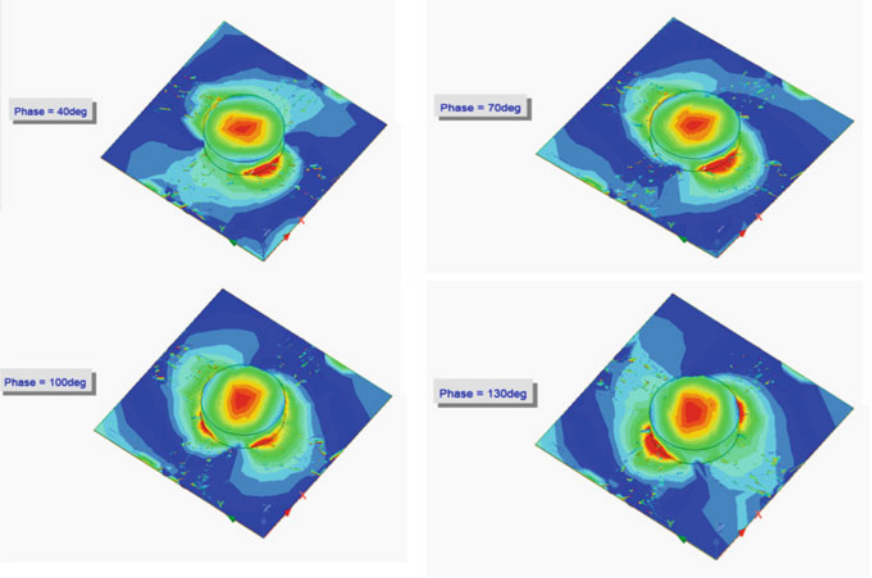


Fig. 3 Cylindrical DRA circular polarisation at frequency 1.5 GHz

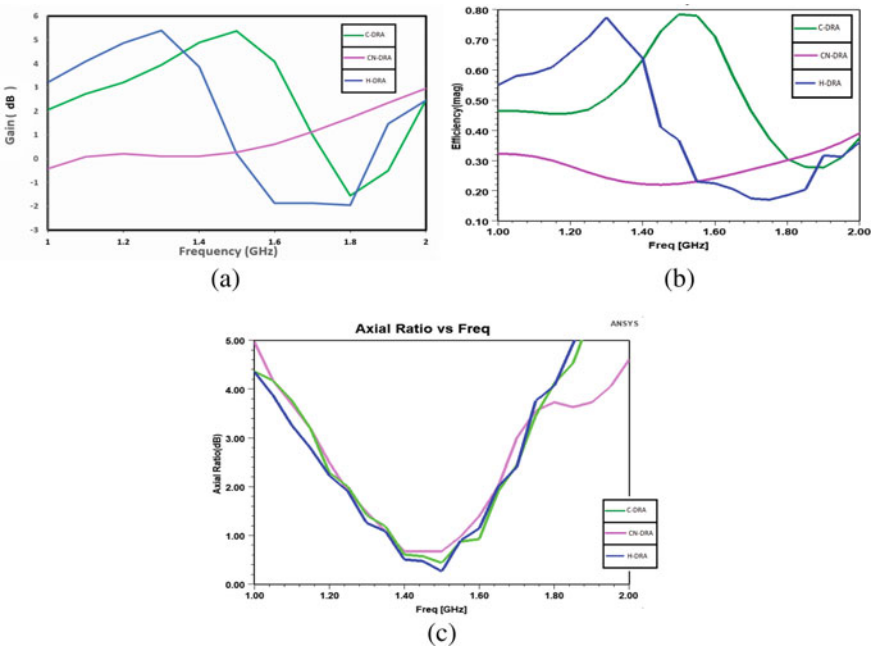


Fig. 4 Simulated results **a** gain versus frequency, **b** efficiency versus frequency, and **c** axial ratio versus frequency for cylindrical C-DRA; cone CN-DRA, and hybrid (cone over cylinder) H-DRA

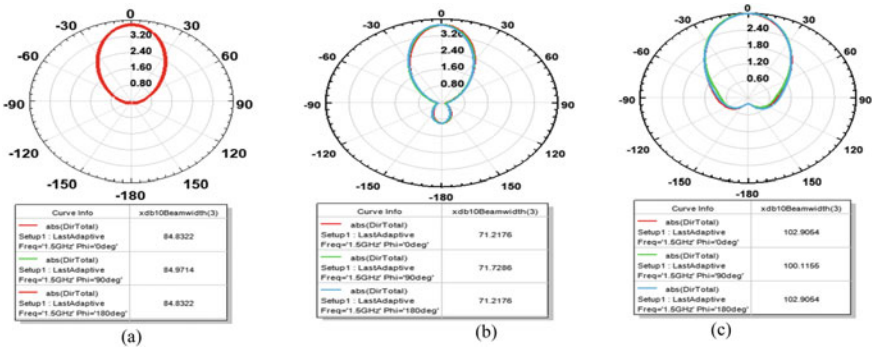


Fig. 5 3 dB beamwidth pattern for different geometries for dielectric resonator antenna (DRA); **a** cylindrical, **b** cone, and **c** hybrid (cone over cylinder)

by exciting the ports with different phase angles polarisation diversity, i.e. linear polarisation (LP), left hand circular polarisation (LHCP), and right hand circular polarisation (RHCP) can be achieved as demonstrated in Fig. 6.

Table 2 explains a reasonable assessment for the dissimilar geometries understudy, contrasting their respective beamwidth, gain, directivity, and efficiency, impedance bandwidth, and axial ratio bandwidth. Further, comparisons among past works within the literature with the proposed DRA have been compiled in Table 3.

4 Conclusion

The method has been offered to obtain circular polarisation with wide axial ratio bandwidth. Different geometries for dielectric resonator antenna (DRA) like cylindrical shaped, cone shaped, and cone over cylinder DRA using bow tie slots feeding technique have been designed and analysed for gigahertz (GHz) applications. All the three geometries are well analysed and presented. The proposed hybrid (cone over cylinder DRA) circularly polarised DRA with bow tie slots feeding technique provides the axial ratio bandwidth of (1.14–1.75 GHz) 40% and impedance bandwidth of (1–1.7 GHz) 47.33% with highest gain of 6.63 dBi and 77.33% efficiency. The designed antenna can be used for L band application.

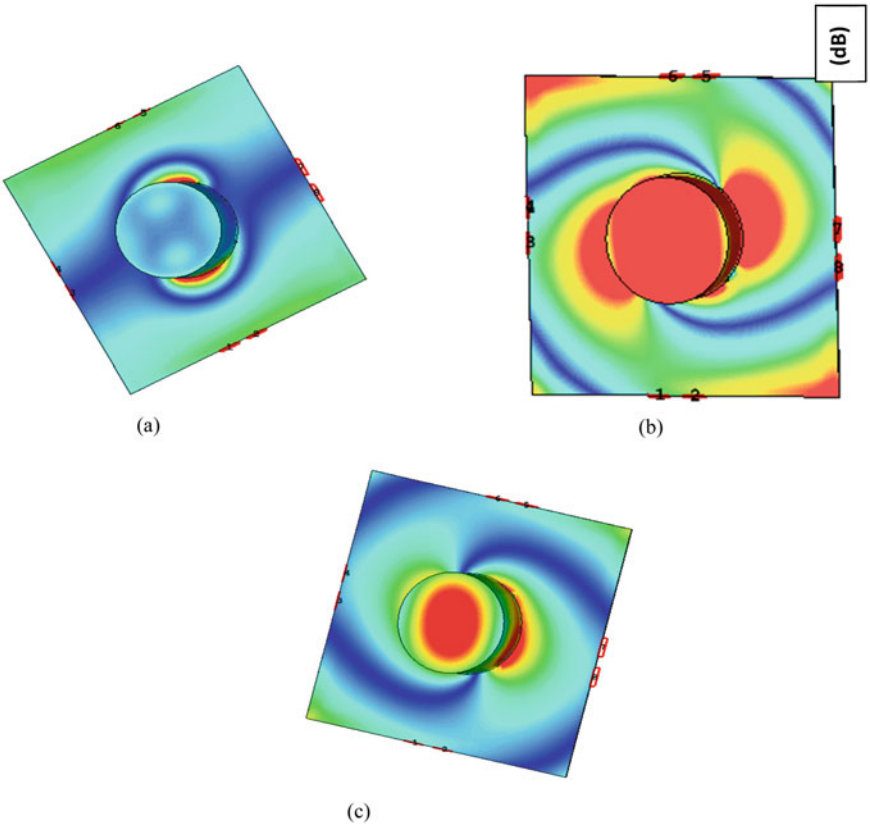


Fig. 6 Simulated polarisation results for LP, RHCP, and LHCP

Table 2 Comparative analysis of different simulated geometries

DRA design	Freq (GHz)	Bandwidth (°)		Gain (dBi)	Directivity (dBi)	Efficiency (%)	Impedance range (GHz)	Impedance bandwidth (%)	Axial ratio range (GHz)	Axial ratio bandwidth (%)
		Phi = 0°	Phi = 90°							
Cylindrical DRA	1.5	84.83°	84.97°	4.70	4.95	78.19	1–1.62	41.33	1.21–1.73	35
Cone DRA	1.5	71.21°	71.71°	3.54	3.82	32	1–1.7	46	1.11–1.75	43
Hybrid DRA (cone over cylinder DRA)	1.5	102.90°	100.11°	6.63	7.73	77.33	1–1.7	47.33	1.14–1.75	40

Table 3 Comparing the proposed design with past works in the literature

References	Technique	Freq (GHz)	Beamwidth (°)		Gain (dBi)	Impedance bandwidth (%)	Axial ratio bandwidth (%)
			Phi = 0	Phi = 90			
[1]	Cross slot	2.6	–	–	5	28.6	24.6
[2]	Spiral slot	2.13	–	–	4.52	25.5	–
[4]	Trapezoid shape DRA	3.6	–		8.39	33.5	21.5
[6]	Outer-fed square spiral strip feeding technique	4.2	80	36	4	11	14
Proposed antenna	Bow tie feed (cone over cylinder DRA)	1.5	102.90	100.11	7.73 dBi	47.33	40

References

1. Pan, J., & Zou, M. (2014). Wideband hybrid circularly polarised rectangular dielectric resonator antenna excited by modified cross-slot. *Electronics Letters, 50*(16), 1123–1125.
2. Zou, M., Pan, J., & Nie, Z. (2015). A wideband circularly polarized rectangular dielectric resonator antenna excited by an Archimedean spiral slot. *IEEE Antennas and Wireless Propagation Letters, 14*, 446–449.
3. Chair, R., Yang, S.L.S., Kishk, A.A., Lee, K.F., Luk, K.M. (2006). Aperture fed wideband circularly polarized rectangular stair shaped dielectric resonator antenna. *IEEE Transactions on Antennas and Propagation, 54*(4), 1350–1352
4. Pan, Y., & Leung, K. W. (2010). Wideband circularly polarized trapezoidal dielectric resonator antenna. *IEEE Antennas and Wireless Propagation Letters, 9*, 588–591.
5. Wang, K. X., & Wong, H. (2015). A circularly polarized antenna by using rotated-stair dielectric resonator. *IEEE Antennas and Wireless Propagation Letters, 14*, 787–790.
6. Sulaiman, M. I., & Khamas, S. K. (2010). A singly fed rectangular dielectric resonator antenna with a wideband circular polarization. *IEEE Antennas and Wireless Propagation Letters, 9*, 615–618.
7. Lee, J. M., Kim, S. J., Kwon, G., et al. (2015). Circularly polarized semi-eccentric annular dielectric resonator antenna for X-band applications. *IEEE Antennas and Wireless Propagation Letters, 14*, 1810–1813.
8. Gotra, S., Varshney, G., Yaduvanshi, R. S., et al. (2019). Dual-band circular polarisation generation technique with the miniaturisation of a rectangular dielectric resonator antenna. *IET Microwaves, Antennas and Propagation, 13*(10), 1742–1748.
9. Kumar, R., Thummaluru, S. R., & Chaudhary, R. K. (2019). Improvements in Wi-MAX reception: A new dual-mode wideband circularly polarized dielectric resonator antenna. *IEEE Antennas and Propagation Magazine, 61*(1), 41–49.
10. Kumar, R., & Chaudhary, R. K. (2015). A wideband circularly polarized cubic dielectric resonator antenna excited with modified microstrip feed. *IEEE Antennas and Wireless Propagation Letters, 15*, 1285–1288.

11. Kumari, R., & Gangwar, R. K. (2018). Circularly polarized rectangular dielectric resonator antenna fed by a cross aperture coupled spiral microstrip line. *International Journal of RF and Microwave Computer 28*(2)*,* 1–7.
12. Lu, K., Leung, K. W., & Pan, Y. M. (2011). Theory and experiment of the hollow rectangular dielectric resonator antenna. *IEEE Antennas and Wireless Propagation Letters*, *10*, pp.631–634.
13. Gupta, R., Varshney, G., & Yaduvanshi, R. S. (2021). Tunable terahertz circularly polarized dielectric resonator antenna. *Optik, 239*, 166800.
14. Yaduvanshi, R. S., Gupta, R., & Katiyar, S. (2020). Smart DRA for beam width and orientation control. Frequenz, 1 (ahead-of-print).
15. Gupta, R., Gaur, A., Gupta, S., & Bakshi, G. (2021). Circularly polarized multiple layer dielectric resonator antennas. *Progress In Electromagnetics Research C, 112*, 139–151.
16. Gupta, R., Bakshi, G., & Bansal, A. (2020). Dual-band circularly polarized stacked sapphire and TMM13i rectangular DRA. *Progress In Electromagnetics Research, 91*, 143–153.

Handwritten Character Recognition from Image Using CNN

Partha Chakraborty, Shanta Roy, Sadia Nowshin Sumaiya, and Aditi Sarker

Abstract Handwritten character identification has always been an intriguing area of study in the realm of pattern recognition in image processing. Because of its numerous applications, the requirement for identifying handwritten characters is growing every day. Many scholars have defined their work in this field, and additional research is being carried out to obtain high precision. In compared to other major languages such as Bangla, there are numerous works in handwritten character recognition available for English. The goal is to present a comprehensive, effective, and efficient method for classifying and recognizing both Bangla and English letters. An extended convolution neural network (CNN) model has been suggested to recognize Bangla and English characters. Character recognition is achieved through segmentation, feature extraction, and classification. CNNs were recently discovered to be adept at English text detection. A CNN-based Bangla handwritten character recognition system is also being researched. A total of 23,040-character samples have been used, with 25% of the data having served as a test set and the remaining 75% having been used to train the recognition model.

Keywords Convolutional neural network · ReLU · Pooling · Extraction

1 Introduction

Character recognition is becoming increasingly important in our digital age. Handwritten character recognition is harder than printed character recognition. Handwritten letters, written by various people, are not similar and vary in size and shape. Approximately, 1.35 billion people speak English and 260 million people speak Bangla worldwide. The size, form, and stroke of both Bangla and English handwritten characters can be varied. As a result, a complex model such as CNN is

P. Chakraborty (✉) · S. Roy · S. N. Sumaiya · A. Sarker
Department of Computer Science and Engineering, Comilla University, Cumilla 3506, Bangladesh
e-mail: partha.chak@cou.ac.bd

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_4

required, which can automatically extract features from images without any explicit description [1].

The extraction of features from the character set is the first step in developing a handwritten character recognition system, followed by the use of learning tool(s) to classify individual characters [2]. After characters are extracted, a validation engine is utilized to distinguish the associated computer character. To train neural network classifier, a source images training set is used. The trained network then does the word identifications. In its own way, any neural network learns the properties that separate training images. The ability of a computer to detect and interpret meaningful handwriting input from photographs is referred to as handwritten character recognition. The primary goal of this research is to develop an expert system for handwriting character identification using a neural network technique [3].

The following are the primary goals of this article:

- Implement user friendly computer-assisted character representation.
- Develop a system to address the problem of accuracy in handwriting character recognition systems.
- To investigate and illustrate neural network technology's utility.

2 Related Work

Digit recognition for handwritten Bangla deep learning [4] techniques for recognizing Bangla digits using deep belief networks (DBN), convolutional neural networks (CNN), CNN with dropout, CNN with dropout and Gabor filters, and CNN with dropout and Gaussian filters are shown by Zahangir, Sidike, and Tarek. They tested the method's performance on the publicly available Bangla numeral image database CMATERdb 3.1.1.

Convolutional neural network for handwritten character recognition in Bangla [2], Mahbubar and Akhand developed an approach that uses CNN to categorize individual characters after first normalizing the written character images. 20,000 handwritten characters of complex styles and variants are employed.

A survey of handwritten character recognition techniques for various Indian languages [5], Dholakia and Krupa, this paper is primarily process character recognition and performance assessment for various Indian languages to recognize handwritten characters. Some other authors have worked on various techniques in these sectors [6–20]. The goal of this research is to convey a bundle of techniques for preprocessing, segmentation, feature extraction, and classification.

3 Structural Model

If we look at our system, we will find 5 major steps that are performed for all the characters. The structural model is Fig. 1.

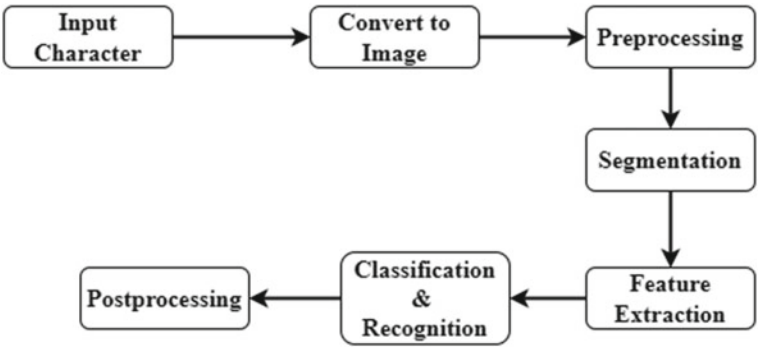


Fig. 1 Structural model of the system

4 Methodology

4.1 Preprocessing

First and foremost, the supplied image is transformed to grayscale. Binarization, size normalization, morphological procedures, noise removal employing filters, thresholding, skeletonization, thinning, cleaning approaches, and filtering mechanisms are all performed [5]. It streamlines the processing of the input image in order to improve the recognition system's overall efficiency.

4.2 Segmentation

Only during the testing stage is segmentation done. It compares all points to the average distance between segmentation points in the incomplete image to look for any improperly included points. The method creates "super pixels," which are numerous picture segments. The purpose of segmentation is to make an image's representation simpler so that it can be analyzed more simply.

4.3 Feature Extraction

The procedure of converting input data into a set of features that can accurately signify the input data is known as feature extraction. Elimination of aspect and feature extraction is linked [21]. When the input data is too big to handle, it can be reduced to a smaller set of features.

4.4 Classification and Recognition

To classify the handwritten characters from the input image, a convolutional neural network is utilized as a classifier. An input and output layer, as well as several hidden layers, makes up a CNN [21]. Classification stage is where the recognition system makes its decisions. The quality of the extracted features determines a classifier's performance.

4.5 Post-processing

Post-processing is the last phase of the character recognition system. It generates structured text with the relevant recognized characters.

4.6 Dataset

For 96 Bangla and English characters, we generated a relatively big handwritten dataset. Our produced dataset is 23,040 bytes in size, with 240 samples per character. Because of the various writing styles, the dataset comprises a wide range of distinct characters. Some of these character pictures have intricate shapes and are related to one another [1]. The character classes that we chose for honor are listed below (Tables 1, 2 and 3)

Table 1 Set of Bangla alphabets

অ	আ	ই	ঈ	উ	ঊ	ঋ	এ	ঐ	ও
ঔ	ক	খ	গ	ঘ	ঙ	চ	ছ	জ	ঝ
ঞ	ট	ঠ	ড	ঢ	ণ	ত	থ	দ	ধ
ন	প	ফ	ব	ভ	ম	জ	য	র	ল
শ	ষ	স	হ	ড়	ঢ়	য়	ৎ	ং	ঃ
ঁ									

Table 2 Set of English alphabets

A	B	C	D	E	F	G	H	I	J
K	L	M	N	O	P	Q	R	S	T
U	V	W	X	Y	Z				

Table 3 Set of Bangla and English digits

০	১	২	৩	৪	৫	৬	৭	৮	৯
0	1	2	3	4	5	6	7	8	9

4.7 System Architecture

The image input layer accepts handwritten character images in Bangla and English with a dimension of 80 * 80 * 1.

Preprocessing the inputs is required for every model to provide the images a consistent form before feeding to any classifier [1]. All of the images were transformed to 32 * 32 pixels.

In the first convolutional layer, the input pictures are padded by zero padding of size 1. After that, eight 3 * 3 * 1 kernels were used to extract eight different characteristics. The convolution operation formula is if the kernel has m rows and n columns (Fig. 2).

$$Z\,(x,\ y)\ =\ \sum\ \sum\ (i,\ )ni\ =\ 1mj\ =\ 1\ I\ (x\ -\ i)(y\ -\ j)$$

We get a 32 * 32 * 8 feature map by stacking the activation maps. The ReLU layer is then applied to our feature map. We used the ReLU activation function to ensure positive values as,

$$f\,(x)\ =\ \begin{cases} x, x \geq 0 \\ 0, x \leq 0 \end{cases}$$

System then uses a max-pooling layer with a kernel size of 2 * 2. If the kernel size is P * P, it will cover an area A of the feature map with dimension P * P.

The 1st layer's features are then supplied to the 2nd convolutional layer, which is subsequently fed to the 3rd convolutional layer. The flattened feature map is now given to the fully connected layer. The soft-max layer determines the probability of each of the predefined character classes.

Eventually, a classification layer follows the soft-max layer. A single epoch of the training process is now complete.

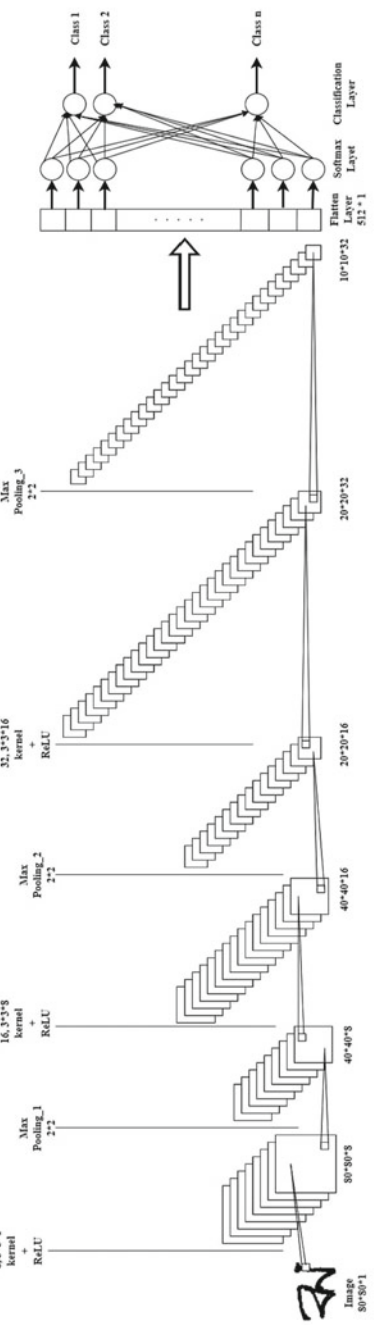


Fig. 2 Architecture of convolutional neural network

4.8 Working Sequence of the System

In the system, the author works with both Bangla and English characters. But compared to English, Bangla is very much more versatile. The recognition process is relatively difficult due to their diversity in shape and size. But using CNN, every image is classified into layers and the system easily predicts the letter or digit (Fig. 3).

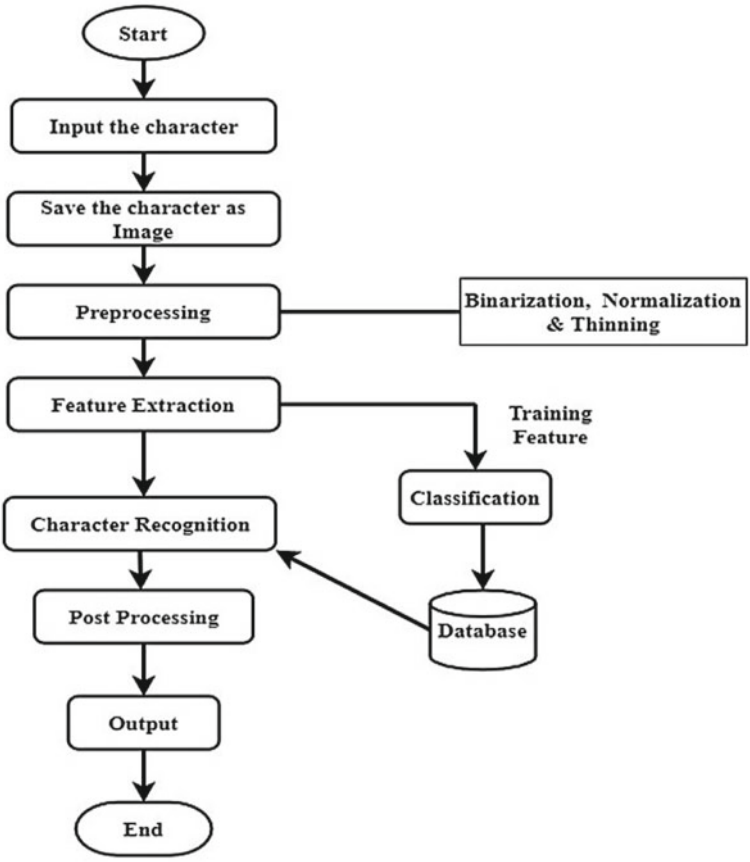


Fig. 3 Flowchart of the system

5 Result and Discussion

5.1 Analysis and Comparison

Python 3 is used to implement the recommended approach. The input can be an alphabet, a number, or a Bangla character. The data is preprocessed, scaled, and standardized before being fed into the CNN classifier. Because the CNN classifier is trained on the dataset, it can predict the input character.

The following table gives the comparison between some previous work. From this table, we found that our system combined Bangla and English character (Table 4).

We used 75% of the data from each class to create the training set, and 25% of the samples from each class to conduct the testing. We achieved a loss of 0.5579 when we used the CNN model on handwritten characters. After ten epochs, we had an accuracy of 85.96 percent. The accuracy percentages suggest that our model was properly trained with the training set (Fig. 4).

After analyzing the results, the author got some misclassified characters from our validation set. The model performed well for classifying characters. But several mistakes can also be made by humans. Majority of the erroneous classifications are driven by errors in labeling. Owing to the vast deviation in writing patterns, such character images are challenging to classify, even by humans.

Table 4 Comparison between different system

Index	Work	Accuracy (%)
1	Convolutional neural network used for Bangla handwritten character recognition	85.36
2	Use extended CNN method for recognized Bangla character	92.25
3	Artificial intelligence neural network and image processing used for handwriting recognition	83.40
4	BornoNet: Bangla handwritten characters recognition 95.71% using convolutional neural network	95.71
5	Handwritten character recognition from image using CNN	85.96

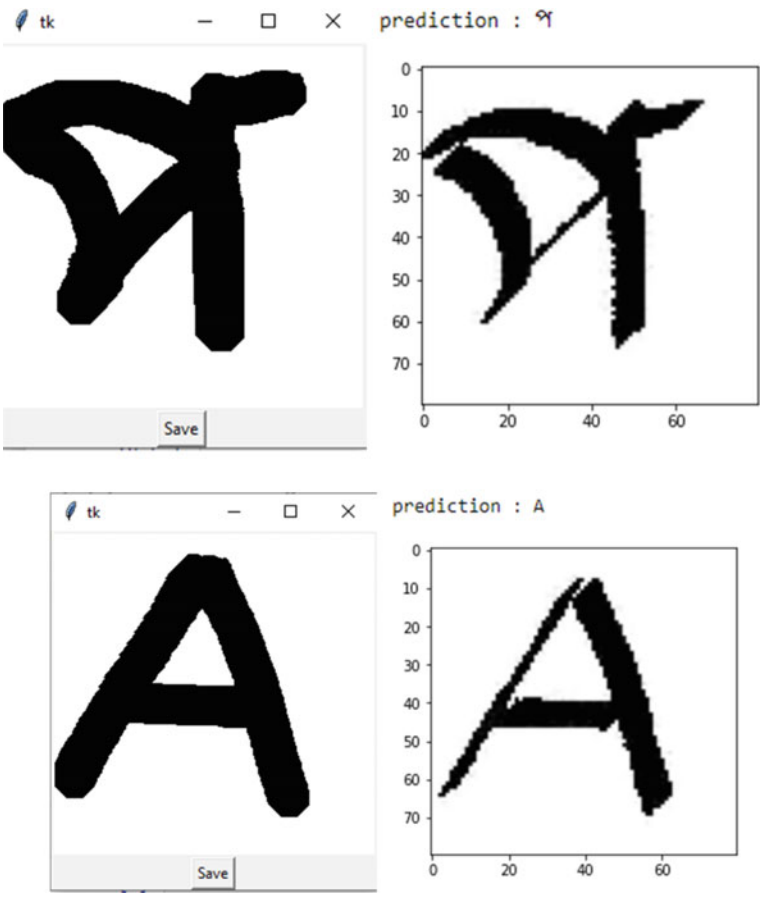


Fig. 4 Input and output

6 Summary

Many regional languages around the world have distinct writing styles that HCR systems may identify with the right algorithm and methodology. According to this paper, the existence of unusual characters or similar shapes for many characters makes handwritten character identification difficult. A cleaned image is created by preprocessing the scanned image. Normalization and filtration are performed, utilizing preprocessing techniques to provide a noise-free and clean output. Managing our evolution algorithm with correct training, evaluation, and other step-by-step processes will result in a successful system output with improved efficiency.

6.1 Future Scope

In this research, the author combined both Bangla and English characters, for which we had to work with a huge dataset. The versatility of the shapes of each character made the model more complex. But we tackle the problem smoothly. The model became confused when attempting to understand overwritten characters, and the system failed to recognize the character. In the future work, it should be done to fix the dataset and overcome the limitation of overwriting characters. Creating a baseline model for handwritten characters, including numerals, basic characters, modifiers, and compound letters, is trying to set audio for each character.

7 Conclusion

The primary goal of this study was to develop a system that would help in the classification and recognition of handwriting characters and numbers. In digital world, the ability to recognize characters and numbers is crucial. Convolutional neural networks (CNNs) can recognize visual patterns directly from pixel images with little preparation. As a result, in this study, a CNN structure is studied without any feature selection for Bangla and English handwritten pattern classification. The approach was evaluated on a huge handwritten character dataset, and the results were compared to other popular Bangla or English methods. On a standard dataset, we tested the performance of CNN with a dropout and several filters.

References

1. Das, T. R., et al. (2021). Bangla handwritten character recognition using extended convolutional neural network. *Journal of Computer and Communications 9*(3), 158–171.
2. Rahman, M. M., Akhand, M. A. H., Islam, S., Shill, P. C., & Rahman, M. H. (2015). Bangla handwritten character recognition using convolutional neural network. *International Journal of Image, Graphics and Signal Processing, 7*(8), 42.
3. Aqab, S., & Tariq, M. U. (2020). Handwriting recognition using artificial intelligence neural network and image processing. *International Journal of Advanced Computer Science and Applications 11*(7), 137–146.
4. Alom, M. Z., Sidike, P., Hasan, M., Taha, T. M., & Asari, V. K. (2018). Handwritten Bangla character recognition using the state-of-the-art deep convolutional neural networks. *Computational Intelligence and Neuroscience, 2018*, 13 pages, Article ID 6747098
5. Dholakia, K. (2015). A survey on handwritten character recognition techniques for various Indian languages. *International Journal of Computer Applications, 115*(1).
6. Chakraborty, P., Ahmed, S., Yousuf, M. A., Azad, A., Alyami, S. A., & Moni, M. A. (2021). A human-robot interaction system calculating visual focus of human's attention level. IEEE Access.
7. Chakraborty, P., Yousuf, M. A., Rahman, M. Z., & Faruqui, N. (2020). How can a robot calculate the level of visual focus of human's attention. In: *Proceedings of International Joint Conference on Computational Intelligence* (pp. 329–342). Springer.

8. Chakraborty, P., Muzammel, C. S., Khatun, M., Islam, S. F., & Rahman, S. (2020). Automatic student attendance system using face recognition. *International Journal of Engineering and Advanced Technology (IJEAT), 9*, 93–99.
9. Sayeed, S., Sultana, F., Chakraborty, P., & Yousuf, M. A. (2021). Assessment of eyeball movement and head movement detection based on reading. *Recent Trends in Signal and Image Processing: ISSIP 2020 1333*, 95.
10. Chakraborty, P., Yousuf, M. A., & Rahman, S. (2021). Predicting level of visual focus of human's attention using machine learning approaches. In *Proceedings of International Conference on Trends in Computational and Cognitive Engineering* (pp. 683–694). Springer.
11. Muzammel, C. S., Chakraborty, P., Akram, M. N., Ahammad, K., & Mohibullah, M. (2020). Zero-shot learning to detect object instances from unknown image sources. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 9*(4), 988–991.
12. Sultana, M., Ahmed, T., Chakraborty, P., Khatun, M., Hasan, M. R., & Uddin, M. S. (2020). Object detection using template and hog feature matching. *International Journal of Advanced Computer Science and Applications 11*(7) (2020). https://doi.org/10.14569/IJACSA.2020.0110730
13. Faruque, M. A., Rahman, S., Chakraborty, P., Choudhury, T., Um, J. S., & Singh, T. P. (2021). Ascertaining polarity of public opinions on Bangladesh cricket using machine learning techniques. *Spatial Information Research*, 1–8.
14. Sarker, A., Chakraborty, P., Sha, S. S., Khatun, M., Hasan, M. R., & Banerjee, K. (2020). Improvised technique for analyzing data and detecting terrorist attack using machine learning approach based on twitter data. *Journal of Computer and Communications, 8*(7), 50–62.
15. Ahammad, K., Shawon, J. A. B., Chakraborty, P., Islam, M. J., & Islam, S.: Recognizing Bengali sign language gestures for digits in real time using convolutional neural network. *International Journal of Computer Science and Information Security (IJCSIS) 19*(1).
16. Sultana, M., Chakraborty, P., & Choudhury, T. (2022). Bengali abstractive news summarization using Seq2Seq learning with attention. In *Cyber Intelligence and Information Retrieval* (pp. 279–289). Springer, Singapore.
17. Ahmed, M., Chakraborty, P., & Choudhury, T. (2022). Bangla document categorization using deep RNN model with attention mechanism. In: *Cyber Intelligence and Information Retrieval* (pp. 137–147). Springer, Singapore.
18. Chowdhury, R. R., Hossain, M. S., ul Islam, R., Andersson, K., & Hossain, S. (2019). Bangla handwritten character recognition using convolutional neural network with data augmentation. In *2019 Joint 8th International Conference on Informatics, Electronics & Vision (ICIEV) and 2019 3rd International Conference on Imaging, Vision & Pattern Recognition (icIVPR), Spokane, 30 May-2 June 2019*, pp. 318–323.
19. Chakraborty, P., Rakib Mia, M., Sumon, H. K., Sarker, A., Imtiaz, A., Mahbubur Rahman, M., ... & Choudhury, T. (2022). Recognize meaningful words and idioms from the images based on OCR tesseract engine and NLTK. In *Pattern Recognition and Data Analysis with Applications* (pp. 297–310). Singapore: Springer Nature Singapore.
20. Chakraborty, P., Islam, A., Abu Yousuf, M., Agarwal, R., & Choudhury, T. (2022). Bangla handwritten character recognition using convolutional neural network. In *Machine Intelligence and Data Science Applications: Proceedings of MIDAS 2021* (pp. 721–731). Singapore: Springer Nature Singapore.
21. Kishan, Anandh, S., Clinton David, J., Sharon Femi, P. (2018). Handwritten character recognition using CNN.

Traffic Scenarios and Vision Used Cases for the Visually Impaired Clients

Bhoopesh Chaudhary, Vipin Rawat, Prateek Kumar, and Manisha Vashisht

Abstract The modern technology generates issues for visually impaired people as well as provides the solution. Independent adaptation involves various difficulties in individuals with visual impairment or blindness (VIB). Most phones are available for people with VIB who use open applications in electronic stores. Few uses support the free movement of VIB clients on safe transit across the street. Road signage disclosure and verification (TSDR) is a cross-examination of VIB populations. Existing research offers a variety of strategies for spotting a road sign in an open road area. However, the building did not see the road sign clearly. This inspection solved the issue of road sign verification to help VIB people to cross the road safely. Traffic ID and verification ID are achieved using the novel random gradient succession with momentum (RGSM), which extracts part of the novel shape. Finally, the CNN section will be used to edit pre-programmed result margins, which, in turn, convert over a traffic signal into an audio signal in both the editing phase and the test phase. Results are tested for exhibiting gauges such as accuracy, identity, accuracy, F grade, Jaccard coefficient, kappa, and dice coefficient. The results trial shows the most common improvement at this limit in distinguishing the proposed structure from the current methods. The proposed road signage identification framework includes a strong sign that communicates and extends partial releases and application submissions. The proposed game plan solves obstacles that are clearly perceived by sections of the disabled community to facilitate independence. Facilities for visually impaired are available but few support the free movement of such section traffic sign detection can aid free and safe movement of visually impaired people across streets and roads. They are providing them assistance as well.

Keywords Advance driver assistance system (ADAS) · Lane departure warning system (LDWS) · Support vector machine (SVM) · Global positioning system (GPS)

B. Chaudhary (✉) · V. Rawat · P. Kumar · M. Vashisht
Manav Rachna International Institute of Research and Studies, Faridabad 121003, India
e-mail: bhoopesh7838@gmail.com

M. Vashisht
e-mail: manisha.fet@mriu.edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_5

1 Introduction

According to the World Health Organization (WHO) [1], 254 million people are tested to see if they are properly connected. Despite the decline in quality of life and opportunity, visual impairment causes a one-size-fits-all decrease. We are moving the PC vision parameters from Advanced Driver Assistance Systems (ADAS) to a seemingly blocked road client to remedy this. But other ID item tests in the gridlock cases of busy time are clearly weak, there is a very high proportion of research in the ADAS field [2, 3]. After this, it makes sense to benefit from the advancement of driver assistance and make it ideal for people who appear to be weak on foot. However, the idea of trading is important when considering how the rates will not move without any changes. Therefore, we collect cases where obviously disabled customers need support. We do this by driving circles, always looking up by checking the traffic conditions of those who are normally blocked. In circles, we use techniques from human science, especially ace meetings using a cantered communication method. We are focussing on advancing the current system as the ADAS has certain flaws which can be covered by SVM. As shown in Fig. 1, it is a basic terminology how a basic SVM and ADAS work [4].

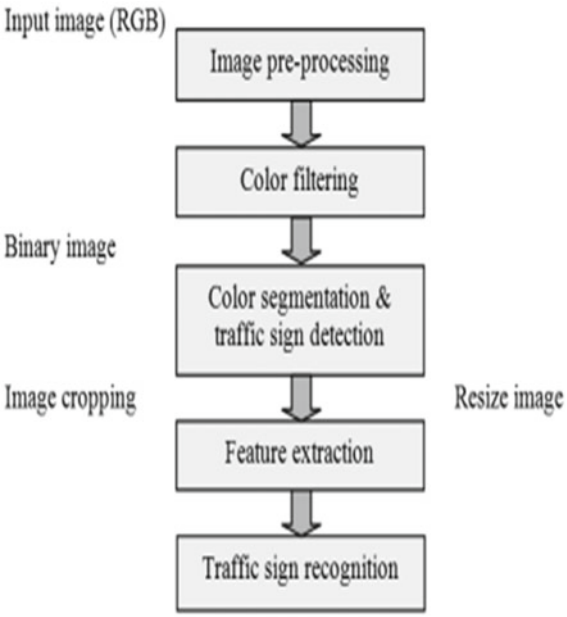


Fig. 1 Basic image recognition

2 Methodology

In any case, we filter out why we are leading the ace meet and look at the selected interview release strategy.

2.1 Expert Interviews

Professional meetings' hallmark is covering important issues that people who seem to be declining apparently face in busy situations. In addition, we analyse traffic situations where a camera-based assistance system may provide assistance to road customers who may not be able to operate transparently. In dealing with the same thing, we portray professionals as people who are honestly connected with a skill or hard work who are sensitive to the various interactions of people who are obviously disabled in terms of age, direction, and degree of failure [5]. As a procedure for professional meetings, we suggest that we issue cheaper discussions the way it is resolved between account discussions and integrated rule. During the meeting, the occurrence of requests is addressed to the dynamic accomplishment of the conversation between the interviewee and the examiner [6].

2.2 Interview Guideline

We create a standard as a study of the collection of four required interview materials:

1. Acceptance and definition of our assessment.
2. Safety mode: Includes a game planner for the person being interviewed for recording and recording.
3. Brief survey: Gather information about the person interviewed (age, direction, calling) and clearly weak contact people (age distribution, types of visual deficits, developmental discrimination).
4. Traffic situations: At the outset, we would like to ask the interviewee to mention three things that greatly affect the weak people who are experiencing it during busy times and we expect there to be differences in the issues of people of different ages, directions, and levels of incontinence. By resolving problems, the interviewer often shows unexpected news interviews [7].
5. Postscript.

3 Current Situation of Visually Impaired Road Users

This section introduces the evaluation of integrated professional meetings and shows traffic conditions that we have removed from circles. Six instances were found in

these circles. They can be grouped into three characters: portable situations (common topic, local investigation), viewer situations (crossing the road, avoiding blocks), and public transport conditions (boarding car, train station) [8].

For our further analysis, we are based on determined use cases. We see that there are two usage scenarios associated with broader scenarios: traffic sign recovery and TGGS. Acquisition of traffic signs is equally prone to ADAS and because of its importance and flexibility, it is the main method of use from ADAS. The OCR and departmental acquisition are interested in the topic and conditions of the open vehicle, however, it is not discussed in ADAS. At the same time, there are no cases of ADAS used in the subject or conditions of a public vehicle, but in and out of reference, it refers to the acquisition of traffic signs. In the same way with circumstances, however, there is a large number and a large number of cases associated with the ADAS agreement [9].

Current issues faced by visually impaired are as follows:

3.1 Portable situations (local and common topic investigation).
3.2 Viewer situations (crossing road, terrain, blocks, obstacles, etc.)
3.3 Public transport (boarding and deboarding a car, train, or any public vehicle).

Such problems can be faced due to weather conditions, irregular sign boards' wear and tear shapes, poor lighting, or any unexpected scenarios (e.g. tesla detected a horse kart as a human as well as a car). A vast number of cases associated with ADAS can be studied for further reference. We can assume certain cases as a general example:

Case 1: A visually impaired person is easily lost due to their lack of awareness which can stress them out easily thus they need a fully fledged system to make them aware about their surroundings and their destination. Thus, it leads to the development of apps and mobile devices to aid in this situation where they cannot navigate easily and also announce the characteristics of their surroundings to protect them from falling tripping and even any major mishap in case of elderly visually impaired. The data needs to be updated simultaneously and regularly because if not updated, the app or device may guide the person through the data in the database and can cause discomfort for the customer.

Case 2: In this case, a visually impaired person must find a way to the entrances or either question someone for the directions to it and even verify that they are entering the right spot (entrance) or not. In this, it is pre-determined that the visually impaired needs to navigate to a certain location. The apps and ADAS and SVM system supported by GPS may enable an easier navigation to the spot or the address. In this system, there is a large variety of flaws like the problem of navigation, i.e. the connection to database may be interrupted or the entrances to the building they want to enter may not be specified. The case means if a person visits hospital, they need to recognise the hospital road sign in order to navigate to its entrance for this vision use case we need Traffic sign detection for visually impaired.

Case 3: In this case, if a person needs to cross a busy road in order to make that possible the recognition system needs to detect the zebra crossing and the traffic light system (when the light goes red, green, and yellow). The impaired person either

needs someone's assistance to cross the road or need someone to tell where the zebra crossing is and when does the light goes green. The customer may be unsure about the condition of road, i.e. the width the traffic density and the relay distance. Traffic light detection and crossing detection play an important role in such cases. We also need to define a system which detects the light state at real time so that the person knows when to cross.

Case 4: When crossing a road, the traffic density is a great threat for visually impaired people. The roads are not always empty the density of road varies on the conditions like traffic light state and working hours of the vicinity. What if the traffic light goes down due to any reason like weather condition or power cut the device will not be able to detect the signal when to cross the road thus need to measure the density of the traffic in region. Overall, the system needs to detect any mobile vehicle and signal if none so that all the conditions are met and person will be able to cross the road with all precautions and safety guidelines.

Case 5: Obstacles may act as a major issue because they may interrupt the basic path of the person and delay the flow of operation. Moreover, the impaired may lose the direction they were walking, causing discomfort. The visually impaired person needs to keep a watch of surroundings while even walking on a side walk in order to prevent any obstacles they may collide into like rocks and other human beings. Currently, such scenarios have been avoided by much physical means that are guide dogs and white cane (sticks). In the worst case, a guide dog can run off and a stick may fall causing the impaired person unable to even move or even find the lost asset. The sense of direction and obstacle avoidance is a major issue in such cases.

Case 6: Public transport can be another issue for visually impaired like if a person wants to board a bus, he/she needs to reach the bus stop in order to catch a bus. The person waits for the bus to arrive generally at the entrance not in case of impaired vision. In the worst case scenario, the client might not be able to navigate the bus stop. They might not know the entrance of the vehicle and can even face the wrong direction. The traffic sign detection works for the detection of bus stop signs and GPS also enables to navigate the client to nearest bus stand.

Case 7: In case of public transport vehicles like trains and trams, it is difficult to navigate a station and board the transport as the application needs to detect the track and public density to prevent any mishap. If not standing at an appropriate position, the client may trip over on the track and suffer fatal loss. The person needs to know which platform they need to be at and when to board. Such cases can be resolved using ADAS, GPS, and text to speech recognition.

4 Advance Driver Assistance System (ADAS)

Automatic vehicles and machines are all set and ready to operate along the roads. Autonomous machines and devices use ADAS to move or drive/assist the movement of a person or a vehicle. Not only for visually impaired people but also for autonomous

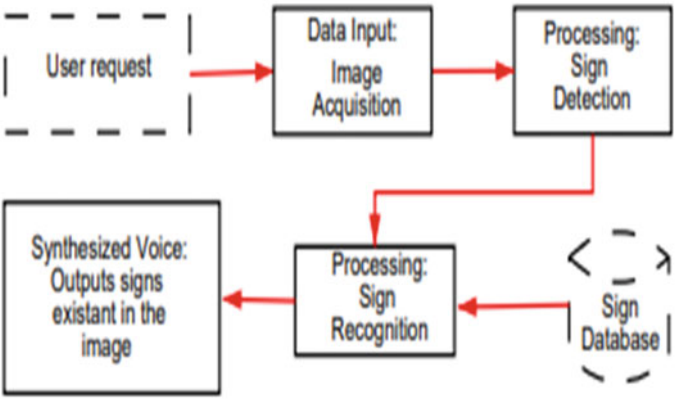


Fig. 2 ADAS block diagram

vehicles it is difficult to identify the traffic signs and analyse the obstacles. Missing a crucial sign or obstacle can cause fatal damage or accidents hence cannot be ignored.

But even after the usage of autonomous assistance system using an integrated camera due to some of the reasons, the detection system misses out on some traffic signs:

1. Poor Illumination-Poor lighting either on the road on over the streets or footpaths can cause ADAS to fail in the process of image capturing and lead to a hazard.
2. Traffic Density-The traffic available over the roads can lead to inability of the system to recognize the signs properly.
3. Lack of concentration-The focus of cameras may vary at distances and lead to generation of pixelated images thus causing failure in ADAS system.

The ADAS algorithm includes steps as shown in Fig. 2.

1. User request-This step focusses on the request generated by user or even automatic request focusing on the visually impaired.
2. Data Input-The cameras based on user request either manual or automatic captures the images of traffic signs.
3. Processing Signs-Then, the automated system focusses on the road sign by the process called pre-processing and generates a boundary around the specific road sign.
4. Post-processing or analysis-Then, the pre-processed image is compared to the road sign database.

For example, use ADAs system in automated cars. In this, a camera is fitted on the roof of the car or on the dash board to provide a clear view of the surroundings and captures as refined images as possible.

Now, after capturing the images or the image acquisition, it follows 4 basic steps [10, 11].

1. Pre-processing
2. Detection
3. Recognition (i.e. comparing database)
4. And transmission.

5 Support Vector Machine (SVM)

Support Vector Machine (SVM): It is basically machine learning model with self-learning capabilities and real-time processing. Basically, SVM has an external storage for database in which it compares the sign in real time and also saves new results for further reference. SVM is helpful for text and hypertext categorisation thus making it easier to process the image and even faster. It works on vector spectrum, i.e. divides the image into vectors of colours and compares each vector to data stored in database. If the vectors cannot be recognized, it saves them for future reference.

Algorithm of SVM works on 4 steps-[10]

1. Data acquisition
2. Pre-processing
3. Feature extraction (using vector distribution)
4. Comparing them to database.

The following block diagram Fig. 3 as of article [12, 13] from references has been given by Lin Hao which is based on the SVM vector detection method for pattern recognition used average speed as the situation indicator.

It is used for congestion detection and traffic paralysis. First of all, the traffic flow data is collected then the parameters are selected as per the user requirement; the SVM then generates vector and pattern is selected as per the recognized model, and the parameters are then optimized by training pattern recognition model and then the patterns which are recognized are then tested by the vector images that have been stored in the database. The vector uses the image capturing function for each and every colour which is displayed on the sign boards and generates the output and then displays it as per the user requirement. The vector finally stimulates the congestion and helps the user to drive within the congestion using ADAS and SVM.

If the output generated is not present in the database, the machine learning assists to store the unrecognized data for future reference.

6 Solutions from ADAS

We first investigated the ADAS route acquisition plans and considered possible door openings to assist visually disabled people. With these lines, we provide the ADAS deals with additional cover cases.

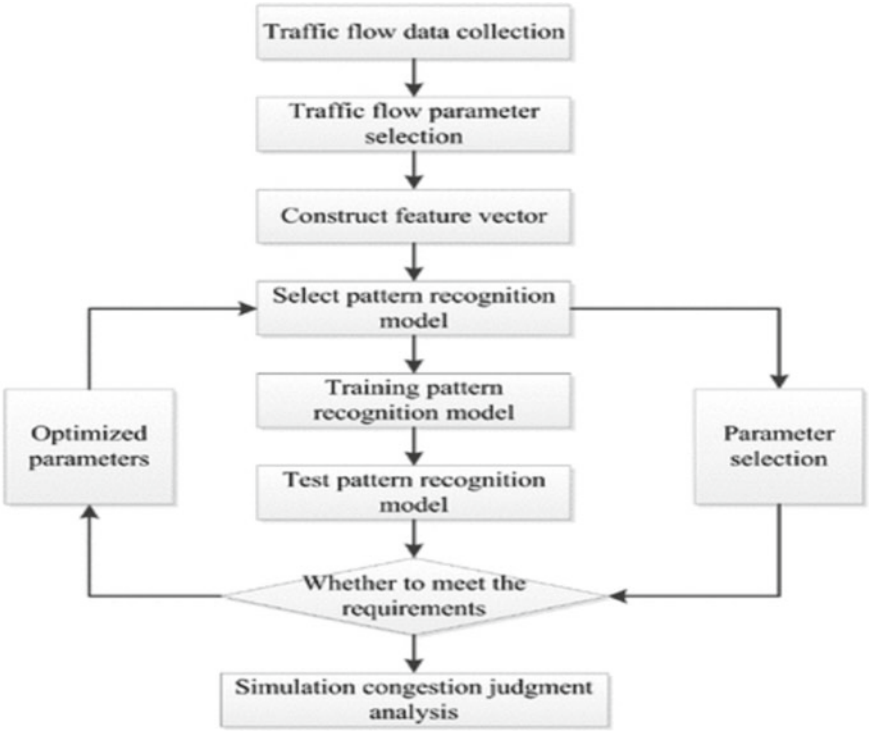


Fig. 3 Algorithm of SVM

As the current image detection and recognition system are flawed, we can improve the system by combining both ADAS and SVM. Keeping a physical watch over, the condition of the road signs and lighting to confirm that the images captured can be easily analysed and accessed by the ADAS system.

6.1 Route Detection

To explore the case of using lane detection for the driver and apparently blocked the viewer's route, we really want to consider the different situations in which the lane detection calculation can keep clients. For driver assistance, the central application is the Traffic Warning System (LDWS), which measures whether the vehicle's reception is in the correct position. Experts interviewed point out one situation in which lane detection can keep people who appear to be disabled from walking: crossing a road can be difficult if they are aware of a road-sized experience and then admit that there is a very attractive section. In additional circles with people from the goal

gathering group, the term was coined: normal carrying can be improved by knowing the previous route (e.g. twists).

6.2 Other Use Cases

Verification of traffic signals always involves two squares: disclosure and exposure. Similarly, the following is used to combine the validation level. In order to be accepted, there are one-way approaches that are considered diversity and position and then later AI approaches, for example, processing vector support equipment (SVM). Following the visual signals of the Kalman channels is worth careful attention to a few points. For example, the following can be used to combine the results of a revelation from different houses or to discard the effects not found in the middle edges. Since the traffic signal game system is a problem for a standard article application, corresponding statistics are used. Following partial release, SVM, neural networks, and various techniques are used. Since road signs that indicate access routes are often excused systems verification systems will solve this problem.

Vehicle acquisition in metropolitan areas suitable for the various areas where the vehicle is being recorded, presented to it. The paper additionally contains a haemodialysis test to identify a vision-based vehicle. Vehicle acquisition should be seen as part of obstacle obstruction, as the various blockchain progression in ADAS surrounds the fixed object environment. Apart from cars, pedestrians and bicycles were spotted. Previous data regarding restriction area, variability, and shape is used to suit models.

7 Future Work and Conclusion

7.1 Future Work

As the basis for our future research, it is fundamental to collect appropriate perspective conditions that may keep road clients who appear disabled and equally prone to ADAS. Next, we examine the more outspoken conversations with people who are obviously weak around their self-esteem. Preliminary reviews indicate that the results of this paper will be reported and expanded to specific institutions. In order to evaluate existing ADAS ratings and adapt to the changes introduced in the area of damaged traffic customers, comparable video test game systems are required. To achieve this, we created frameworks to improve coverage operating conditions from the driver and standard view. In each case, they have seized it, despite obstacles, we can scarcely imagine. Future work in the following field includes converting the recognized text and traffic signs to voice commands detected and analysed by combining ADAS and SVM system. As the basis for our future research, it is fundamental to collect

appropriate perspective conditions that may keep road clients who appear disabled and equally prone to road accidents. We can use text to speech synthesizer which lets the AI-based devices to convey the detected signs to visually impaired people.

7.2 Conclusion

The following research paper focusses on the combination of two current existing system to improve the traffic sign detection for VIB, i.e. combining ADAS and SVM and the existing solutions for the following set of problems have been researched thoroughly and have been analysed to generate a feasible model that can be used for the visually impaired people and implement the following in hardware devices. The model hence produces the voice commands after detecting and recognizing the traffic signals that can be used by the visually impaired as an aid for recognizing the traffic signs.

References

1. Sachan, S., Sharma, R., & Sehgal, A. (2021). Energy efficient scheme for better connectivity in sustainable mobile wireless sensor networks. *Sustainable Computing: Informatics and Systems, 30*, 100504.
2. Azad, C., Bhushan, B., Sharma, R., et al. (2021). Prediction model using SMOTE, genetic algorithm and decision tree (PMSGD) for classification of diabetes mellitus. *Multimedia Systems*. https://doi.org/10.1007/s00530-021-00817-2
3. Singh, R., Sharma, R., Akram, S. V., Gehlot, A., Buddhi, D., Malik, P. K., & Arya, R. (2021). Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. *Safety Science, 143*, 105407. ISSN 0925-7535.
4. Ghanem, S., Kanungo, P., Panda, G., et al. (2021). Lane detection under artificial colored light in tunnels and on highways: An IoT-based framework for smart city infrastructure. *Complex and Intelligent Systems*. https://doi.org/10.1007/s40747-021-00381-2
5. Sahu, L., Sharma, R., Sahu, I., Das, M., Sahu, B., & Kumar, R. (2021). Efficient detection of Parkinson's disease using deep learning techniques over medical data. *Expert Systems*, e12787. https://doi.org/10.1111/exsy.12787
6. Sharma, R., Kumar, R., Sharma, D. K., et al. (2021). Water pollution examination through quality analysis of different rivers: A case study in India. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-021-01777-3
7. Ha, D. H., Nguyen, P. T., Costache, R., et al. (2021). Quadratic discriminant analysis based ensemble machine learning models for groundwater potential modeling and mapping. *Water Resources Management*. https://doi.org/10.1007/s11269-021-02957-6
8. Dhiman, G., & Sharma, R. (2021). SHANN: An IoT and machine-learning-assisted edge cross-layered routing protocol using spotted hyena optimizer. *Complex and Intelligent Systems*. https://doi.org/10.1007/s40747-021-00578-5
9. Sharma, R., Gupta, D., Polkowski, Z., & Peng, S.-L. (2021). Introduction to the special section on big data analytics and deep learning approaches for 5G and 6G communication networks (VSI-5g6g). *Computers & Electrical Engineering, 95*, 107507. ISSN 0045-7906. https://doi.org/10.1016/j.compeleceng.2021.107507

10. Sachan, S., Sharma, R., & Sehgal, A. (2021). SINR based energy optimization schemes for 5G vehicular sensor networks. *Wireless Personal Communications*. https://doi.org/10.1007/s11277-021-08561-6
11. Priyadarshini, I., Mohanty, P., Kumar, R., et al. (2021). A study on the sentiments and psychology of twitter users during COVID-19 lockdown period. *Multimedia Tools and Applications*. https://doi.org/10.1007/s11042-021-11004-w
12. Priyadarshini, I., Kumar, R., Tuan, L. M. et al. (2021). A new enhanced cyber security framework for medical cyber physical systems. *SICS Software-Intensive Cyber-Physical Systems*. https://doi.org/10.1007/s00450-021-00427-3
13. Priyadarshini, I., Kumar, R., Sharma, R., Kumar Singh, P., & Satapathy, S. C. (2021). Identifying cyber insecurities in trustworthy space and energy sector for smart grids. *Computers and Electrical Engineering, 93*, 107204.

Statistical Analysis in Indian Banking Industry

Himani Bansal, Ritu Agarwal, Tanupriya Choudhury, Bikram Pratim Bhuyan, Ravi Tomar, and Gaurica Puri

Abstract In the monetary framework, banks assume a significant part and their reality is basic to the strength of the economy. Banking organizations had played a huge effect in the financial improvement of India since the country's freedom in 1947. The financial area controls the greater part of the country's monetary resources, laying out it as the prevailing power in the country's monetary business sectors. Banks in India are encountering huge changes because of the monetary area changes that are being executed dynamically the country over. This examination work means fostering an effective and sufficient model for the financial business in India using a measurable technique in light of the major proportions. It gives a concise measurable investigation of the twelve bank-explicit factors for every 22 banks. It concentrates on the hole in monetary execution between various banks by doing a similar concentrate on the relapse strategies.

H. Bansal, R. Agarwal, T. Choudhury, B. P. Bhuyan, R. Tomar and G. Puri:: These authors contributed equally to this work.

H. Bansal · T. Choudhury (✉) · G. Puri
Informatics Cluster, School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand 248007, India
e-mail: bansal.himani820@gmail.com

R. Agarwal
Raj Kumar Goel Institute of Technology, Ghaziabad, Uttar Pradesh 201003, India
e-mail: agarwalritu7@gmail.com

T. Choudhury
Graphic Era Hill University, Dehradun, Uttarakhand 248002, India
e-mail: tanupriya1986@gmail.com

B. P. Bhuyan
LISV Laboratory, University of Paris Saclay, 10-12 Avenue of Europe, 78140 Velizy, France

School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttrakhand 248007, India
e-mail: bikram-pratim.bhuyan@universite-paris-saclay.fr; bikram23bhuyan@gmail.com

R. Tomar
Persistent Systems, Pune 411057, India
e-mail: ravitomar7@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_6

Keywords Fundamental ratios · Statistical analysis · Banking sector · Regression · Indian market

1 Introduction

In this day and age, each economy is unequivocally dependent on monetary development, it is a significant underlying part of the monetary area and expects a critical part in the legitimate running of any economy. Trade, industry, and farming should be supported with additional commitment and obligation since they are basic parts of a country's financial advancement. Thus, the improvement of a nation is personally connected to the extension of monetary services [1]. As part of the current economy, banks are no longer merely considered money merchants; they are now considered to be development leaders. Branches of financial institutions serve an important role in soliciting deposits and disbursing loans to a diverse variety of companies and sectors. What is happening in the economy is mirrored in what is happening in the financial system. The strength and efficiency of an economy's financial system are reliant on the existence of a sound and solvent banking system, which in turn is dependent on the existence of a strong and efficient financial sector. In the case of a financial crisis, a solvent banking system ensures that the bank will be able to meet its commitments to its depositors as soon as possible. While the ongoing change process is in progress, Indian banking addresses a chance to change into major areas of strength for a, and energetic area that can execute its capabilities proficiently and really without placing excessive expectations on government [2]. The overall financial emergency in 2007–2008 has brought to the consideration of policymakers a large number of worries relating to the proficiency and dissolvability of the financial business which was again hit by COVID-19 [3, 4], in addition to other things. Endeavors are being made by the Indian government and the Reserve Bank of India (RBI) to draw examples from the emergency as it reaches a resolution. The RBI has been changing its strategies to keep up with the steadiness of the economy's estimating level. Different changes are being pursued to expand the proficiency of the financial region in general as well as the productivity of individual foundations. Accordingly, it is important that Indian banks be assessed to execute restorative moves toward work on the all-around well-being of the banking area [5]. This construction of paper continues as we play out a short writing survey of the subject, then make sense of the wordings with the legitimate conventional portrayal. We gather the information for the Indian financial industry and afterward perform a factual investigation on the equivalent at last we close the exploration with a future objective.

2 Literature Review

the central investigation takes a gander at an organization's monetary standing, its workers, its overseeing body, its money related status, its year report, its assest sheets, its pay proclamations, as well as its geological and climatic circumstances, like catastrophic events and political data [6]. Key examination utilizing measurements

is carried out widely in research [7]. As to the Indian financial area, different articles are distributed so far [8–11]. A factual relative examination between two Indian banks was seen in [12]. The gathered manner of thinking of this study is to mine and analyze the data of one of the vitally confidential Indian bank. AI calculations were completely used to foresee the future worth of Infosys and Reliance, with the prescient rate expanding if the different exchanging boundaries were tended to as deterministic example data instead of as an irregular conveyance [13]. Statistics in Russian banking sector was analyzed in [14] and similar analysis in Kenya, Palestine, and Ukrain is seen [15–17]. Analysis in balance sheet figures for micro decision was made in [18]. A proper statistical analysis for the Indian banking sector is yet to be perused.

3 Terminologies

We present a few terminologies beforehand for the smooth flow of the paper. The symbols used for the same are shown in Table 1.

3.1 Financial Ratios in Banking Sector

3.1.1 Price-to-Earnings Ratio (P/E)

The price-to-earnings proportion (P/E proportion) is the proportion of an organization's ongoing securities exchange worth to its earnings per share (EPS). Benefit multiplier and worth multiplier are different terms used to depict the P/E proportion. Officially,

$$\text{P/E} = \frac{\text{SP}}{\text{EPS}} \tag{1}$$

3.1.2 Return on Capital Employed (ROCE)

It is a proficiency degree, which works out how successfully an association is using making benefits capital. The benefit from capital used estimation is seen as one of the most astonishing advantage extents and is regularly used by monetary supporters to choose if an association is sensible to place assets into or not. Officially,

$$\text{ROCE} = \frac{\text{EBIT}}{\text{CE}} \tag{2}$$

Table 1 Symbols used

Symbols used in the article	
Symbol	Definition
P/E	Price-to-earnings ratio
SP	Share price
EPS	Earnings per share
$ROCE$	Return on capital employed
$EBIT$	Earnings before interest and tax
CE	Capital employed
ROE	Return on equity
NI	Net income
SE	Share holder's equity
P/B	Price to book
CAR	Capital adequancy ratio
$MPPS$	Market price per share
$BVPS$	Book value per share
$CASA$	Current and savings account
$AOCS$	Average outstanding commonshare
BC	Bank's capital
OS	Operating costs
OI	Operating income
D	CASA deposits
TD	Total deposits
RWA	Risks weighted assets
PD	Provisions related to unpaid debt

3.1.3 Return on Equity (ROE)

The return on equity is an extent of the advantage of a business as per the equity. Since an investor's value is to be determined by taking all resources and deducting all liabilities, ROE is a profit from resources with fewer liabilities. Formally,

$$\text{ROE} = \frac{\text{NI}}{\text{SE}} \tag{3}$$

3.1.4 Price to Book (P/B)

The Price to book, or P/B proportion, is a financial extent used to differentiate an association's current market value with its book value. The price-to-book (P/B) proportion has been leaned toward by esteem financial backers for quite a long time and is generally utilized by market examiners. Customarily, any worth under 1.0 is

viewed as a decent P/B value, showing a possibly underestimated stock. Formally,

$$\text{P/B} = \frac{\text{MPPS}}{\text{BVPS}} \tag{4}$$

3.1.5 Current and Savings Account (CASA)

The CASA ratio denotes the ratio of checking to savings accounts. To calculate a bank's CASA ratio, sum up the number of accounts in the bank's current and savings records. The CASA percentage is concerned with the current and bank account proportion. The CASA ratio measures how much money is being held in current and savings accounts as a monetary reserve. Formally

$$\text{CASA} = \frac{D}{\text{TD}} \tag{5}$$

3.1.6 Earnings Per Share (EPS)

EPS is determined by deciding an organization's net benefit and designating that to each extraordinary portion of common stock. EPS is at times known as the bottom line– the final statement, both in a real sense and allegorically, of a company's worth. Stocks with an 80 or higher rating have the most obvious opportunity for progress. In any case, organizations can support their EPS figures through stock buybacks that decrease the number of exceptional offers. Formally,

$$\text{EPS} = \frac{\text{NI}}{\text{AOCS}} \tag{6}$$

3.1.7 Capital Adequacy Ratio (CAR)

Capital Adequacy Ratio is otherwise called Capital to Risk Assets Ratio, is the proportion of a bank's funding to its gamble. Public controllers track a bank's CAR to guarantee that it can ingest a sensible measure of misfortune and consents to legal Capital prerequisites. It is a proportion of a bank's capital. Formally,

$$\text{CAR} = \frac{\text{BC}}{\text{RWA}} \tag{7}$$

3.1.8 Cost to Income

Cost-to-income proportion is determined by isolating the working costs by the working pay produced, i.e., net interest pay in addition to the next pay. Cost-to-pay pro-

portion is significant for deciding the productivity of a bank. Formally,

$$\text{Cost to income} = \frac{\text{OS}}{\text{OI}} \tag{8}$$

3.1.9 Profit Growth

To work out profit growth as a rate, you take away the past period's income from this period's income, and afterward partition that number by the past period's income. Formally,

$$\text{Profit growth} = \frac{\text{current} - \text{previous}}{\text{previous}} \tag{9}$$

3.1.10 Net NPA

NPA stands for non performing asset. Net NPA to propels proportion is the proportion of the Net NPA to the Net Advances. It estimates the nature of the credit of the foundation and its general wellbeing. Net NPA is brought about by the low number of arrangements for neglected obligations. The higher measure of Net NPA influences the liquidity and productivity of the organization. Formally,

$$\text{Net NPA} = \frac{\text{Gross NPA} - \text{PD}}{\text{Gross Advances}} \tag{10}$$

3.1.11 ROIC

Return on invested capital (ROIC) is an estimation used to evaluate an organization's effectiveness at allocating the capital under its influence to beneficial ventures. ROIC gives a feeling of how well an organization is producing profits capital. Formally,

$$\text{ROIC} = \frac{\text{net income} - \text{dividends}}{\text{debt} + \text{equity}} \tag{11}$$

3.1.12 PEG

The price/earnings to growth proportion (PEG proportion) is a stock's cost/income proportion (P/E proportion) isolated by its rate development rate. The subsequent number communicates how costly a stock's cost is compared with its profit Execution. Formally,

$$\text{PEG} = \frac{\text{P/E}}{\text{EPS}} \tag{12}$$

3.2 Descriptive Statistics

Enlightening insights sum up or depict the qualities of an informational collection. It is useful because it allows you to make sense of the data. Helps to explore and make conclusions about the data to make rational decisions. Includes calculating things such as

3.2.1 Mean

Arithmetic mean (also called mean) refers to the amount of all the observations divided by the number of observations. Mathematically, if $x_1, x_2, \ldots, x_n$ are the n observations with $f_1, f_2, \ldots, f_n$ as their respective frequencies; their mean is computed as

$$\bar{X} = \frac{\Sigma_{i=1}^{n} f_i x_i}{\Sigma_{i=1}^{n} f_i} \tag{13}$$

3.2.2 Variance

Variance is the average of the square of deviations of the qualities taken from the mean. Taking a square of the deviation is a superior strategy to get free of negative deviations. Variance is characterized as:

$$Var(x) = \sigma^2 = \frac{\Sigma_{i=1}^{n} f_i (X_i - \bar{X}^2)}{n} \tag{14}$$

3.2.3 Covariance Measure

Covariance Measure In probability and bits of knowledge, a covariance cross-section is a square network giving the covariance between every game plan of parts of a given sporadic vector.

$$\text{Cov}(x, y) = \frac{\Sigma_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{n} \tag{15}$$

3.2.4 Correlation

It is the proportion of how two factors are connected with one another. It is the examination of the linear connection between two elements.

$$R = \text{corr}(x, y) = r = \frac{\Sigma (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(\Sigma_{i=1}^{n} (x_i - \bar{x})^2) \Sigma_{i=1}^{n} (y_i - \bar{y})^2}} \tag{16}$$

3.3 Regression

It alludes to the examination of how one independent variable is reliant upon another reliant variable.

3.3.1 Linear Regression

It goes under supervised learning. It performs regression assignments. It is the examination of the straight association among reliant and free factors. It is utilized to foresee dependent factors utilizing independent factors. For Y on X, line of regression:

$$(Y - \bar{Y}) = \frac{r\sigma y}{\sigma x}(x - \bar{(x)}) \tag{17}$$

3.3.2 Elastic Net Regression

Elastic Net is a notable sort of formalized straight relapse that unites two renowned disciplines, unequivocally the L1 and L2 discipline limits. Elastic Net is an extension of direct regression that adds regularization disciplines to the shortage work during preparation. The coefficients of the model are tracked down through a general joint effort that endeavors to limit the all-out squared blunder between the figures ($\hat{y}$) and the normal objective characteristics (y).

$$\text{Loss} = \Sigma n_i (y_i - \hat{y}_i)^2 \tag{18}$$

$$\text{l2penalty} = \Sigma_{i=0}^{p} \beta_j^2 \tag{19}$$

$$\text{l1penalty} = \Sigma_{i=0}^{p} \text{abs}(\beta_j) \tag{20}$$

$$\text{elasticnetpenalty} = (\alpha * \text{l1penalty}) + ((1 - \alpha) * \text{l2penalty}) \tag{21}$$

3.3.3 Bayesian Ridge Regression

Bayesian regression allows a trademark framework to get through lacking data or insufficiently appropriated data by shaping straight regression using probability wholesalers rather than pointing measures. The outcome or response 'y' is supposed to be drawn from a probability allocation rather than surveyed as a solitary worth.

Numerically, to acquire a completely probabilistic model the reaction y is thought to be Gaussian appropriated around X_w

X as follows

$$P(y|X, w, \alpha) = N(y|X_w, \alpha) \tag{22}$$

3.3.4 Polynomial Regression

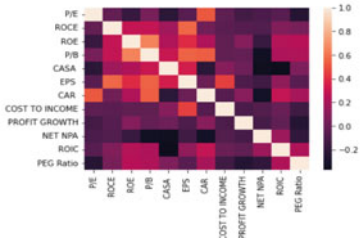
Polynomial Regression is a regression calculation that models the relationship between a dependent (y) and free variable (x) as a flat-out limit polynomial. The Polynomial Regression condition is given under:

$$y = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_n x_n \tag{23}$$

4 Results and Discussion

We performed statistical analysis on 21 banks of Indian banking industry, i.e., HDFC Bank, ICCI Bank limited, Kotak Mahindra, Axis Bank, IndusInd Bank Ltd, Bandhan Bank Ltd., IDBI Bank Ltd., AU Small Finance Bank Ltd., Yes Bank, IDFC First Bank, The Federal Bank Ltd., City Union Bank Ltd., RBL Bank Ltd., Equitas Small Finance Bank Ltd., Karur Vysya Bank Ltd, CSB Bank Ltd., The Jammu & Kashmir Bank Ltd., Ujjivan Small Finance Bank Ltd., DCB Bank, Karnataka bank and finally The South Indian Bank Ltd. We analyzed each bank on the basis of following attributes that are 'Name of Bank', 'P/E', 'ROCE', 'ROE', 'P/B', 'CASA', 'EPS' , 'CAR', 'COST TO INCOME', 'PROFIT GROWTH', 'NET NPA', 'ROIC', 'PEG Ratio'. The statistics for the attributes are shown in Table 2. We now analyze the correlation between the attributes as shown in Table 2. The following observations were made: **Positive correlation**: The positive correlation lies between 0 to 1, excluding 0. '1' indicates Perfect Positive Correlation which is indicated by light pink. In the heatmap, light color units indicate positive correlation and as the color of the units get darker the correlation coefficient tend to approach 0. So from the heatmap P/E and CAR, ROCE and ROE, ROCE and P/B, ROCE and CASA, ROCE and EPS, ROCE and ROIC, ROE and P/B, ROE and CASA, ROE and EPS, ROE and ROE and CAR, ROE and Profit growth, ROE and ROIC, ROE and PEG ratio, P/B and CASA, P/B

Table 2 Figures



Correlation heat-map between the attributese

	count	mean	std	min	25%	50%	75%	max
P/E	21.0	3.014571e+01	7.363614e+01	-33.23	7.5900	15.74	25.12	338.61
ROCE	21.0	6.918000e+01	3.166147e+02	-0.13	0.0700	0.10	0.12	1451.00
ROE	21.0	8.000000e-02	7.141428e-02	-0.13	0.0500	0.08	0.12	0.22
P/B	21.0	1.890476e+00	1.579245e+00	0.30	0.6900	1.52	2.18	5.96
CASA	21.0	3.700476e+01	1.235856e+01	15.42	29.1500	34.22	46.12	60.45
EPS	21.0	1.427857e+01	1.986206e+01	-10.39	2.1000	7.56	29.82	63.28
CAR	21.0	1.835857e+01	3.545685e+00	12.20	15.4000	17.50	19.67	26.44
COST TO INCOME	21.0	1.981951e+06	9.082218e+06	29.13	41.6900	47.60	58.16	41620000.00
PROFIT GROWTH	21.0	1.193670e+02	3.527519e+02	-97.63	-0.0064	18.51	104.17	1616.35
NET NPA	21.0	3.009524e-01	8.726964e-01	0.00	0.0100	0.02	0.04	2.96
ROIC	21.0	7.598571e+00	1.954447e+01	-65.79	4.8500	9.19	15.27	37.68
PEG Ratio	21.0	1.118095e+00	1.459118e+00	0.01	0.1300	0.40	1.43	3.96

Statistics of the attributes in consideration

Table 3 Comparative analysis between the regression models

Comparative analysis between the models				
Type of model	Coefficients	Intercept	Mean squared error	R^2
Linearregression	1.25563942e−01 1.00281470e+02 1.63244074e+00 1.87285041e+00 −4.07889499e+00 2.80953406e+01 3.96725676e−06 −9.14474316e−02 2.59512159e+01 −1.33399195e+00 −1.32383471e+01	−496.7632534431893	617.20	0.90
SGD	-2.44869926e+13 −1.61562406e+10 −3.76193128e+11 −5.91445868e+12 −3.07671413e+12 −2.84255401e+12 4.99402533e+16 −2.20491972e+13 6.70991220e+09 −6.25614599e+11 −1.83034302e+11	−1.46703888e+11	2700e+13	440e−12
ElasticNetregression	1.18884514e−01 0.00000000e+00 4.29263124e+00 1.09400137e+00 −3.82817803e+00 2.33869970e+01 3.65869915e−06 −8.31874512e−02 6.35988277e+00 −1.14823475e+00 −7.96210393e+00	−382.211630898028	782.22	0.87
Bayesianregression	1.24292193e−04 2.68874383e−08 1.03002686e−06 7.38886217e−06 2.14195726e−05 −4.50370094e−07 1.16666002e−07 −1.11324003e−05 −2.27862882e−07 7.49863743e−06 −1.74961486e−07	13.62245581035131	249.37	0.01
PolynomialRegression	−2.45642e−02 0.00000000e+00 3.76899955e+00 2.29829929e+00 2.92928778e+00 −3.82826712e+01 2.82899299e−03 −2.8292929e+01 2.59512159e+01 3.726272885e+00 −2.76282889e+01	83.87432526	83.6	0.96

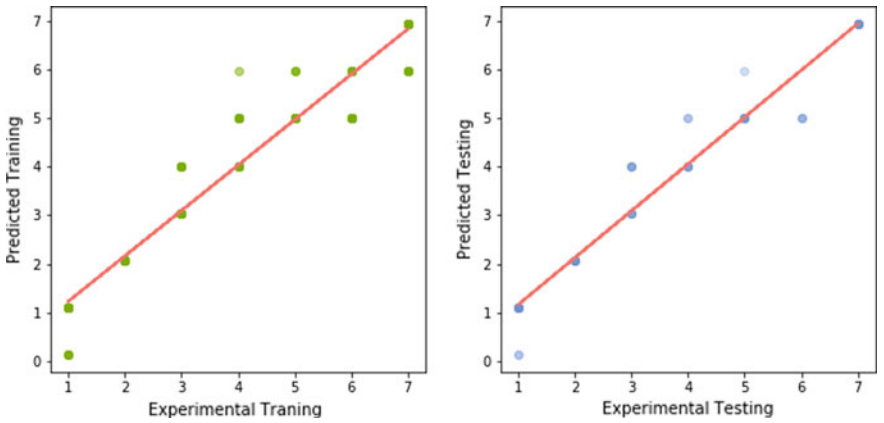


Fig. 1 Plot of training and testing data with Polynomial model performance

and EPS, P/B and CAR, P/B and Profit growth, P/B and ROIC, P/B and PEG ratio, CASA and EPS, CASA and Cost to income, CASA and PEG ratio, EPS and COST to Income, EPS and ROIC has Positive Correlation. **Negative correlation**: The negative correlation lies between −1 and 0. '−1' indicates Perfect Negative Correlation. In the heatmap, dark color units indicate negative correlation. So from the heatmap P/E and PEG Ratio, ROE and NET NPA, P/B and NET NPA, CASA and NET NPA, CASA and ROIC, CASA and CAR, CAR and NET NPA, P/E and CASA, PROFIT GROWTH and PEG Ratio, NET NPA and PEG Ratio has Negative Correlation. **Zero correlation**: The attributes/variables which do not have any correlation is indicated by purple color from the heatmap. So from the heatmap P/E and ROCE, P/E and P/B, P/E and EPS, P/E and ROIC, P/E to Cost to income, ROCE and CAR, ROCE and Profit Growth, ROCE and COST TO INCOME, ROCE and NET NPA, ROE and COST TO INCOME, P/B and Cost to income, EPS and CAR, EPS and Profit Growth, EPS and NET NPA, EPS and PEG Ratio, CAR and Cost to income, CAR and Profit Growth, Cost to income and Profit Growth, Profit Growth and NET NPA has Zero Correlation. Next the regression models described in the previous section are implemented to find a relationship between the factors or attributes and the coefficients of regressions are generated with respect to the intercept, Mean squared error and R^2 value as shown in Table 3.

The polynomial model is seen to have the best performance with the least mean squared error and the best possible R^2 value. Figure 1 shows the performance plot.

5 Conclusion

This paper presents every one of the essential proportions connected with the financial area and played out a factual investigation of the Indian banks. Relapse techniques

were utilized to track down the connection between them. Polynomial relapse supposedly is the best fit for the reason. In future, we will generally utilize this subtleties to foresee a dark swan occasion like emergency.

References

1. Ahmad, N., Naveed, A., Ahmad, S., & Butt, I. (2020). Banking sector performance, profitability, and efficiency: A citation-based systematic literature review. *Journal of Economic Surveys, 34*(1), 185–218.
2. Kumar, K., & Prakash, A. (2019). Developing a framework for assessing sustainable banking performance of the Indian banking sector. *Social Responsibility Journal*.
3. Demirgüç-Kunt, A., Pedraza, A., & Ruiz-Ortega, C. (2021). Banking sector performance during the Covid-19 crisis. *Journal of Banking and Finance, 133,* 106305.
4. Aldasoro, I., Fender, I., Hardy, B., & Tarashev, N. (2020). Effects of Covid-19 on the banking sector: the market's assessment. *Bank for International Settlements*.
5. Tongurai, J., & Vithessonthi, C. (2018). The impact of the banking sector on economic structure and growth. *International Review of Financial Analysis, 56,* 193–207.
6. Abarbanell, J. S., & Bushee, B. J. (1997). Fundamental analysis, future earnings, and stock prices. *Journal of accounting research, 35*(1), 1–24.
7. Renu, I. R., & Christie, P. (2018). Fundamental analysis versus technical analysis-a comparative review. *International Journal of Recent Scientific Research, 9*(1), 23009–13.
8. Sodhi, A. K., & Waraich, S. (2016). Fundamental analysis of selected public and private sector banks in India. *NMIMS Management Review, 28*(2), 34.
9. Sharma, R. K., & Chaudhary, A. (2016). A study of Indian banking sector using fundamental analysis. *IITM Journal of Management and IT, 7*(2), 12–23.
10. Agustin, I. N. (2019). The integration of fundamental and technical analysis in predicting the stock price. *Journal Management Maranatha, 18*(2), 93–102.
11. Al-Homaidi, E. A., Tabash, M. I., Farhan, N. H., & Almaqtari, F. A. (2018). Bank-specific and macro-economic determinants of profitability of Indian commercial banks: A panel data approach. *Cogent Economics & Finance, 6*(1), 1548072.
12. Adhana, D., & Gulati N. (2019). Financial performance analysis: A comparative study of AXIS Bank and ICICI Bank. *Journal of Information and Computational Science, 9* (7).
13. MO, S. (2018). Predicting stock market movements of India using data deterministic approach. *Academy of Strategic Management, 17*(2).
14. Lisin, A. (2020). Valuation of the activities of foreign banks in the Russian banking sector. *Orbis, 15*(45), 53–63.
15. Mugo, C. (2021). Banking sector consolidation and stability in Kenya. *Journal of Applied Finance and Banking, 11*(3), 129–159.
16. Bondarenko, Y. K., Zhuravka, O. S., Aiyedogbon, J. O., Ologunla, E. S., & Andrieieva, V. (2020). Structural modeling of the impact of bank nonperforming loans on the banking sector: The Ukrainian experience.
17. Abugamea, G. (2018). Determinants of banking sector profitability: Empirical evidence from Palestine.
18. Jackson, C., & Matilainen, J. (2012). Macro-mapping the euro area shadow banking system with financial sector balance sheet statistics. In *InIFC Conference on Statistical Issues and Activities in a Changing Environment Basel 2012* (pp. 28–29).

Smart Home Based on IoT by Using Machine Learning

K. Lavanya and K. S. Archana

Abstract Smart homes have surfaced as the coming wave of technological advancement. It is a collection of smaller systems connected to home network and comprising a variety of communication technologies which can assist inhabitants' convenience, security, safety, and comfort. This paper examines several IoT based smart house approaches, which were divided as 2 categories depending on application: smart home security system and smart home automation. We explored several sensors, doors, and communication protocols utilized in IoT-based smart homes in this paper. We also discussed about research problems and also open research objectives.

Keywords IoT · Survey · Machine learning · Smart home automation · Smart home security system

1 Introduction

The Internet of Things (IoT) is the network of interconnected mechanical and digital devices, items, people or animals, computing devices having UIDs (unique identifiers), and potential to send information without needing human-to-computer/human-to-human interactions. Human with the cardiac monitor implant, vehicle with built-in sensors to notify user when tire level is reduced, or any other man-made or natural object that has Internet Protocol (IP) address and therefore exchange data over the Internet are all examples of things in the IoT. According to a report, approximately fifty billion devices will be connected to the Internet by 2020, and this number will grow rapidly over time [1]. Statista [2] predicts that IoT will capture an 3.9 to 11.1 trillion USD commercial industry by 2025. Figure 1 depicts the number of linked

K. Lavanya
CSE, Vels Institute of Science, Technology & Advanced Studies, Chennai, India

Present Address:
K. S. Archana (✉)
Department of Data Science and Business Systems, School of Computing, SRM Institute of Science and Technology, Kattankulathur, Chennai, India
e-mail: archanak1@srmist.edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_7

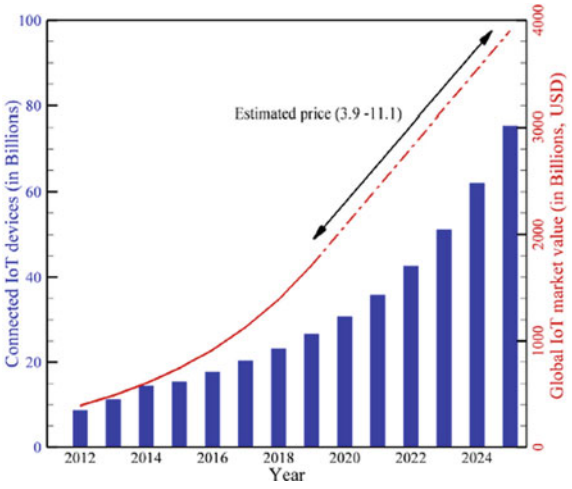


Fig. 1 Graph depicting the total number of linked IoT devices and the worldwide IoT market to date, as well as projections for the future. *Source* [6]

IoT devices and also global market for IoT systems in recent years, as well as future expectations by 2025 [3–6]. As a result, study on IoT and its evolution and security has gotten a lot of interest in the electrical and computer fields over the past several decades.

Companies in a variety of industry sectors have been progressively using IoT to work more efficiently understand customers better to achieve enhanced customer service, improve decision-making, and boost the value of a company. By collecting information from IoT devices and analyze this data for sensing and understanding the environment, sophisticated systems can be made to improve standard of living, like machine health diagnosis, localization and structural monitors, health monitoring, and human body activities.

Machine Learning Techniques used:

Machine learning (ML) is utilized by IoT for data collection procedures to be simpler and more dynamic. ML is a sophisticated artificial intelligence technology that requires no explicit programming and outperforms in dynamic networks. ML approaches train the machine to recognize different types of attacks and give appropriate defensive policies. Attacks were recognized at early stage in this situation. Furthermore, ML approaches appear to be promising in identifying new attacks and effectively dealing with them. As a result, ML algorithms give potential security standards for IoT devices, making them more trustworthy and accessible than ever.

Classification: The goal of this activity is to determine which category the provided observation belongs to. It includes data that has been properly specified.

Regression: This is similar to the classification problem, except the data is numerical rather than categorical. When thinking about smart home, a choice must be made on how to utilize or anticipate thermostat heaters with the same sensor qualities.

IOT System:

Originally, IoT was feasible through machine-to-machine communications (M2M), which involved connecting a device to a cloud and using it to control and gather data. IoT devices on the network access sensor data via gateway. Without particular instructions from an individual, device to device communication is carried out. People may set up devices and view data. Figure 2 is the example of a basic IoT system. Connection and real-time nature of IoT technologies provide several benefits, including cost savings and increased productivity. Smart homes are a frequent application of IoT technology, in which all gadgets are linked to Internet and contribute owner's comfort, security, and power efficiency. Wi-Fi and Bluetooth were widespread communication mediums, and Z-Wave and ZigBee were commonly used in home automation communications. By combining smart home technologies with AI and ML, apps can adapt to their surroundings. This allows energy usage to be handled appropriately and provides some level of predictive maintenance. Figure 1 depicts a basic example of IoT systems. IoT systems were composed of sophisticated web-enabled devices to make use of embedded communication hardware, processors, and sensors in smart device. These devices were linked to a single gateway or hub, which distributes data over the entire network of devices, where it may be evaluated cloud or locally. As they react on the shared information between themselves, the devices generally do their tasks automatically. It is feasible for people to bypass the system's succession of autonomous loops and send direct orders and tasks to the devices.

IoT-based Smart home:

Smart homes, cellphones, automobiles, and other devices with sensors are among the numerous IoT applications. Embedded actuators and sensors will be able to be controlled remotely through the Internet thanks to a range of monitoring and control methods. Because the devices record the customer movements, they may

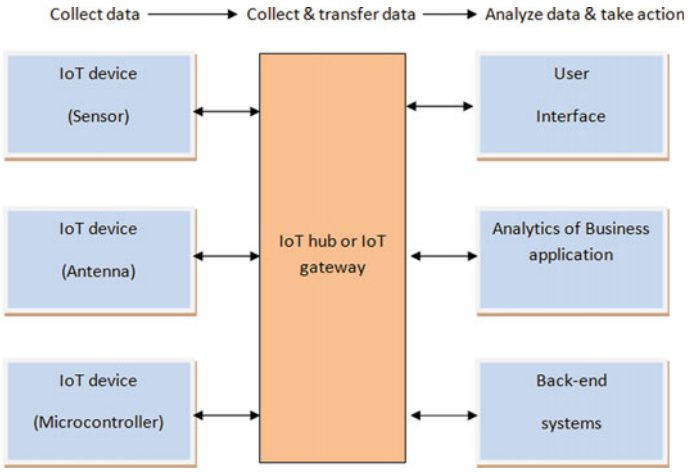


Fig. 2 Illustration of how an IoT system functions, from data collection to action

predict the future behavior and deliver one step further to the consumer desire. As a result, the gadgets provide the highest level of security, capability, relaxation, luxury, and sustainability. These technologies can help inhabitants improve their lifestyle by providing comfort, safety, and convenience. Furthermore, smart homes are appropriate for consumers of various ages and financial levels. Smart home technologies have become more economical and accessible to individuals of all income levels as they have evolved. Furthermore, smart houses highlight the aging population, who require greater care and help. It was unimaginable in prior decades to believe that the house could be administered automatically even while the owner was not present. However, with IoT, it is now achievable.

Using numerous actuators and sensors, IoT enhances the smartness of household appliances. Various low cost sensors like passive infrared (PIR) and temperature sensors were utilized to monitor environment factors and device status, which provide information for the IoT doorway. Hardware and software are used to create doorway devices. These devices serve as a hub for connecting numerous actuators and sensors. Doorway acts as a connection point between Internet and IoT sensors. The user could monitor and operate numerous actuators and sensors through these doorways. Data is forwarded to users through the Internet which is stored in cloud or in database. Arduino and Raspberry Pi are two of the most popular IoT doorways.

IoT communication technologies like ZigBee, Wi-Fi, and MQTT protocol were utilized to link doorways and sensors. Figure 3 depicts an overview of IoT-based smart home. To record smart home data, some researchers employed a database and a web server. IoT smart home approaches were divided as 2 categories depending on application: smart home security system and smart home automation based on IoT.

Smart Home Security systems based on IoT

One of the most significant concerns to a household is security. Researchers employed IoT approaches to secure the home.

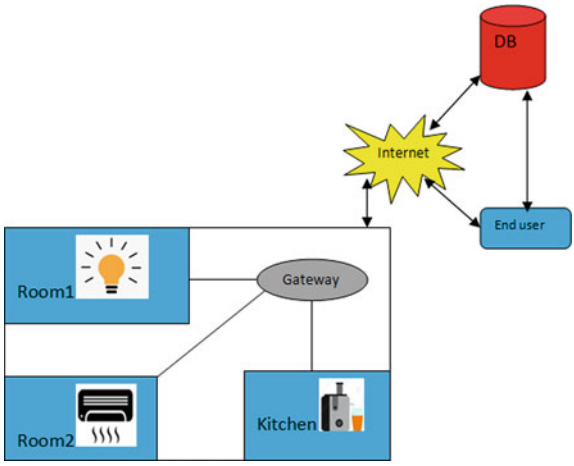


Fig. 3 Smart home overview

Smart Home Automation based on IoT

Researchers employed a combination of actuators and sensors to monitor and operate household appliances from far away. The end user of smart home automation could monitor and handle various household appliances from anywhere and anytime.

2 Literature Survey

This section covers a wide range IoT-based smart home applications in depth for smart home automation, and smart home security system based on IoT and summary is specified in Table 1.

Table 1 Summary on Iot-based smart home automation and security systems

Refs. No.	Features	Communication technique	Actuators, sensors, doorways	Storage
[7]	Security alert	Wi-Fi	Webcam, Raspberry Pi	–
[8]	Security alert	Wi-Fi	USB cam, Raspberry Pi	–
[9]	Security alert	Wired	Webcam, PIR, Raspberry Pi	–
[10]	Security alert	IPV6, Wired	Relay, Raspberry cam, motion sensor (PIR), Raspberry Pi	–
[11]	Door, light, fan control	Wi-Fi	Cam, LDR, PIR, IR, Raspberry Pi, relay, GPIO	–
[12]	Various electric devices	ZeeBee	Capacitors, resistors, current measuring circuit board, sound sensor, motion sensor, humidity sensor, temperature sensor, Arduino pro (ATMega32U4)	–
[13]	Fire detection for smart home	RESTful	Analog temperature sensor, Raspberry Pi	–
[14]	Smart home automation	MQTT protocol	Rotary sensor, motion sensor, sound sensor, Arduino	Mobius server, MYSQL
[15]	TV, steamer, water boiler, rice cooker	ZigBee	Analog-to-digital convertors, low pass filter, e-meter, laptop	MYSQL

Authors presented an IP webcam security system to IoT-based smart homes in [7]. IP webcam records live footage and sends signals to the Raspberry Pi whenever it identifies an object. Current object images were compared to previously saved images on the Raspberry Pi. When a mismatch is discovered, Raspberry Pi sends alert email to specified address. The communication system was established using a Wi-Fi module.

Authors introduced video streaming security system to the Internet of Things-based smart home in [8]. Real-time video was captured using a USB camera, which was compressed and delivered using the H.264 encoding and decoding technology. The Raspberry Pi is utilized like a doorway, which gets streamed videos. By using Wi-Fi module, doorway sends the collected video to a website. Low-cost sensor nodes provide the user with information on environmental parameters like as humidity and temperature.

The authors of [9] proposed IoT-based smart home security alarm. To send and detect motions and objects, the author employs PIR and webcam, correspondingly. The collected data was fed to Raspberry Pi that sends email for authorized person only when recorded object does not match with stored object.

Authors suggested smart home security alarm in [10]. The PIR motion sensor has been utilized to detect movement in this system, and the Raspberry Pi camera module is utilized to record human images, which were then delivered to the Raspberry Pi doorway. When a guest comes to the residence, user gets email notice from IoT system. The user has the ability to unlock (or lock) the door at any time. A wired medium connects the sensor and the devices.

To automate household appliances, the authors employed a PIR, light dependent resistors (LDR), infrared sensor (IR), and a video camera in [11]. The smart house employed IR sensors for monitoring and operate lights, a PIR sensor to sense human presence, and an LDR to predict fire. Wi-Fi connectivity was used to link these sensors to Raspberry Pi. The Raspberry Pi provides information to the web server, which users can access through a mobile app or web interface. General-purpose input and output (GPIO) and relay device are also included in the system, which may be used to turn on/off fans and lights.

The authors of [12] employed a variety of IoT devices for analyzing environment parameters as well to reduce energy use in school building. Electricity consumption monitor is part of the system that is made up of a variety of IoT and electrical components including current measuring circuit board, capacitors, resisters, and an Arduino XBee module-board. The monitor analyzes the electricity consumption of electric components and transmits the information to doorway. Arduino Pro Mini, sound sensor, motion sensor, humidity sensor, temperature sensor, and other components are included in the system's environment comfort meters. The device monitors a variety of environmental conditions and transmits the information to the doorway. As a doorway, an Arduino Pro with an ATMega32U4 is employed. For data transfer, model employs IEEE 802.15.4 (ZeeBee communication).

The authors of [13] employed an IoT approach to monitor and identify fire confidence in a household. The Raspberry Pi was utilized as doorway device, an thermistor

(analog temperature sensor) detects fire in building. ADC and DAC were implemented using an I2C integrated circuit (PCF8591). To present and transport data between devices and end users, a Representation State Transfer (RESTful) service was employed. The fuzzy logic approach was utilized to identify fire confidence. This technology assists the user in preventing fires in the home.

The authors of [14] proposed three intelligent smart house models based on IoT. The first model gathers information from actuators and sensors. Second type functions as server, integrating several devices, and monitoring overall data. Machine learning and neural networks techniques are used to examine the data. The third model offers a variety of services. These models are put to the test in a real-time smart home app. Environmental characteristics in the residence were monitored using a rotary sensor, motion sensor, and sound sensor which all sent information to Arduino board. MQTT protocol was utilized for communications, and data was saved in Mobius IoT platform using a MYSQL database.

Authors created a smart home electrical energy auditing system based on IoT in [15]. By using smart electric meters, electrical equipment like rice cookers, water boilers, steamers, and televisions were monitored in terms of currents and voltages. Data acquisition (DAQ) devices of low pass filters and analog-to-digital (ADC) converter transform device used data (current and voltage signals) to digital signals. The ZigBee protocol is used to send signals from electronic devices to laptop (which serves as doorway). Electrical device workloads were classified using neural fuzzy classifiers, and events were discovered using a load monitoring approach built in LabView. The recognized events and devices load are saved in MYSQL database in web server. A web interface allows the end user to access the data.

3 Challenges

It is a technological difficulty to replace every wired devices to wireless ones. Ones in any ordinary home without security its seems unsecured. This can lower the cost of initial wire installation and increase the system's scalability, as well as changing the house's instruction. Consider the scenario when hackers get access to your home, open your doors, and deactivate your alarm system. Providing a solid security system which detects any thieves/hacker who may enter your home is a different problem. Another technological problem is that instead of adopting a single protocol like ZigBee or Z-Wave, there are multiple protocols to construct a smart house. Smart homes can sometimes waste more energy than they save. The problem in creating a system is to improve the proposed model's reliability so that it can be used on a smaller or bigger scale. Developing a good sensor would necessitate more exact data from the physical world, as well as the creation of data management systems to handle and store data for subsequent analysis.

4 Research Objectives

(1) To create an Android application for controlling basic electrical appliances remotely, as well as monitoring and displaying environmental elements at home and its surroundings.
(2) To install a sensor-based automation system in the house to detect motion and intrusion.
(3) To avoid false alerts from the security system, a machine learning method for distinguishing photos of home will be used.

Future Scope:

Many people are interested about smart home technologies. In the future work, I will focus about all the aged people and handicapped people. They are happy to utilize the smart home automation. With a minimal investment, they can use this automation techniques.

5 Conclusion

Everyone is choosing for automation in today's era of digitalization. Smart home automation is a breakthrough in living standards that makes life at home more convenient, comfortable, and cost-effective. When devices are connected to Internet which is monitored and controlled from anywhere in the world. Smart home automation systems could be controlled from any location. We looked at a variety of IoT-based smart home solutions in this paper. Smart house approaches are divided into 2 categories: smart home security systems and smart home automation. Different IoT actuators, sensors, and communication technologies were addressed for smart home automation systems. The limitations of smart home approaches based on IoT were examined, as well as their future directions. This study will help in understanding the architecture, current trends, difficulties, and future direction of IoT-based smart home automation.

References

1. da Cruz, M. A. A., et al. (2018). Performance evaluation of IoT middleware. *Journal of Network and Computer Applications, 109*, 53–65.
2. Statista. (2019). *Internet of things to hit the mainstream by 2020.* https://www.statista.com/chart/2936/internet-of-things-to-hit-the-mainstream-by-2020/.
3. Manyika, J., et al. (2015). Unlocking the potential of the Internet of Things. *McKinsey Global Institute, 1*.
4. Juniper Research. (2015). *Internet of things connected devices to almost triple to over 38 billion units by 2020.* http://www.juniperresearch.com/press/press-releases/iotconnecteddevices-to-triple-to-38-bn-by-2020.

5. Statista, Technology & Telecommunication. (2019). Consumer Electronics, Source. HIS. https://www.statista.com/statistics/471264/iot-number-of-connected-devicesworldwide/.
6. Tahsien, S. M., Karimipour, H., & Spachos, P. (2020). Machine learning based solutions for security of Internet of Things (IoT): a survey. *Journal of Network and Computer Applications, 161*, 102630.
7. Khanum, A., & Rekha, V. (2019). An enhanced security alert system for smart home using IOT. *Indonesian Journal of Electrical Engineering and Computer Science, 13*(1), 27–34.
8. Suneetha, P., & Venneti, K. (2017). Web based online Home Automation and security system based on wireless Video Streaming using Internet of Things. *International Journal of Science Engineering and Advance Technology, 5*(1), 7–12.
9. Tanwar, S., et al. (2017). An advanced internet of thing based security alert system for smart home. In *2017 International Conference on Computer, Information and Telecommunication Systems (CITS)*, IEEE.
10. Anwar, S., & Kishore, D. (2016). IOT based smart home security system with alert and door access control using smart phone. *International Journal of Engineering Research & Technology (IJERT), 5*(12), 504–509.
11. Pavithra, D., & Balakrishnan, R. (2015). IoT based monitoring and control system for home automation. In *2015 Global Conference on Communication Technologies (GCCT)*, IEEE.
12. Pocero, L., et al. (2017). Open source IoT meter devices for smart and energy-efficient school buildings. *HardwareX, 1*, 54–67.
13. Vujović, V., & Maksimović, M. (2015). Raspberry Pi as a sensor web node for home automation. *Computers & Electrical Engineering, 44*, 153–171.
14. Jo, H., & Yoon, Y.I. (2018). Intelligent smart home energy efficiency model using artificial TensorFlow engine. *Human-centric Computing and Information Sciences, 8*(1), 1–18.
15. Lin, Y.-H. (2018). Design and implementation of an IoT-oriented energy management system based on non-intrusive and self-organizing neuro-fuzzy classification as an electrical energy audit in smart homes. *Applied Sciences, 8*(12), 2337.

Develop Model for Malicious Traffic Detection Using Deep Learning

Kaushal Kishor, Prabhjeet Singh, and Rhea Vashishta

Abstract Malicious traffic is a threat that creates an incident of security. Our paper primarily focuses on the establishment of an intrusion detection system against malware traffic with the help of ideologies such as neural networks and association analysis through data mining and association mining rules on the grounds of machine learning. We'd like to achieve this to create an automated environment against the manual labor often seen as a challenge in intrusion detection systems. The self-learning mechanism which is the prime feature of deep learning is used as the focus to detect unknown or unauthorized access, and usually goes unnoticed. The technology used in our project is based on deep neural networks and with the use of modified datasets such as KDD Cup 1999. Along with this, we are collaborating with DNN-4 model with a higher accuracy than all other DNNs, i.e., 83.74% (Kim et al. in An intrusion detection model based on a convolutional neural network, 2019). The existing scenario with respect to other intrusion detection systems is quite demanding, as most of the IDS are false alarm rates which can be countered by using deep learning as it associates the difference between normal and abnormal traffic. At the same time, other problems like low detection rates and unbalanced datasets can also be excluded by using machine learning through generalization, training, and testing the performance of IDS with the help of one of the latest technologies at hand.

Keywords Intrusion detection system (IDS) · Deep neural network (DNN) · Malicious traffic · Intruder

1 Introduction

The Internet is a flow of traffic that is data. Whenever we connect to the Internet, there is an instantaneous flow of data. That is, data is sent and received over the World Wide

K. Kishor (✉) · P. Singh · R. Vashishta
Department of Information Technology, ABES Institute of Technology, Ghaziabad, Uttar Pradesh, India
e-mail: kaushal.rastogi07@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_8

Web. Not all of this data has to be good data, and there is a ton of bad data that needs to be stopped. Basically, an attack is initiated by an unauthorized user called an intruder [1]. An attacker could remotely access a computer over the Internet or remotely disable services. The accuracy of intrusion detection requires understanding how to successfully attack a system. Because computers and networks are programmed by humans, errors can occur in both hardware and software. These human errors and mistakes lead to vulnerabilities. First of all, the IDS system aims to detect all these attacks and prevent malicious behavior of computers and networks. Detecting malicious traffic is protecting your computer [2–4]. A literature review relevant to our project is an Intrusion detection system (IDS), defined as a device or software that monitors network or system activity and identifies malicious activity. Excellent growth and use of the Internet increases concerns about how to safeguard digital information. Various attacks on today's world hackers use valuable information. Most intrusion detection techniques and algorithms assist in identifying these numerous threats [5]. The main purpose of this article is to provide an IDS tool development for intrusion detection, intrusion detection method type, attack type, various tools, and methods, research needs, problems, finals, and possible research goals. Detecting and preventing an attacker's invasion. The goal of our paper is to create an interactive intrusion detection system based on deep learning and data analysis that prevents malicious traffic from interfering with our systems [6].

2 Literature Review

Halimaa et al. used autoencoders with classifiers for intrusion threats. The DL approach is trained using the NSLKDD dataset [7]. Similar to Abdulhammed et al. and Kishor K. presented a hybrid deep learning approach based on auto-coding and RF algorithms to focus on the problem of denial-of-service attacks in SDN. The reported accuracy of the proposed approach reached 97.89% using the NSLKDD dataset [8–10]. Also Alkasassbeh et al. applied deep autoencoder (DAE) for intrusion detection to detect malicious network traffic. Classifiers are used in the last hidden layer to classify sample data according to normal or attack criteria. Greedy methods were used to train deep learning models to prevent overfitting [11, 12]. Taher et al. have been proposed in the KDD Cup 99 dataset, which contains 2 convolutional layers, 2 max pooling layers, 2 full join layers, and 1 classification layer. However, the proposed approach does not allow detecting samples of a specific class. Additionally, the average accuracies of Probe and R2L attacks are 68.98 and 62.56, respectively [13]. Elsayed et al. [14] efficiently trained an intrusion detection model with KDDCup 99 using LSTM [14]. Althubiti et al. [15] proposed a DL approach using recurrent neural networks to protect against denial-of-service attacks in SDN networks. The accuracy of the model studied reached 87% [15, 16]. Elsayed et al. [14] analyzed the performance of deep neural networks compared to traditional machine learning methods. Experimental results showed that DNNs with

three hidden layers outperform all other classical ML algorithms [17–19]. The developed a method to detect illicit attacks in IoT networks using the SVM algorithm. The model is trained using several features derived only from the rate characteristics of incoming packets. The extracted features are obtained by calculating the average, median, and maximum values of the packet arrival rate features. The method used was still not a promising solution [20]. The proposed model incorporates a long short-term memory (LSTM) autoencoder into unsupervised learning. The proposed model provides efficient results for the NSLKDD dataset, but fails to do soon the new attack dataset [21]. The proposed an anomaly detection-based method to protect software-defined networks. The presented composite material model is two step. There are two stages to this model. An algorithm called the bat algorithm with various mutations to reduce the number of features in a multivariate input. And the second stage uses radio frequencies to classify network traffic into different classes by selecting features from the initial stage [22]. Elsayed et al. [23] used the AdaBoost algorithm for anomaly detection. Two feature selection algorithms are used to select common features from the CICIDS dataset: ensemble feature selection and principal component analysis. The observed results showed that the combination of AdaBoost and ensemble feature selection gave better performance than AdaBoost with principal component analysis [23]. Kishor et al. [24] used a LeNet5 model-based CNN with Softmax function to develop a new classifier. The authors successfully achieved an accuracy of 99.74% using the validation method [24]. Jahromi et al. [25] proposed introducing various DTs along with an adaptive voting algorithm. The NSLKDD dataset is used to test the proposed accuracy. Experimental results show that adaptive ML models give better results than single algorithms. Prediction accuracy is improved when using multi tree, the accuracies are 83.98% and 87.96%, respectively [25]. Rai et al. [26] investigated the effectiveness of four different ML algorithms: SVM, RF, DT, and multilayer perceptron (MLP) against DDoS attacks within the framework of the SDN concept. Also, the performance of these methods in IDS classification is highly dependent on the nature of the mining method [26]. This paper proposed two different detection systems to protect networks from malicious traffic. Signature-based methods are implemented to detect known attacks, and flow-based anomaly detection is used as a second approach to provide threat detection in network architectures. The anomaly detection system uses neural network pattern recognition to evaluate the NSLKDD dataset. However, the 2-IDS approach was more complex and increased the computation time [27]. Khan et al. applied CNN for exploration using the KDD dataset. The calculated accuracies for SVM and DBN are 97.99% and 96.89%, respectively [28]. Yong et al. improved intrusion detection performance on KDD datasets using batch normalization. The best performance of the model is achieved when using two convolution layers with kernels. Experimental results show and convincingly prove that CNN is the best approach compared to deep neural networks and SVMs [29]. HU et al. further improved CNNs with the ADASYN algorithm, which primarily aims to handle unbalanced data by adding new inputs and preventing the system from being biased toward frequent inputs. Advanced model CNN (SPCCNN) achieved an accuracy of 85.49% with better accuracy than standard CNN on the test data [30]. Xiao et al. presented an approach based on a CNN model using the KDDcup99

dataset. They used principal component analysis (PCA) and autoencoder reduction techniques to reduce input data features and prepare the input data for CNN requirements. We use PCA to obtain two sets of features and extract different sets from the autoencoder. From the accumulated results, it can be concluded that the autoencoder is more efficient in feature reduction than the PCA method [31]. Jiang et al. proposed a hybrid model to learn spatial features by combining CNN and interactive long-term short-term memory. It is an algorithm used to solve the problem of imbalance in data and consists of a resampling method. Two datasets, NSLKDD and UNSWNB15, are used to evaluate the model. This model achieved overall accuracy of 85.67% and 74.62%, respectively [32]. Gu et al. [33] integrated SVM and sparse autoencoder (SAE) for intrusion detection on the NSLKDD dataset. This engine provides feature extraction and size reduction for unsupervised learning, while SVM is used for classification to improve model detection capabilities [33]. Khan et al. [34], particular attention is paid to the use of deep learning methods that provide high performance when the sample size of the labeled data is small. It has the ability to automatically learn deep structures from raw data [34].

3 Proposed Model

The attacks can be identified as a result of the fact that the attackers are trying to give the rules of the systems, which are the criminals, and easier access to, or correct, any information, even to the destruction of the vehicle. Due to the inherent open nature of Wi-Fi channels, the development of wireless technologies for the conduct of any negotiation in terms of structures poses serious threats to the conservation of the community, and in particular, security system, Wi-Fi wireless communication systems, it can be projected with the aid of a joint network, and combat operations. Taking into account the fact that, as its name suggests, it has a tendency to have a tendency to be present on the machine hosting, the knowledge, and the mass of the information age, a cyber security in a Wi-Fi network structures, it is very important for the customers to get the community to protect a laptop and an understanding of the attack. There are many different types of seizures and for cyber systems, such as a flood, a distributed denial-of-service attacks, the batch-specific attacks, and spoofing. To manipulate this type of attack flow for cyber security, scientists have projected the number of responses. Most of the answers are: attack, detection, and is one of the most effective methods, which provides a comprehensive, dynamic security protection, a mechanism to be able to look forward to, you have to make it and resist the attack. In particular, the attack detection, it can collect data from the network of observations, gadget, status and behavior, and, in addition, with the help of a gadget that allows the employee to him, and the detection of any unauthorized use of the device for the clients and external attacks of intruders in the car.

The figure shown above depicts the internal working of the confusion matrix used in our CNN model. Following these patterns, this paper researches the part of AI approach (CNN) in investigator work transmission control convention affiliation

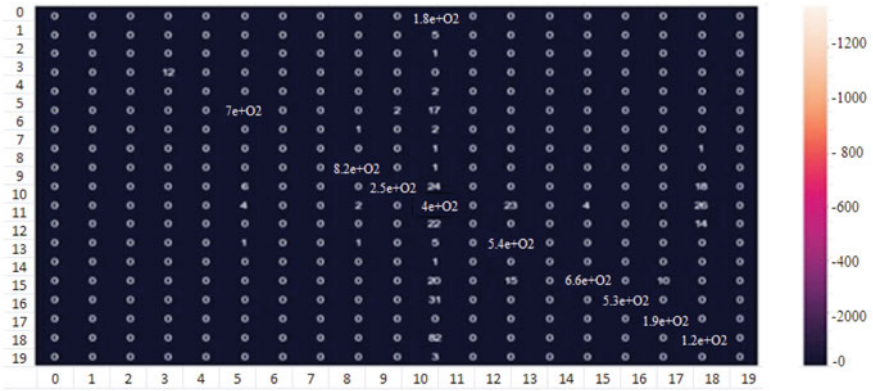


Fig. 1 Confusion matrix

traffic as ordinary or dubious one. Yet, abusing CNN is a costly strategy. In this paper, combining 2 classifiers has been arranged, where counterfeit neural organization (CNN) classifiers were used. Moreover, our arranged goal permits us to inspect acquired characterization results. Exactness of the arranged goal has been contrasted and elective classifier results. Examinations are directed with a totally extraordinary organization association chosen from NSLKDD DARPA dataset. Observational results show that joining CNN method for intrusion identification might be a promising course (Fig. 1).

The suggested system is made up of feature selection and learning algorithms. The feature selection elements are in charge of extracting the most relevant characteristics or attributes to identify the sample to a certain group or class. Using the feature selection component's results, the training set component constructs the requisite intelligence or learning. The model is trained and becomes intelligent by using the training dataset. The learnt intelligence is then applied to the testing dataset to determine how well the model identified unknown data (Fig. 2).

This is a scatter plot graph which represents the true relation between the true values of the dataset versus the predicted values that are evaluated.

Advantages of Proposed System:

1. It improves the accuracy of the result.
2. It analyzes the result of identifying most network traffic, reduces the workload.
3. The benefit of the usage of machine learning is that it is going to confirm whether or not a code or a document is malicious or now no longer throughout a} very little bit of time even as not the requirement of analyzing it in the course of a sandbox to carry out the analysis.

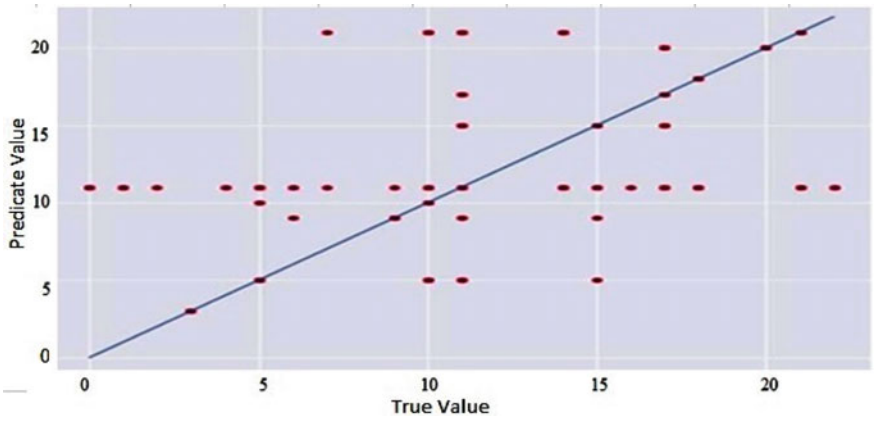


Fig. 2 Scatter plot

4 Result

We use various classifiers such as naive Bayer classifier, k-nearest neighbor, and random forest to analyze the performance of the model. You can see significant performance in multi-classification intrusion detection systems. Compared with the general CNN, which relies on the characteristics of the content, the proposed CNNMCL can suppress streaming content and can be adapted to learn the mutation detection function directly from the data. Therefore, the experimental results show that manual feature extraction and unbalanced training can detect anomalies even in the absence of data by CNNMCL. The best way to test the effectiveness of an intrusion detection model is to evaluate how it can perform on new data that has not been seen before and during training.

In the figure shown as model accuracy, it depicts two sets: train and test. Train set consists of the 80% dataset, while the test set consists of the remaining 20% dataset, and the graph represents the gradual increase in the training of raw data, while the test set slightly runs parallel to it. The model shows how it trains the data while the model extracts useful features which can be proved using the test set. In this, figure shows the relative relationship between the success rates of recognizing faulty datasets in comparison with the unknown faults which were missed. Observing the diagram, it can be proved that the rate of loss decreases exponentially. According to the results and observations, we were able to get a high accuracy of 97% (Fig. 3).

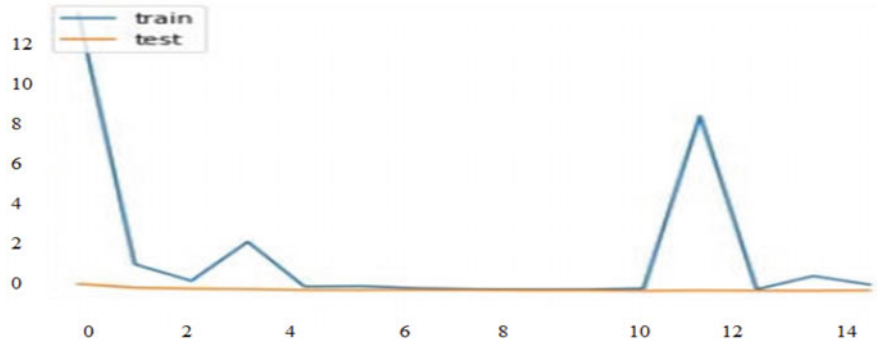


Fig. 3 Loss graph

5 Conclusion

There is still a lot of room for improvement in the proposed model as more time is needed for training and testing areas that can be worked on in the future. CNN models are better at detecting anomalies in traffic datasets to prevent false attacks by intrusion detection systems (IDSs) than traditional intrusion detection systems when using the same dataset. In the near future, we will try to add more features and ideas to improve the accuracy and performance of our models. The classic intrusion prevention system detects network traffic using trying to ensure based on a state of knowledge, which has several drawbacks such as poorer accuracy and a high number of false alarms. DNN and association analysis are used to power this system. The DNN can mine deep network traffic characteristics and classify unknown traffic assaults. The reason for this is because the DNN still has a minor false rate; thus, following segmentation, we filter the classified data using feature matching to eliminate normal traffic that has been misclassified as malware traffic.

6 Future Scope

In the near future, we will try to add more features and ideas to improve the accuracy and performance of our model. Several approaches to machine learning and deep learning have been used for their implementation. You can also use a stack-based autoencoder approach to scale your operations to reduce computational resources. You can also pay more attention to optimization of computation time. Therefore, the future scope of the proposed method is to develop datasets that represent current network traffic patterns, detect intrusions using anomaly detection methods, and integrate them with automated systems to block intrusions.

References

1. SaidElSayed, M., et al. (2021). A novel hybrid model for intrusion detection systems in SDNs based on CNN and a new regularization technique.
2. Kishor, K., Nand, P., & Agarwal, P. (2017). Subnet based ad hoc network algorithm reducing energy consumption in manet. *International Journal of Applied Engineering Research, 12*(22), 11796–11802.
3. Kishor, K., Nand, P., & Agarwal, P. (2018). Notice of retraction design adaptive Subnetting hybrid gateway MANET protocol on the basis of dynamic TTL value adjustment. *Aptikom Journal on Computer Science and Information Technologies, 3*(2), 59–65.
4. Kishor, K., Nand, P., & Agarwal, P. (2018). Secure and efficient subnet routing protocol for MANET. *Indian Journal of Public Health, 9*(12).
5. Kim, J., Shin, Y., & Choi, E. (2019). An intrusion detection model based on a convolutional neural network.
6. Said Elsayed, M., et al. (2021). The role of CNN for intrusion detection systems: An improved CNN learning approach for SDNs.
7. Halimaa, A., & Sundarakantham, K. (2019). Machine learning based intrusion detection system. In: 2019, *3rd International Conference on Trends in Electronics and Informatics (ICOEI)* (pp. 916–920). IEEE.
8. Abdulhammed, R., Musafer, H., Alessa, A., Faezipour, M., & Abuzneid, A. (2019). Features dimensionality reduction approaches for machine learning based network intrusion detection. *Electronics, 8*(3), 322.
9. Kishor, K. (2022). Communication-efficient federated learning. In S. P. Yadav, B. S. Bhati, D. P. Mahato, & S. Kumar (Eds.), *Federated Learning for IoT Applications. EAI/Springer Innovations in Communication and Computing*. Springer, Cham (2022). https://doi.org/10.1007/978-3-030-85559-8_9
10. Kishor, K. (2022). Personalized Federated Learning. In: Yadav, S. P., Bhati, B. S., Mahato, D. P., & Kumar S. (Eds.), *Federated Learning for IoT Applications. EAI/Springer Innovations in Communication and Computing*. Springer, Cham. https://doi.org/10.1007/978-3-030-85559-8_3
11. Alkasassbeh, M., & Almseidin, M. (2018). Machine learning methods for network intrusion detection. ArXiv preprint arXiv:1809.02610
12. Kishor, K., Sharma, R., & Chhabra, M. (2022). Student performance prediction using technology of machine learning. In: Sharma, D. K., Peng, S. L., Sharma, R., & Zaitsev D. A. (Eds.), *Micro-Electronics and Telecommunication Engineering. Lecture Notes in Networks and Systems* (Vol. 373). Springer, Singapore. https://doi.org/10.1007/978-981-16-8721-1_53
13. Taher, K. A., Jisan, B. M. Y., & Rahman, M. M. (2019). Network intrusion detection using supervised machine learning technique with feature selection. In *2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)* (pp. 643–646). IEEE.
14. Elsayed, M. S., Le-Khac, N.-A., & Jurcut, A. D. (2020). Insdn: a novel sdn intrusion dataset. *IEEE Access, 8*(165), 263–165 284.
15. Althubiti, S. A. Jones, E. M., & Roy, K. (2018). Lstm for anomaly-based network intrusion detection. In *2018 28th International Telecommunication Networks and Applications Conference (ITNAC)* (pp. 1–3) IEEE.
16. Jain, A., Sharma, Y. & Kishor, K. (2021). Prediction and analysis of financial trends using Ml algorithm (July 11, 2021). In *Proceedings of the International Conference on Innovative Computing & Communication (ICICC) 2021*, Available at SSRN: https://ssrn.com/abstract=3884458 or https://doi.org/10.2139/ssrn.3884458
17. Elsayed, M. S., Le-Khac, N.-A., Dev, S., & Jurcut, A. D. (2020). Ddosnet: A deep-learning model for detecting network attacks. In *2020 IEEE 21st International Symposium on" A World of Wireless, Mobile and Multimedia Networks"(WoWMoM)* (pp. 391–396) IEEE.
18. Gupta, S., Tyagi, S., & Kishor, K. (2022). Study and development of self sanitizing smart elevator. In D. Gupta, Z. Polkowski, A. Khanna, S. Bhattacharyya, & O. Castillo (Eds.),

Proceedings of Data Analytics and Management. Lecture Notes on Data Engineering and Communications Technologies (Vol 90). Singapore : Springer. https://doi.org/10.1007/978-981-16-6289-8_15

19. Sharma, A., Jha, N., Kishor, K. (2022). Predict COVID-19 with Chest X-ray. In D. Gupta, Z. Polkowski, A. Khanna, S. Bhattacharyya, & O. Castillo (Eds.), *Proceedings of Data Analytics and Management. Lecture Notes on Data Engineering and Communications Technologies* (Vol. 90). Singapore: Springer. https://doi.org/10.1007/978-981-16-6289-8_16
20. Kishor, K., Tyagi, R., Bhati, R., & Rai, B. K. (2023). Develop model for recognition of handwritten equation using machine learning. In *Proceedings of international conference on recent trends in computing. Lecture notes in networks and systems.* Singapore: Springer. https://doi.org/10.1007/978-981-19-8825-7
21. Kishor, K., Saxena, N., Pandey, D. (2023). *Cloud-based intelligent informative engineering for society 5.0* (1st edn., pp. 1–234). New York: Chapman and Hall/CRC. eBook ISBN: 9781003213895. https://doi.org/10.1201/9781003213895
22. Kishor, K., Pandey, D. (2022). Study and development of efficient air quality prediction system embedded with machine learning and IoT. In D. Gupta et al. (Eds.), *Proceeding international conference on innovative computing and communications. Lecture notes in networks and systems* (Vol. 471). Singapore: Springer. https://doi.org/10.1007/978-981-19-2535-1_24
23. Elsayed, M. S., Le-Khac, N.-A., & Jurcut, A. D. (2021). Dealing with covid-19 network traffic spikes [cybercrime and forensics]. *IEEE Security & Privacy, 19*(1), 90–94.
24. Kishor, K., & Nand, P. (2023). Wireless networks based in the cloud that support 5G. In *Cloud-based intelligent informative engineering for society 5.0* (1st edn., pp. 23–40). New York: Chapman and Hall/CRC. eBook ISBN: 9781003213895. https://doi.org/10.1201/9781003213895-2
25. Jahromi, H. Z., & Delaney, D. T. (2018). An application awareness framework based on SDN and machine learning: Defining the roadmap and challenges. In *2018 10th International Conference on Communication Software and Networks (ICCSN)* (pp. 411–416). IEEE.
26. Rai, B. K., Sharma, S., Kumar, G., & Kishor, K. (2022). Recognition of different bird category using image processing. *International Journal of Online and Biomedical Engineering (iJOE), 18*(07), 101–114. https://doi.org/10.3991/ijoe.v18i07.29639
27. Kishor, K. (2023). Impact of cloud computing on entrepreneurship, cost, and security. In: *Cloud-based intelligent informative engineering for society 5.0* (1st edn., pp. 171–191). New York: CRC Press. eBook ISBN: 9781003213895. https://doi.org/10.1201/9781003213895-10
28. Khan, R. U., Zhang, X., Alazab, M., & Kumar, R. (2019). An improved convolutional neural network model for intrusion detection in networks. In: *2019 Cybersecurity and Cyberforensics Conference (CCC). IEEE* (pp. 74–77).
29. Yong, L., & Bo, Z. (2019). An intrusion detection model based on multi-scale cnn. In: *2019 IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC)* (pp. 214–218). IEEE.
30. Hu, Z., Wang, L., Qi, L., Li, Y., & Yang, W. (2020) A novel wireless network intrusion detection method based on adaptive synthetic sampling and an improved convolutional neural network. *IEEE Access, 8*, 195741–19195 751.
31. Xiao, Y., Xing, C., Zhang, T., & Zhao, Z. (2019). An intrusion detection model based on feature reduction and convolutional neural networks. *IEEE Access, 7*, 42210–42219.
32. Jiang, K., Wang, W., Wang, A., & Wu, H. (2020). Network intrusion detection combined hybrid sampling with deep hierarchical network. *IEEE Access, 8*, 32464–32476.
33. Gu, J., Wang, Z., Kuen, J., Ma, L., Shahroudy, A., Shuai, B., Liu, T., Wang, X., Wang, G., Cai, J., et al. (2018). Recent advances in convolutional neural networks. *Pattern Recognition, 77*, 354–377.
34. Khan, A., Sohail, A., Zahoora, U., & Qureshi, A. S. (2020). A survey of the recent architectures of deep convolutional neural networks. *Artificial Intelligence Review, 53*(8), 5455–5516.

Mine Safety Monitoring System Based on WSN

Avni Sharma, Arpit Kumar, Yamini Gupta, Aaradhya Nain, Rachit Patel, and Ahmed Alkhayyat

Abstract Rapid infrastructure development and expanded automobile production are helping India's mining sector. With all of this, plus millions of people working in mines, there is a considerable potential of mine hazards, resulting in substantial losses of resources/assets and human life. The environment in underground mines has a considerable impact on production, productivity, and safety management. Mines must be constantly monitored, but human observation is dangerous; hence, mine surveillance without human intervention is essential. As a consequence, a wireless sensor network (WSN) is proposed for the safe and intelligent wireless monitoring of elements that contribute to coal mine disasters, such as toxic flammable gases, high temperature, humidity, and pressure, using low-cost and low-power consuming NodeMCU. The proposed WSN identifies the parameters, and based on the criteria, immediate notifications can be sent to any rising or possible threat arising, speeding up the evacuation procedure. These real-time values are accessible through the live status, password-protected dashboard. The system itself is an efficient, low-cost, and low-power consuming as the used NodeMCU is inclusive of Wi-Fi module; therefore, no need of external transceiver for communication.

Keywords NodeMCU ESP8266 · Wireless sensor network · Monitoring system · TCP · IP · HTTP · SSE · VS Code · JSON · LittleFS · XAMPP · PHP

1 Introduction

Coal is extracted from the ground via coal mines. Coal is used to extract iron from iron ore and to make cement in the steel and cement industries. Its paramount use has always been to generate heat energy. Petroleum and natural gas have supplanted

A. Sharma · A. Kumar · Y. Gupta · A. Nain · R. Patel (✉)
Electronics and Communication Engineering, ABES Institute of Technology, Ghaziabad, India
e-mail: rachit05081gece@gmail.com

A. Alkhayyat
College of Technical Engineering, The Islamic University, Najaf, Iraq
e-mail: ahmedalkhayyat85@iunajaf.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_9

it as the world's major energy suppliers. Surface and underground coal mining is today a highly profitable and industrialized operation. Temperature, humidity, carbon monoxide (CO), sulfur dioxide (SO_2), and methane content in the air are the major reasons that influence problems for miners working underground [1]. The increased demand for coal results in a significant expansion of coal mines around the world. As a result, the miners working in these mines are numerous, and their safety takes precedence. While scientific improvements and firm safety regulations have reduced coal mining-related deaths, accidents are still too common. Underground mine wiring requires constant supervision, and the manual interference expected for this safety precaution is extensive and time-consuming. So, our proposed system will monitor the parameters, which are critical for safety, and it will then be transmitted on a regular basis to the control room. The alarm is triggered if the measured values exceed a specified limit [2]; data transmitted via wireless technology NodeMCU is observed through the web server in the control room [3, 4].

Wireless technology is utilized to prevent disasters or explosions caused by a breakdown in electrical wiring maintenance. The monitoring of these indicators is crucial in ensuring the miners' safety. A WSN is made up of spatially dispersed sensors and one or more sink nodes. A WSN, unlike other network systems, has its own design and resource constraint. Less processing power, a limited range of communication, and storage issues are among the drawbacks. Many earlier used systems have been using different microcontrollers such as Arduino Uno, MSP430, CC253, STCT89S52, Atmega328p, AVR microcontroller, and MSP430 [1–9]. The Arduino Uno microcontroller is used to monitor individual's health. A smoke sensor, a heartbeat sensor, and a respiratory sensor are used in the proposed system to monitor the smoke in the mine area as well as mine workers' health characteristics such as heartbeat and respiration rate [1]. MSP430 is used in the mine gas integrated sensor alerting system. It has the potential to be used in mine inspection [2]. The wireless communication system consists of radio frequency data collectors, routers, and a coordinator; therefore, the proposed system's data collectors, routers, and coordinators are built using Texas Instruments' CC2530-based ZigBee development boards. Three major components make up the complete system: sensor board tailored to the application, low-power wireless data transfer system, and data collecting and management [3]. The front and terminal two subsystems of a multipoint methane monitoring and control system based on the wireless transceiver chip nRF2401 are introduced [4]. Using Arduino Uno, a mine safety helmet is designed for real time monitoring of mine parameters as well as usage of NRF24L01 module for wireless communication [5]. Specifications for a portable wireless indicator for underground mines are given in [6]. This indicator was created by polling multiple access methods and it can communicate with multiple transmitters at the same time and without any data inconsistencies. Here, a smart safety helmet is implemented with the use of Arduino Uno and Lab view is used for monitoring the carbon monoxide and methane concentration [7]. The Atmega 328p-pu-based microcontroller board is combined with the Xbee Shield to provide a multimode sensor platform [8]. In [9], the WSN is based on AVR microcontroller for the surveyance of the parameters. Now, here

Table 1 Major coal mining disasters over the years

Reference [11]	Place	Year	Fatalities	Reason of disaster
Benxihu Colliery disaster	Liaoning province, China	1942	1549	Coal dust explosion
Dhanbad Coal Mine Disasters	Dhanbad, India	1975	372	Coal dust explosion
Upper Big Branch Mine disaster	West Virginia, USA	2010	29	Coal dust explosion
Anjan Hill Explosion	Maharashtra, India	2010	14	Coal dust explosion
Raspotocje mine	Bosnia	2014	5	Earthquake
Gypsum Mine (Pingyi)	Shandong Province, China	2015	75	Construction
Lalmatia open cast coal mine	Rajasthan, India	2016	17	Landslide
Diaoshuidong colliery	Chongqing, China	2020	18	Poisonous gas leakage

represents a list of death tolls [10] caused due to various disturbances in the mine environment (Table 1).

2 Proposed system

The sensing unit is considered first in our proposed system, followed by the complete monitoring section or the coordinate unit. The proposed system's basic architecture is depicted in Fig. 1. The sensing unit consists of various sensors such as temperature sensor, humidity sensor, pressure sensor, and an alerting device called buzzer or alarm. And, coordinate unit has the control room where the web server or webpage is present, showing the real-time values.

3 System Working

WSN is used in the complete perception, which receives underground parameters and transmits it to a Wi-Fi and IP-enabled gateway for additional data communication with the web server. The sensing unit is the most important part of the system. All those components mentioned above are integrated to the NodeMCU (Esp8266). The code for the proposed system has been compiled on the Arduino IDE. The sensors detect harmful and inflammable gases such as carbon dioxide and carbon monoxide, temperature, atmospheric pressure as well as humidity level. They sense a specific level of parameters and transmit the information to the base station. If those sensor values rise beyond a certain threshold, the NodeMCU will sound a buzzer connected

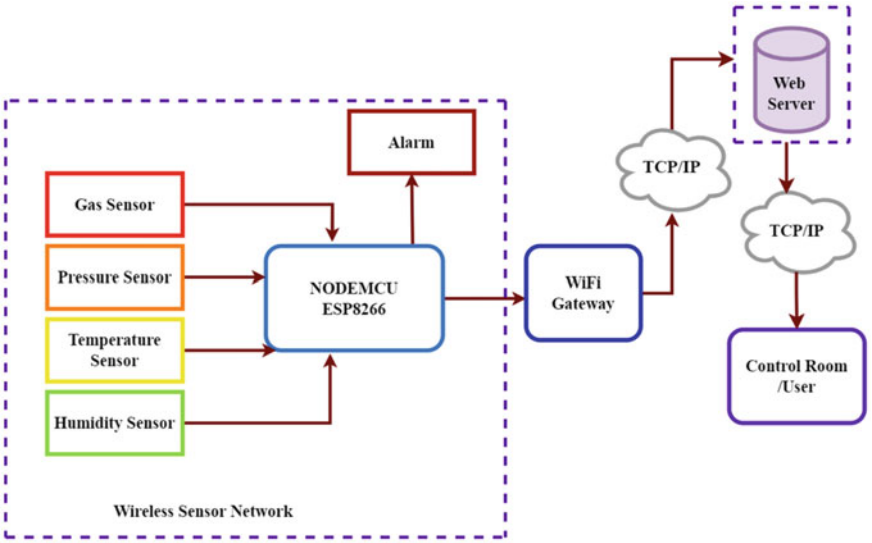


Fig. 1 Block diagram of proposed system

to it. The data is then communicated to the monitoring section via Wi-Fi, TCP/IP, HTTP, and SSE. The SSE feature allows the browser to receive automatic updates from a server over an HTTP connection on a NodeMCU Web Server created in Arduino IDE. Thus, in the monitoring section, a webpage is created using HTML5, CSS, and JavaScript for evaluating the sensed data, the login and register pages are configured using XAMPP to provide a local host and server for the website, and PHP is used as the backend scripting language. Firstly, a password-protected login page will appear which can be accessed by the supervisor or the registered user only by entering their credentials. When a user logs in to the dashboard, it is directed to the coordinator. Furthermore, real-time data for the corresponding parameters is displayed on the dashboard. The complete process flowchart is shown below (Fig. 2).

4 Results

4.1 Sensor Unit

Figure 3 depicts the proposed system's implementation. The threshold or limit value is received by the sensor. The microcontroller's output decides whether the buzzer is turned on or off. The results produced from the mining environment are constantly updated on the IoT portal.

The MQ4 sensor threshold percentage is set 5% as shown in Table 2, i.e., because the range between LEL and UEL is known as the flammable range, and as the name

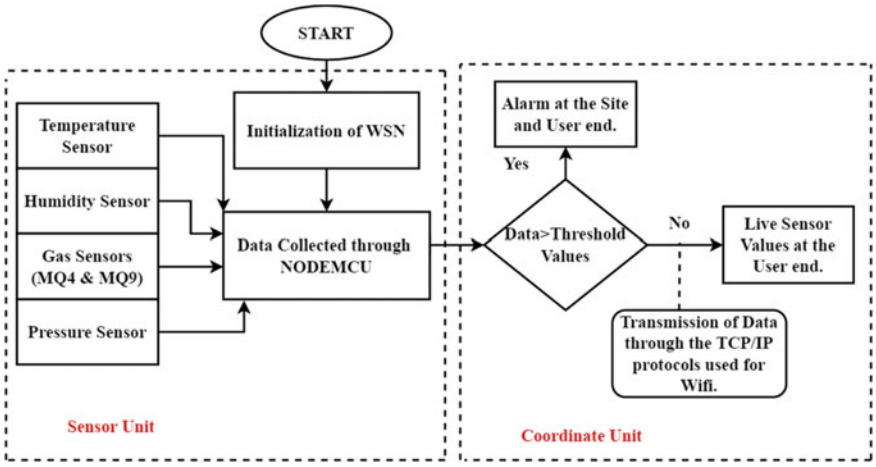


Fig. 2 WSN flow design

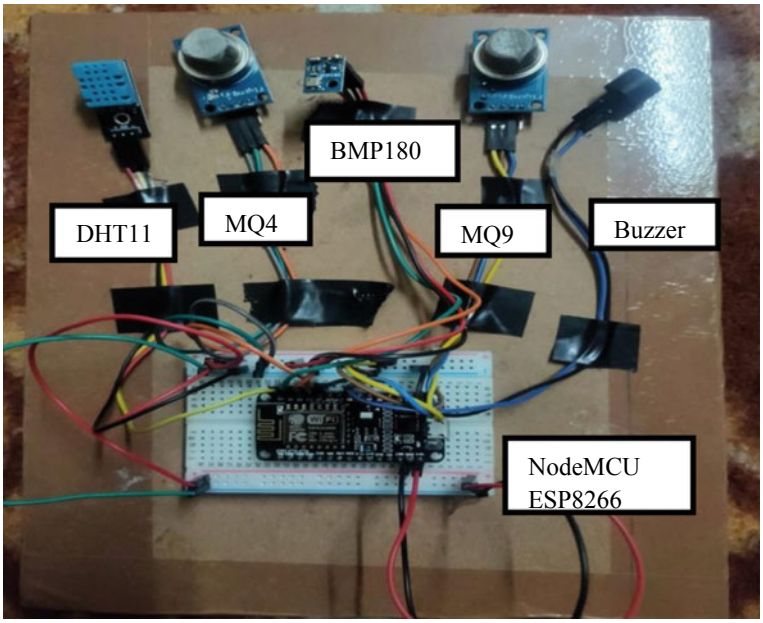


Fig. 3 Proposed system's hardware prototype

implies this is when fire/explosions will occur. For methane, the LEL is 5% and UEL is 15%, whereas 9% is considered the most volatile state of concentration.

For the MQ9 sensor, the threshold is set to be 450ppm (as CO is a toxic gas) and the >450ppm causes nausea and dizziness or complete black out. Temperatures above

Table 2 Threshold limit of sensing parameters [12]

Sensor name	Sensing parameters	Sensor range	Threshold set	Health hazard
MQ4	Methane, natural gas	300–10,000 ppm	5%	> 5%-Asphyxiation
MQ9	Carbon monoxide, LPG	10–1000 ppm	450 ppm	>450 ppm-Nausea, dizziness >1000 ppm-Death after one hour of exposure
DHT11	Temperature	0–50 °C	49 °C	>49 °C-Hyperthermia
DHT11	Humidity	0–80 °C	70%	Dehydration, fatigue
BMP180	Barometric pressure	300–1100 hPa	–	–

50 °C can cause hypothermia if the values from the DHT11 sensor are exceeded. Similarly, the threshold range for humidity is set to be 70% as high humidity due to rise in temperature of the underground mines causes dehydration, stroke, and fainting.

There is some possibility for airborne contaminants to become more harmful when barometric pressure rises, however, as ambient pressure rises, so do partial pressures of other gases in the atmosphere, including oxygen. As a result, the higher barometric pressure at a mining depth of 5000 m would have no effect on gaseous pollutant toxicity [13, 14]. Therefore, for BMP180 which has the range 300–1100 hPa, does not require threshold. The system was tested at household level to ensure that it adhered to a defined range. When the readings collected from the sensors exceed the defined threshold, the environment is considered abnormal, and the buzzer is activated.

4.2 Monitoring Unit

As illustrated in Fig. 1, the data collected from the coal mining environment is regularly updated in the monitoring area via NodeMCU. A password-protected dashboard is constructed using Visual Studio Code for reviewing sensed data at the intersection of WSN and Wi-Fi gateway, as illustrated below [15]. The Wi-Fi gateway is first initialized, after which it looks for and locates the secure network. As a result, the allocated webpage has a distinct IP address and a buffer size for incoming and outgoing data packets. As a result, obtaining sensor data and displaying it on the webpage [16] (Fig. 4).

When a user logs in to the dashboard, it takes them to the live status page. Furthermore, data for the related parameters is shown on the homepage (Fig. 5).

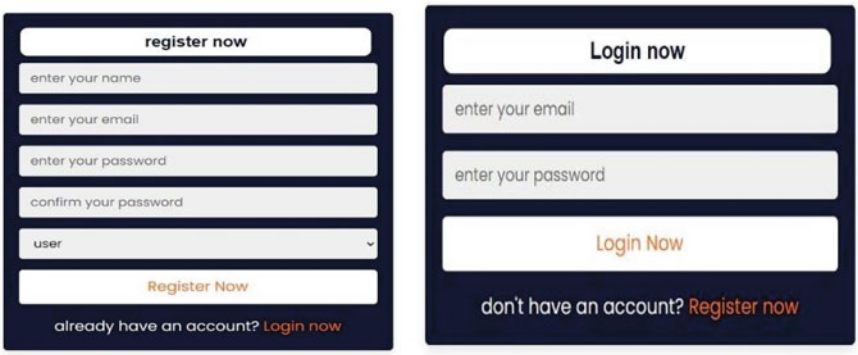


Fig. 4 Register page and login page output screen

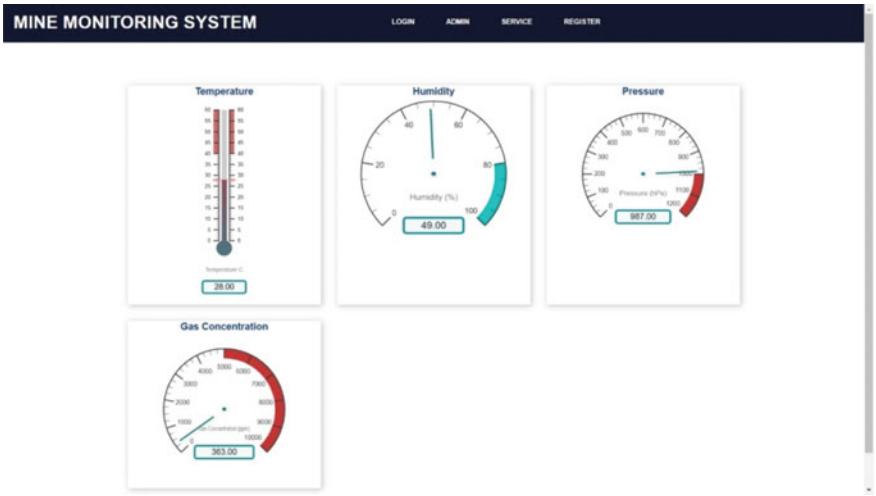


Fig. 5 Live status page, which represents various gauges for monitoring the real-time live values

4.3 Comparison

The proposed system is compared with some existing mine safety and health monitoring systems to highlight some merits of the system. As the Table 3 shows, the microcontrollers used by the existing systems are mainly Atmega microcontrollers with different technologies like LoRaWAN, ZigBee, ASK, and NRF240 making it expensive but we have used NodeMCU which has the feature of in-built Wi-Fi module as the communication technology and is cheaper too. Wi-Fi-enabled devices, while consuming more power, can send more data faster than ZigBee-enabled devices. Also, in different regions, LoRa uses distinct frequency bands, whereas Wi-Fi is universally standardized. The sensors used provide better accuracy of the mine

Table 3 Comparison with existing system (involving mine safety and health monitoring)

References	Microcontroller used	Technology	Sensor used	Cost
[1]	Arduino Mega 2560	LoRaWAN	MQ8, heartbeat sensor, respiratory sensor	INR 2550
[5]	Atmega 2560	NRF24L01	DHT11, MQ4	INR 1600
[6]	Atmega328	ASK	DHT22, BMP180	INR 2150
[8]	Atmega328p-pu	ZigBee	Temperature, humidity, gas sensors	INR 6000
Our proposed system	NodeMCU Esp8266	Wi-Fi	DHT 11, MQ4, MQ9, BMP180	INR 1300

parameters [17]. Thus, our proposed system is much better in terms of accuracy, power, connectivity, technology, and cost.

5 Conclusion and Future Scope

The rising number of mining accidents occurring each year highlights the need to implement effective safety measures for mine workers. To automate mine monitoring and communication, an integrated system based on the WSN is introduced; the suggested method improves safety, operational management, and lowers operating expenses. The system has a monitoring system for the underground environment of a coal mine that monitor's data in real time and transfer it to the monitoring section. It also has the benefits of easy networking, high adaptability and expansibility, and inexpensive installation and maintenance costs, all of which are critical to the safety production and intelligent level of mines. It is also a less expensive alternative due to the use of low-power consumption wireless sensors and the inclusion of a Wi-Fi module in the NodeMCU. It can, however, be changed to match the needs of individual coal mines, depending on the environment. In comparison with standard wire data gathering method, this technology is simple, inexpensive, and fast. The web page is constantly updated with information on the mineworkers' surroundings. Hence, it is both affordable and efficient. Wireless sensor networks will be widespread in the future, allowing future technology, the environment, and infrastructure to be as smart as feasible. The range of our proposed system can be extended by constructing a mesh wireless network. Wi-SUN protocol can be employed since it provides high data rates and Wi-SUN-based network devices have a battery life of roughly 15 years. The system's size will also be reduced due to the flexible PCB.

References

1. Porselvi, T., Ganesh, S., Janaki, B., & Priyadarshini, K. (2021). IoT based coal mine safety and health monitoring system using LoRaWAN, In *2021 3rd International Conference on Signal Processing and Communication (ICPSC)* (pp. 49–53). https://doi.org/10.1109/ICSPC51351.2021.9451673
2. Guan, J., & Wang, X. (2009). Application of integrate sensor in gas alert system of coal mine. *International Workshop on Intelligent Systems and Applications, 2009*, 1–3. https://doi.org/10.1109/IWISA.2009.5072745
3. Dohare, Y. S., Maity, T., Paul, P. S., & Prasad, H. (2016). Smart low power wireless sensor network for underground mine environment monitoring. In *2016 3rd International Conference on Recent Advances in Information Technology (RAIT)* (pp. 112–116). https://doi.org/10.1109/RAIT.2016.7507885
4. Zhang, P., Ma, L., & Li, H. (2012). Design of wireless mine gas monitoring and control system based on nRF2401. *International Conference on Computer Science and Service System, 2012*, 1051–1054. https://doi.org/10.1109/CSSS.2012.266
5. Mishra, A., Malhotra, S., Ruchira, Choudekar, P., & Singh, H. P. (2018). Real time monitoring & analyzation of hazardous parameters in underground coal mines using intelligent helmet system. In *2018 4th International Conference on Computational Intelligence & Communication Technology (CICT)* (pp. 1–5). https://doi.org/10.1109/CIACT.2018.8480177
6. Indra, S., Barik, S., & Pati, U. C. (2018). Design of portable indicator for underground mines using 433 MHz wireless communication. In *2018 2nd International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech)* (pp. 1–5). https://doi.org/10.1109/IEMENTECH.2018.8465257
7. Hazarika, P. (2016). Implementation of smart safety helmet for coal mine workers. In *2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES)* (pp. 1–3). https://doi.org/10.1109/ICPEICES.2016.7853311
8. Mishra, P. K., Kumar, S., Pratik, et al. (2019). IoT based multimode sensing platform for underground coal mines. *Wireless Pers Commun, 108*, 1227–1242. https://doi.org/10.1007/s11277-019-06466-z
9. Khurana, C., Ahluwalia, P., Varshney, M., & Pandey, S. (2018) Surveyance of ambient conditions in mines using intelligent sensor nodes. In *2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI)* (pp. 1126–1131). https://doi.org/10.1109/ICOEI.2018.8553962
10. Kumar, S., & Chouksey, S. (2021). Gas leakage source localization and boundary estimation using mobile wireless sensor network. In *2021 2nd International Conference on Computation, Automation and Knowledge Management (ICCAKM)* (pp. 276–281). https://doi.org/10.1109/ICCAKM50778.2021.9357732
11. The World's Worst Coal Mining Disasters. [online]. Available: https://www.mining-technology.com/features/feature-world-worst-coal-mining-disasters-china/
12. Majee, A. (2016). IoT based automation of safety and monitoring system operations of mines. In *2016 SSRG International Journal of Electrical and Electronics Engineering* (Vol.3, No.9, pp. 17–21).
13. Shahzad, K., & Oelmann, B. (2014). A comparative study of in-sensor processing vs. raw data transmission using ZigBee, BLE and Wi-Fi for data intensive monitoring applications. In *2014 11th International Symposium on Wireless Communications Systems (ISWCS)* (pp. 519–524). https://doi.org/10.1109/ISWCS.2014.6933409
14. Franz, R. M., & Schutte, P. C. (2005). Barometric hazards within the context of deep-level mining. *Journal of The South African Institute of Mining and Metallurgy, 105*, 387–389.
15. Singh, R., & Sharma, D. K. (2020). Fault-tolerant reversible gate based sequential QCA circuits: Design and contemplation. *Journal of Nano-electronics and Optoelectronics, American Scientific Publications, 15*(4), 331–344.

16. Sharma, R., Kumar, R., Sharma, D. K., Son, L. H., Priyadarshini, I., Pham, B. T., Bui, D. T., & Rai, S. (2019). Inferring air pollution from air quality index by different geographical areas: A case study in India. In *Air Quality, Atmosphere & Health.* Springer Publication.
17. Sharma, D. K., Kaushik, B. K., & Sharma, R. K. (2014). Impact of driver size and interwire parasitics on crosstalk noise and delay. *Journal of Engineering, Design and Technology, 12*(4), 475–490 (Emerald Pub., UK).

Comparative Analysis of Dual Metal Gate Fully Depleted SOI FET With/Without δ-Doped Insulated Layer for AF Application

Jay Prakash Narayan Verma and Prashant Mani

Abstract This paper presents and compares dual metal gate fully depleted SOI FET with/without δ-doped insulated layer for thermal efficacy, scalability and analog/RF performance. In the proposed device, a delta doped layer (DMG SOI FET-δ) is incorporated to boost its analog performance. Also, the proposed study analyzes the effect on transconductance, and voltage gain from several structural characteristics. The doped layer is seen to minimize the self-heating and enhance analog parameters such as trans-conductance, output conductance and transconductance generation factor over DMG SOI FET. Furthermore, the diminished short-channel impacts such as DIBL, subthreshold swing and parasitic capacitances make the scaling possible. The brief introduction of fabrication flow of DMG SOI FET-δ has been proposed. The comparison has been done between DMG SOI FET-δ and DMG SOI FET, to validate the advantages of the proposed structure for the realization of low power and high-frequency applications.

Keywords Silicon-on-insulator · Dual-material gate

1 Introduction

The silicon-on-insulator metal oxide semiconductor field effect transistor (SOI-MOSFET) has several distinct qualities, including decreased parasitic capacitance, protection against electrostatic discharge, fewer short-channel impacts (SCEs), lower noise and low subthreshold slope [1–3]. To overcome this difficulty, many topologies have been proposed, including thin film fully depleted (FD-SOI), graded-channel FD-SOI, halo-doped FD-SOI, ground plane FD-SOI and various gate designs. In addition, they have outstanding compliance, higher resistance to radiation, lesser

J. P. N. Verma (✉) · P. Mani
SRM-IST NCR Campus, Modinagar, Ghaziabad 201204, India
e-mail: jpnverma2@gmail.com

P. Mani
e-mail: prashanm@srmist.edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_10

fringing capacitance, protection for latch up, high speed, high-temperature and high-repetition execution. These attributes have inspired the ongoing research based on SOI-integrated circuits (ICs). Partially or fully depleted SOI is MOSFETs which have SiO_2 as an insulating layer compared to the silicon substrate, and based on the width of the BOX are grouped as PD/FD depleted SOI (PD/FD-SOI). The device is deemed fully depleted if the depth of the depletion region is equal to the thin layer of silicon deposited as the channel region. In our proposed device DMG SOI FET-***δ,*** we have incorporated a thin silicon layer thus making a fully depleted device which can endure higher gate voltages [4]. To benefit from better SCIs in fully depleted SOI, a very thin substrate should be utilized [5–7]. The SOI facilitates pairing in thin substrate structures while reducing random dopants variations (RDVs) [8, 9]. As a result, various low power and high-performance devices are being created using the FD-SOI, which makes low threshold voltage possible [10–12]. This leads to the existing need and interest in the FD-SOI devices as they seem very promising for the future downscaling needs. The study of FD-SOI will also aid the intense competition and the developing research societies [13–15].

Electrostatic coupling present among source-drain (S-D) and the channel is the biggest hurdle in scaling of DMG SOI FETs [1]. To improve the performance, many structures have been proposed, including thin film FDSOI, nanowire FET, Tunnel FET [2]. Thin film FD-SOI seems to be the most lucrative of the options since it has a planar structure and can be effective against the short-channel effects [3]. However, few drawbacks like degraded channel mobility, larger miller capacitances and a risen self-heating affect their use for analog applications [4–6].

Long et al. [17] in 1999 suggested a novel gate material engineering technique known as dual-material gate (DMG)-FET that had positive impact on the carrier transport efficiency along with the SCEs. The choice of the work functions for the metal gates is done in a way such that work function for the part of gate (M1) closer to source is kept greater than the one closer to the drain (M2) for an n-channel MOSFET. The pattern is reversed for a p-channel MOSFET.

In this work, we propose a p-type doped delta film DMG SOI FET-***δ***. The addition of p-type delta doped under the channel hinders the fringing field lines initiating from the drain and minimizes the random dopant variations triggered threshold voltage variations. These factors along with the minimization of the SCEs including DIBL, Vth roll-off and self-heating reduction make this device a suitable candidate for downscaling. Gate material engineering in the DMG structure proposed in this work effectively minimizes the SCEs and presents enhanced carrier transport efficiency and improved transconductance. The potential step is formed within the channel in such novel arrangements, imparting more consistency across the channel. Many concerns, such as the influence of submicron on SOI, are yet to be calculated.

2 Device Design and Structure

The thickness of the silicon layer and the channel doping determines the device is partially/fully depleted on the SOI. In the fully depletion structures, the channel doping concentration is often kept low in order to prolong the gate depletion zone throughout the thickness of the silicon layer.

Figure 1a illustrates the two-dimensional cross-sectional view of our proposed delta doped dual-material gate SOI FET structure. A BOX film (thickness = 30 nm) is below the silicon substrate (thickness = 15 nm). To dope the source/drain of the transistor, N-type material ($1 \times 10^{20}/cm^3$) is used, whereas for the channel doping which has a length of 60 nm P-type doping ($1 \times 10^{16}/cm^3$) is done. The device design values are given in Table 1. As shown in Fig. 1b, the conventional structure is calibrated to show that the simulation and model values of the SOI-MOSFET structure are in accordance [16]. For the majority charge carriers, the recombination and generation at the Si–Si and SOI intersection are accounted for utilizing the Shockley–Read–Hall model [17].

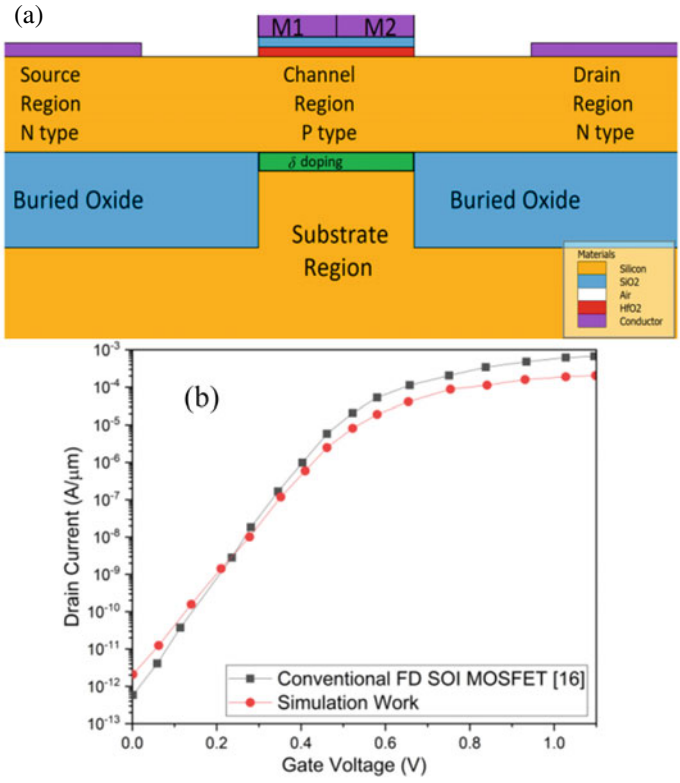


Fig. 1 **a** Cross-sectional representation of **DMG SOI FET-δ** **b** experimental drain curve

Table 1 Design parameters of delta doped DMG-FD-SOI MOSFET

S. no.	Device parameters	Values
1	Physical gate length	60 nm
2	Gate work functions ($Ø_{M1}$ and $Ø_{M2}$)	4.3 and 4.1
3	BOX thickness (T_{box})	30 nm
4	Silicon substrate layer width (t_{si})	15 nm
5	Gate oxide thickness ($SiO_2 + HfO_2$)	(1 + 1) nm
6	Source/drain doping value	N-Type $1 \times 10^{20}/cm^3$
7	Channel doping	P-Type $1 \times 10^{16}/cm^3$
8	Gate metal length (L_1 and L_2)	30 nm and 30 nm
9	Doping value of p-type δ-layer	$1 \times 10^{19}/cm^3$
10	Thickness of ™-layer	5 nm

The post-low-energy instilling selective epitaxy approach is utilized to construct a p-type doped zone under the channel. Low-energy boron implantation is used in this process to form the doped layer, which is then trailed by the development of an undoped silicon epitaxial film.

3 Simulation Results Analysis and Discussion

The simulations have been performed in SILVACO ATLAS TCAD [3]. The simulations have been performed on an n-channel DMG SOI FET with/without δ doped structured in TCAD tool. For a DMG SOI FET, the chosen work function values of M1 and M2 are 4.3 and 4.1 eV, respectively.

1. Fabrication flow of DMG SOI FET-$\boldsymbol{\delta}$

The suggested manufacturing steps for producing the DMG SOI FET device, which employ a partly insulated oxide structure to build the final device structure. The material utilized for doping is a p-type Si. The silicon film is then epitaxial developed on this substrate, trailed by the deposition of SiO_2 and HfO_2 masks. After all of the layers have grown, the Si layers from the active region are etched away to reveal the film [18–20]. After removing the mask films from the non-exposed portion, the silicon is developed through the device. Trench isolation and oxidation procedures are employed to form the partial BOX beneath the source and drain. To do this, the SiO_2 and HFO_2 mask layers are re-deposited.

2. I_Δ versus V_{DS} characteristics

Figure 2 depicts the output characteristics of DMG SOI FET with and without delta doped for various V_{dS} values. At various drain biases, drift–diffusion simulations combined with the lattice heat equivalence were performed to achieve these properties [21–23]. It is clear from the figure that there is a considerable change in drain

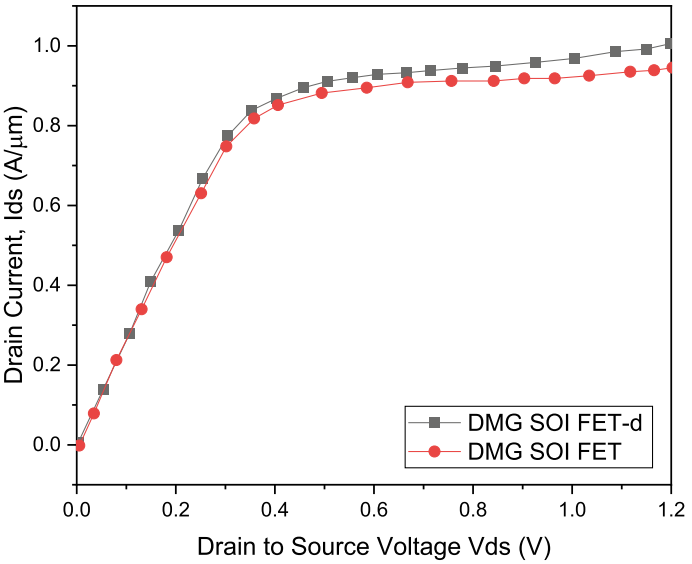


Fig. 2 Drain current with respect to V_{DS} outcomes of DMG SOI FET-***δ*** and DMG SOI FET-***δ*** impact for $L_\Gamma = 60$ nm at $V_{GS} = 1$ V

outcomes of both DMG SOI FET and DMG SOI FET-***δ***. This variation in the output is caused predominantly by the decline in the channel mobility owing to the thermal impacts. Additionally, for DMG SOI FET-***δ***, the output characteristics at $V_{gs} = 1$ and $V_{ds} = 1.2$ are shown in Fig. 2.

3. *Parasitic capacitance evaluation*

Because parasitic capacitances, namely gate-source capacitance (C_{gs}) and gate-drain capacitance (C_{gd}), are significant factors for analog frequency applications [24], and these components must be obtained for both topologies.

Figure 3 indicates the variation of these capacitances with VGS for DMG SOI FET and DMG SOI FET-***δ***. C_{gs} in DMG SOI FET-***δ*** is much larger than in DMG SOI FET, as seen in the figure. The discrepancy in parasitic capacitances is mostly attributable to device dimension modifications. Because the Miller capacitance between S/D and the gate is large in the DMG SOI FET-delta doped structure, Cgs is high [6]. While for the DMG SOI FET, the C_{gs} is low as anticipated from the two-dimensional structures. Likewise, the gate-drain capacitances in DMG SOI FET are almost identical, indicating that the suggested alteration in DMG SOI FET does not significantly modify the parasitic capacitances [22].

4. *DC performance*

Figure 4 depicts the fluctuation of the drain current as a function of VGS in a log scale for DMG SOI FET and DMG SOI FET-δ. The output current in the case of DMG SOI FET is smaller than in the case of DMG SOI FET, as seen in the figure.

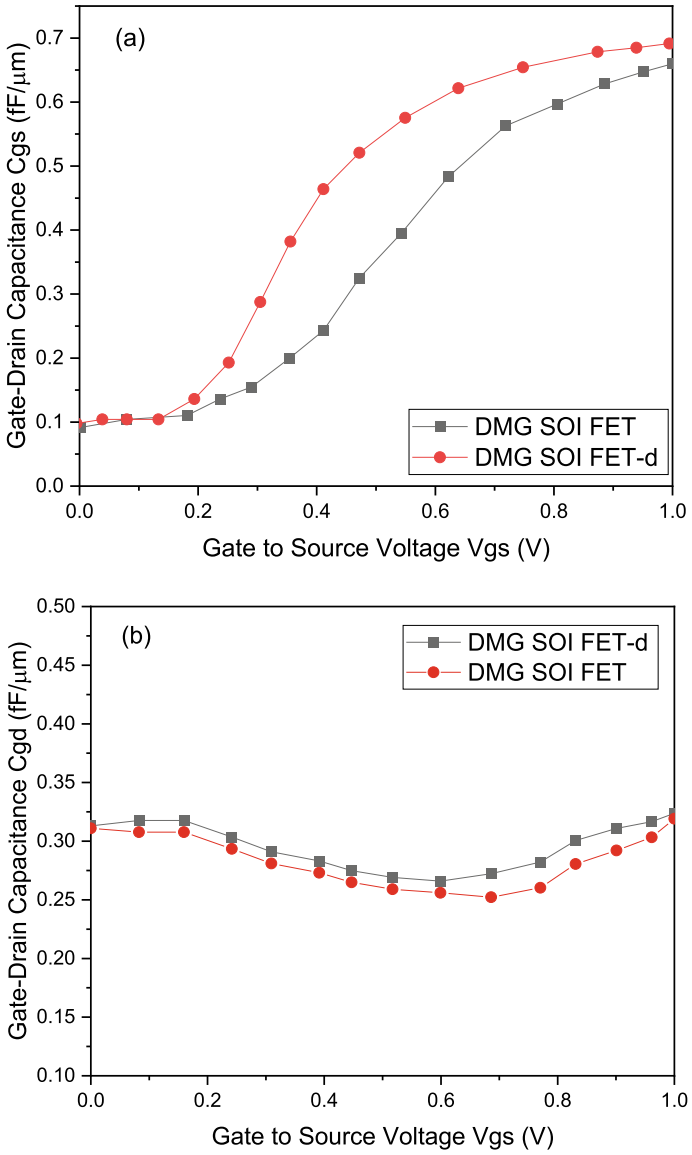


Fig. 3 Change in **a** Gate-Drain capacitance C_{gs} and **b** Gate-Drain capacitance (C_{gd}) along Gate to source Voltage (V_{GS}) for DMG SOI FET and DMG SOI FET-$\boldsymbol{\delta}$ for $L_\Gamma = 60$ nm

The source/drain to channel contact resistance is the primary cause of this decrease in driving current. The introduction of the delta doped layer reduces the contact resistance at this intersection. This is due to the existence of a delta doped layer beneath the channel, which improves the output current driving capabilities of DMG SOI FET structure. Additionally, as illustrated in Fig. 6, the existence of the delta doped below the channel cuts off the route of the fringing field lines emanating from the drain and minimizes the short-channel effects of proposed structure.

5. *Analog performance*

The AF presentation of a device is attributed to the trans-conductance (*gm*), output conductance (*gd*) and transconductance generation factor (*gm/ID*), which depends inversely on drain current (I_D) [18]. *gm* symbolizes the amplification produced by the structure and I_D signifies the power dispersed to get that amplification, making *gm/ID* a notable factor to study for AF performance [22]. Good transconductance generation factor depicts greater function and efficiency of the device for analog applications [23].

Using the first-order models of long-channel MOSFET theory, the gm/I_D in weak and strong inversion zones may be calculated.

Figure 5 shows the change in gm/ID as a utility of the drain current for DMG SOI FET and DMG SOI FET-***δ*** for $L_G = 60$ nm. In a weak inversion section, gm/I_D in of DMG SOI FET-***δ*** is higher among the two because of the lessening in subthreshold slope. Whereas, in a strong inversion section, *gm/ID* in both the cases of DMG SOI FET and DMG SOI FET-***δ*** **devices** is almost equal. This is mostly due to a decrease

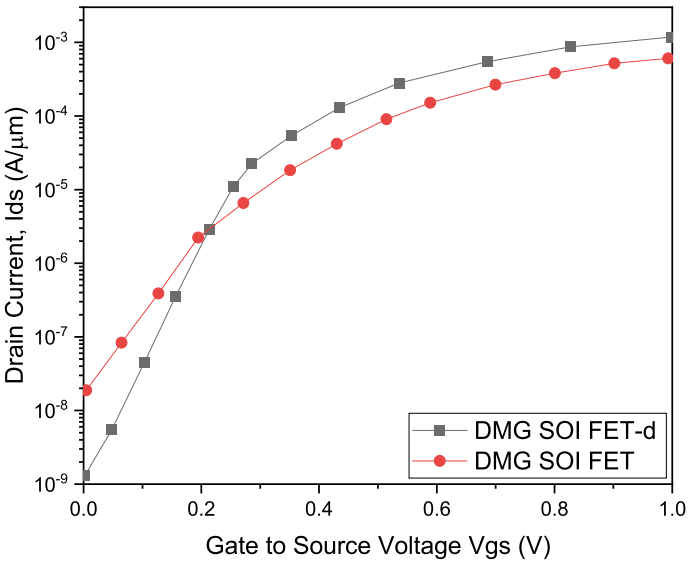


Fig. 4 I_Δ versus V_{GS} characteristics of DMG SOI FET and DMG SOI FET-***δ*** in the log scale for $L_\Gamma = 60$ nm

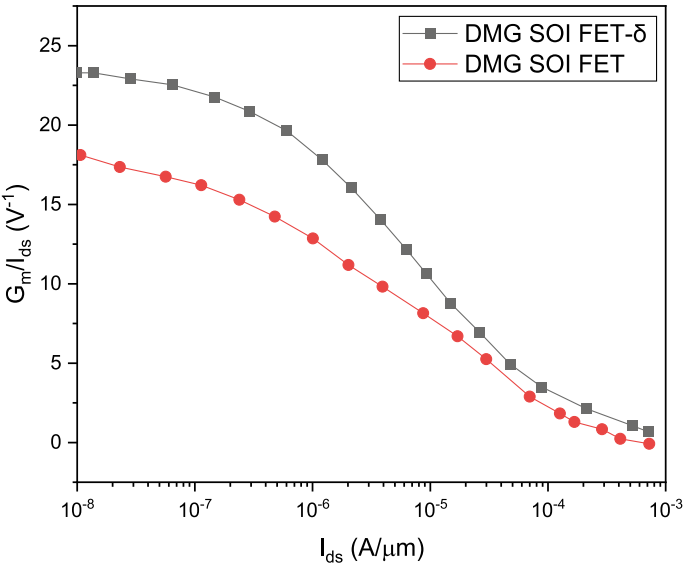


Fig. 5 Change in $g_{\mu}xI\Delta$ with I_{Δ} for of DMG SOI FET and DMG SOI FET-$\boldsymbol{\delta}$ for $L_{\Gamma} = 60$ nm

in channel mobility (n) caused by heat effects in both DMG SOI FET and DMG SOI FET-$\boldsymbol{\delta}$ structures.

Figures 6 and 7 depict how *gm and gd* vary at different gate voltages for DMG SOI FET and DMG SOI FET-$\boldsymbol{\delta}$, respectively, for $LG = 60$ nm. *gm* and *gd* are calculated from the small signal analysis done for the device. Based on the results, we can say that at low gate voltages, *gm* and *gd* in DMG SOI FET and DMG SOI FET-$\boldsymbol{\delta}$ devices are nearly identical, however, as the gate voltage keeps on increasing, the DMG SOI FET's *gm and gd* is found to be significantly lower in comparison with DMG SOI FET-$\boldsymbol{\delta}$ device [23]. The reason for the above is that for DMG SOI FET, the S/D-to-channel contact resistance is higher which lowers the transconductance of the device, while the addition of the p-type δ-layer in DMG SOI FET-$\boldsymbol{\delta}$ leads to improved gate control and enhanced *gm*. Additionally, at higher gate voltages, in spite of the heightened *gd* in DMG SOI FET-$\boldsymbol{\delta}$ devices than DMG SOI FET **device**, the improved *gm* takes over [22]. It is worth noting here that higher gate voltages increase the channel temperature which is known to reduce the channel mobility which effects the *gm* of these devices but the occurrence of δ-layer below the channel in DMG SOI FET-$\boldsymbol{\delta}$ helps to reduce this rise in temperature and hence forms the reason for improved *gm* of this device.

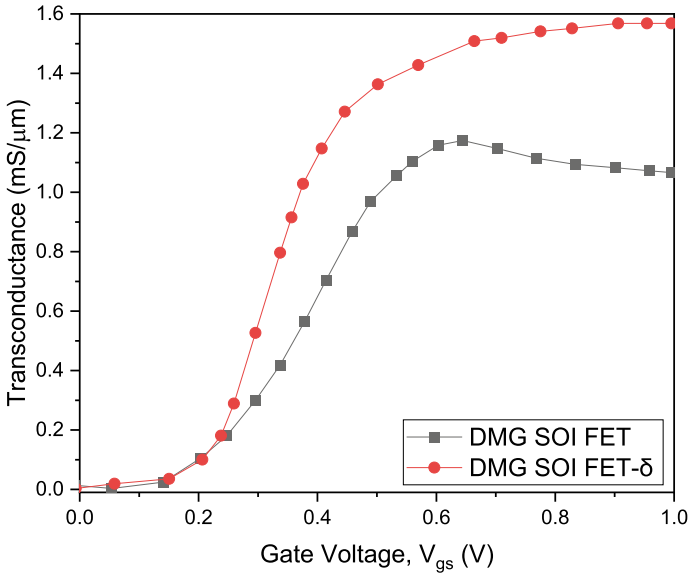


Fig. 6 Change in g_μ with V_{GS} for of DMG SOI FET and DMG SOI FET-δ for $L_\Gamma = 60$ nm

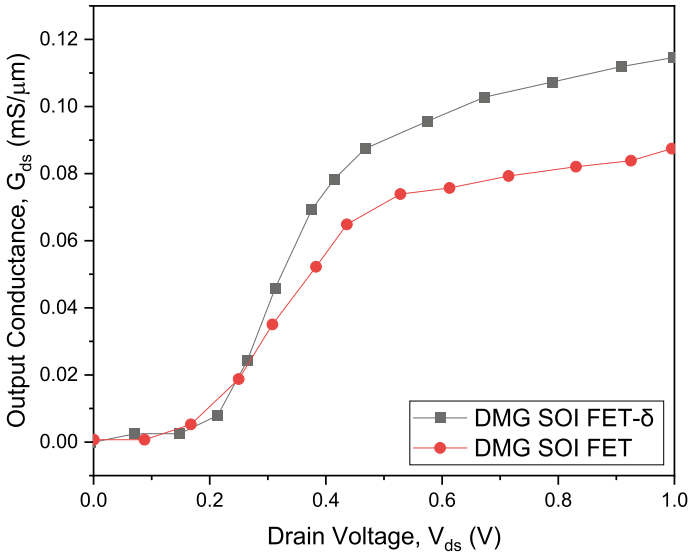


Fig. 7 Change in g_δ with VGS for of DMG SOI FET and DMG SOI FET-δ for $L_\Gamma = 60$ nm

4 Conclusion

A comprehensive study of the DC and RF parameters of DMG SOI FET and DMG SOI FET-δ devices based on identical structural parameters has been conducted via ATLAS CAD tool. Dual metal gate engineering and metal S/D in DMG SOI FET are found to lower S/D series resistance. However, a considerable improvement in high-frequency analysis of DMG SOI FETs has been seen, and in order to reduce the self-heating impact, a novel DMG SOI FET with a partial BOX under S-D and a p-type doped underneath the channel is introduced. The conclusions drawn from the drift–diffusion mechanism imply that the short-channel effects and parasitic capacitances are significantly reduced in DMG SOI FET-δ. Furthermore, as compared to DMG SOI FETs, the drive current and analog frequency excellence such as gm, gd, and gm/ID are greatly enhanced in the DMG SOI FET-δ, indicating the device's appropriateness for AF applications. The suggested fabrication flow of DMG SOI FET demonstrates that integrating the partial BOX with the p-type delta doped underneath the channel not only decreases the heating impact, but also enhances the proposed device's outcome.

References

1. Colinge, J.-P. (2004). *Silicon-on-insulator technology: Materials to VLSI* (3rd ed.). Springer.
2. Choudhry, A., & Kumar, M. J. (2004). Controlling short-channel effects in deep-submicron SOI MOSFETs for improved reliability: a review. *IEEE Transactions on Device and Materials Reliability, 4*, 99–109.
3. Majumdar, A., Ren, Z., Sleight, J. W., Dobuzinsky, D., Holt, J. R., Venigalla, R., Koester, S. J., & Haensch, W. (2008). High-performance undoped-body 8 nm–thin SOI field-effect transistors. *IEEE Electron Device Letters, 29*, 515–517.
4. Morris, D. H., Avci, U. E., & Young, I. A. (2019) Intel Corp, "*Tunnel field-effect transistor (tfet) based high-density and low-power sequential,*" U.S. Patent Application 15/992, 080.
5. Wadhwa, G., & Raj, B. (2018). Parametric variation analysis of symmetric double gate charge plasma JLTFET for biosensor application. *IEEE Sensors Journal, 18*(15), 6070–6077.
6. Zhao, Q. T., Breuer, U., Rije, R., Lenk, S., & Mantl, S. (2005). Tuning of NiSi/Si Schottky barrier heights by sulfur segregation during Ni silicidation. *Applied Physics Letters, 86*, 062108–062113.
7. Zhu, S., et al. (2004). Schottky-barrier S/D MOSFETs with high-K gate dielectrics and metal-gate electrodes. *IEEE Electron Device Letter, 25*, 268–270.
8. Tang, X., Katcki, J., Dubois, E., Reckinger, N., Ratajczak, J., Larrieu, G., Loumaye, P., Nisole, O., & Bayot, V. (2003). Very low Schottky barrier to n-type silicon with PtEr-stack silicide. *Solid-State Electronics, 47*, 2105–2111.
9. Jang, M., Kim, Y., Shin, J., & Lee, S. (2004). A 50-nm-gate-length erbium-silicided n-type Schottky barrier metal-oxide-semiconductor field-effect transistor. *Applied Physics Letters, 84*, 741–743.
10. Wadhwa, G., Singh, J., & Raj, B. (2021). Design and investigation of doped triple metal double gate vertical TFET for performance enhancement. *SILICON, 13*(6), 1839–1849.
11. Wadhwa, G., & Raj, B. (2019). Design, simulation and performance analysis of JLTFET biosensor for high sensitivity. *IEEE Transactions on nanotechnology, 18*, 567–574. https://doi.org/10.1109/TNANO.2019.2918192

12. Valentin, R., Dubois, E., Larrieu, G., Raskin, J.-P., Dambrine, G., Breil, N., & Danneville, F. (2009). Optimization of RF performance of metallic source/drain SOI MOSFETs using dopant segregation at the Schottky interface. *IEEE Electron Device Letters, 30*, 1197–1199.
13. Zeng, L., Liu, X. Y., Zhao, Y. N., He, Y. H., Du, G., Kang, J. F., & Han, R. Q. (2010). A computational study of dopant-segregated Schottky barrier MOSFETs. *IEEE Transactions on Nanotechnology, 9*, 108–113.
14. Zeng, L., Liu, X. Y., Du, G., Kang, J. F., & Han, R. Q. (2008). Impact of gate misalignment on the performance of dopant-segregated Schottky barrier MOSFETs. In *Proceedings of solid state and integrated circuit technology* (pp. 504–507).
15. Zhu, G., Zhou, X., Chin, Y.-K., Pey, K. L., Zhang, J., See, G. H., Lin, S., Yan, Y., & Chen, Z. (2010). Subcircuit compact model for dopant-segregated Schottky gate-all-around Si-nanowire MOSFETs. *IEEE Transactions on Electron Devices, 57*, 772–781.
16. Voldman, S., Hui, D., Warriner, L., Young, D., Williams, R., Howard, J., Gross, V., Rausch, W., Leobangdung, E., Sherony, M., & Rohrer, N. (1999, October). Electrostatic discharge protection in silicon-on-insulator technology. In *1999 IEEE International SOI Conference. Proceedings (Cat. No. 99CH36345)* (pp. 68–71). IEEE.
17. Long, W., Haijiang, O., Kuo, J.-M., & Chin, K. K. (1999). Dual-material gate (DMG) field effect transistor. *IEEE Transactions on Electron Devices, 46*, 865–870.
18. Chaudhry, A., & Kumar, M. J. (2004). Controlling short-channel effects in deep-submicron SOI MOSFETs for improved reliability: A review. *IEEE Transactions on Device and Materials Reliability, 4*(1), 99–109.
19. Rewari, S., Nath, V., Haldar, S., Deswal, S. S., & Gupta, R. S. (2017). Gate-induced drain leakage reduction in cylindrical dual-metal hetero-dielectric gate all around MOSFET. *IEEE Transactions on Electron Devices, 65*(1), 3–10.
20. Trivedi, V. P., & Fossum, J. G. (2004). Nanoscale FD/SOI CMOS: Thick or thin box. *IEEE Electron Device Letters, 26*(1), 26–28.
21. Grenouillet, L., Vinet, M., Gimbert, J. (2012). UTBB FDSOI transistors with dual STI and shrinked back gate architecture for a multi-VT strategy at 20nm node and below. In *Technical digest of international electron devices meeting* (pp. 64–66). San Francisco.
22. Balestra, F., Cristoloveanu, S., Benachir, M., Brini, J., & Elewa, T. (1987). Double-gate silicon-on insulator transistor with volume inversion: A new device with greatly enhaced performance. *IEEE Electron Device Letters EDL, 8*(9), 410–412.
23. Zhou, X., & Long, W. (1998). A novel hetero-material gate (HMG) MOSFET for deep-submicron ULSI technology. *IEEE Transactions on Electron Devices, 45*, 2546–2548.
24. Srivastava, N. (2022). Modeling analysis and geometric investigation of SOI FinFET for RF/AF parameters. *Silicon* s12633-021-01574-7.

Investigating Graph-Based Recommendations Systems and Graph Traversal Algorithms

Gaurica Puri, Abhiram Varanasi, Gagandeep Singh, Harshit Agarwal, Ravi Tomar, and Tanupriya Choudhury

Abstract A recommendation system is used by most if the industries nowadays as it helps in increasing the sales in all. This is due to the personal touch a customer gets because of the recommendations. A recommendation system is a technique that helps in recommending products and other services to consumers using information filtration. Recommendation systems can be of many types a few of them being, collaborative filtering-based recommendation systems, content-based recommendation systems, utility-based recommendation systems and more. During this study we will be using collaborative filtering-based recommendation system along with graph-based learning techniques like Gensim Word2vec and GraphSage. For the collaborative filtering part we will take help of a correlation matrix and a pivot table to get the relationship between the users and products and eventually finding the relationship between different users. And in the graph learning models we will be using the word embeddings created using the graphs made using the gathered data and for the traversal of graphs we will be using deep walk and random walk algorithms, and then using this information we have recommended the products to the users. The assessment of each model is done on the basis of Personalization method.

G. Puri, A. Varanasi G. Singh, H. Agarwal, R. Tomar, T. Choudhury: These authors contributed equally to this work. The corresponding authors are Gaurica Puri, Tanupriya Choudhury and Ravi Tomar.

G. Puri · A. Varanasi · G. Singh · H. Agarwal
School of Computer Science, University of Petroleum and Energy Studies (UPES), Bidholi, Dehradun, Uttrakhand 248007, India
e-mail: gauricapuri@gmail.com

R. Tomar
Senior Architect, Persistent Systems, Pune 411057, India

T. Choudhury (✉)
Senior Associate Professor, Informatics Cluster, School of Computer Science, University of Petroleum and Energy Studies (UPES), Dehradun, Uttarakhand 248007, India
e-mail: tanupriya1986@gmail.com

Adjunct Professor, Graphic Era Hill University, Dehradun, Uttarakhand 248002, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_11

Keywords Recommendation system · Collaborative filtering · Gensim Word2vec · GraphSage · Users · Products · Graph learning · Word embeddings · Deep walk · Random walk

1 Introduction

An essential aspect of computer science is the recommendation system, which predicts what a user will like next. It is a standard benchmark for product designers and engineers to explore various algorithms and feedback systems to find the most effective, why they might be effective or ineffective, and how to optimize the system [1]. Time is the most valuable thing in today's world, and researchers do not have much time to look for relevant articles in step with their research domain. Thus an efficient filtering technique is required to make your mind up on the quality research papers so that researchers' time is commonly saved. A recommender system is an information filtering method utilized in many places presented on websites [2] as per users' habits. The recommender systems use a few significant factors for making their system: datasets, prediction rating supported by users, and cosine similarity [3]. We propose a research-paper recommender system employing a collaborative filtering approach to recommend a user with the most straightforward research papers in their domain in step with their queries and supported the similarities found from other users supported their queries, which can help avoid time-consuming searches for the user. In this paper, we will discuss some basic recommendation systems along with a general overview of other types of graph methods. Finally, we will focus on recommendations for a few practical applications (e.g., recommendations for recommender systems or books) [4]. We survey the sphere of research-paper recommender systems, aspiring to enable researchers to discover the status-quo of research-paper recommender systems [5] and motivate the community to unravel the significant urgent problems currently present hinder the effective use of research. We will have a look at different models employed by recommendation engines.

There are many recommendation systems, as given below, but we have used collaborative filtering-based recommendation systems for our work. The collaborative recommender system is a popular and mature technology made available to gather or collect the ratings or recommendations of various objects for processing to make personal recommendations for different users. In addition, collaborative filtering majorly works on the assumption that the people who have bought a similar object in the past will buy similar things in the future and will like similar objects as they wanted in the past. The recognition of commonalities among the users is primarily based on their scores and generates new tips based on inter-consumer comparisons.

Content-based Recommender System: It is a projection and prolongation of the information filtering research. A content-based recommender gains an understanding of the new user's profile and the interests inflicted by that user based on the elements present in objects or things that particular user has rated. It is a keyword-specific recommender system here. In this type of system, the objects are stipulated primarily

with the help of their corresponding features. Keywords are the word of identification used to describe the items or things rated. Thus, in a content-based recommender system, the things recommended to users are either similar to the things they liked in the past or the ones they are currently examining, as it increases the percentage of the item or service to be more likeable by the user.

Demographic-based Recommender System: This system classifies the users based on their own attributes and makes suggestions on the basis of demographic classes. A good deal of industries has taken up this method because it is very manageable undemanding and easy to implement. Here, the algorithms used call for thorough market research in the required areas or fields, along with this a short survey is necessary for the collection of data for the categorization and classification. Demographic strategies form "uman-to-human" correlations as part of collaborative ones yet implement distinct statistics. The advantage of this approach is that there is no need for it does not require information on a person's ratings, for instance in collaborative and content-based recommender systems.

Utility-based Recommender System: A utility-based recommender system makes a proposition based on the computation of the utility of every object for the person. In this system, every enterprise may have a unique approach for arriving at a consumer-specific utility feature and using it for the gadgets underneath consideration. Of route, the nuisance for this sort of machine is how to create software for man or woman users. The essential pros of an application-based recommender gadget are that it may be a component of non-product attributes, consisting of vendor reliability and product availability, in the software computation. Thus, it is feasible to test the real-time item inventory and present it to the individual.

Knowledge-based Recommender System: Here, the recommender system indicates items primarily based on personal wishes and alternative inferences. Knowledge-based recommendation works on purposeful know-how: they realize how a particular object meets a specific requirement of the consumer and may be the reason for the relationship between a circumstance and a possible recommendation. Hybrid Recommender System: In this type of recommendation system, two or more kinds of recommendation techniques are integrated into any of the two systems in a manner that suits a particular enterprise. It is the trendy recommender system that many companies try to use the most. This is because it has the qualities of more than two recommender systems and gets rid of any weak point when the best recommender device is used.

Graphs are [6] extensively implemented as a famous illustration of the network composition of related records. Graph learning proves powerful for numerous tasks, namely prediction, type, link, and matching. Generally, graph studying methods draw out different relevant features of graphs with the aid of taking advantage of system studying algorithms. Significant attention is given to 4 classes of already utilized graph learning techniques together with matrix factorization graph [7]signal processing, deep walk, and random walk.

Random Walk: The random walk is a mathematical [8] technique/model that describes the movement of a particle in an external environment (i.e., outside any physical constraints). This algorithm cannot predict future outcomes, but it can—in

many cases—display how a system will behave as time progresses. In other words, the [9] random walk algorithm can describe how systems evolve while simultaneously modeling their behavior. It describes how we move from one graph node to another on a random path.

Deep Walk: It is an [10] algorithm used for mastering unseen representations of vertices in a network. These representations bring to symbolize the social illustration amongst two different graphs. A randomized direction is used as a traversing technique to offer insights into localized systems within networks. These random paths are then inturn used for training the Skip-Gram Language Model.

Skip-Gram Model: It predicts the following words in any sentence by avoiding the repetition probability in the words we come across in a sentence. We will use the Word2vec model and the cosine distance to calculate the probability. Some of the graph learning models we used are Gensim Word2vec and GraphSage models.

2 Related Work

To get an insight on the work previously done on graph learning [11] we did a study of a few other works on the same lines. Many different methods and analyses of graph-based learning have helped us immensely in the analysis of the models used [12, 13]

In 2009, the authors of the paper [14] created the first hybrid recommendation system for research papers named Scienstein. This is made as an alternative to academic search engines. The authors also address the problem of better search engines, especially in the research field, to find related papers. Scienstein combines implicit ratings, detailed ratings, author analysis, citation analysis, and source analysis into a recommender system. Scienstein performs better than academic search engines.

Authors of the paper [15] developed a collaborative filtering-based recommendation system for recommending the best papers to researchers in their field, thereby helping them to save time and focus on research. The model finds similar users based on their queries and recommends papers, thus avoiding time-consuming searches. The model uses cosine similarity to find similar users.

Over 200 papers have been reviewed in the paper [16], which covers content-based, collaborative, graph-based, and other recommendation systems. Most of them are content-based recommendation systems. The paper also talks about the graph-based recommendation systems and how the nodes are connected to give better representation and better results. The author here wants to convey the importance of providing complete details of the methodology of their paper.

This paper [17] created and tested a neural network-based clustering collaborative filtering algorithm most commonly used in E-commerce recommendation systems. The paper tries to solve the sparsity problem: n forming the nearest neighbor sets of the chosen users, a collaborative filtering recommendation algorithm often results in information deprivation. This problem can be solved using the neural network-based collaborative filtering algorithm.

Fig. 1 Dataset collected

```
electronics_data.head(10)
```

	userId	productId	Rating	timestamp
0	AKM1MP6P0OYPR	0132793040	5.0	1365811200
1	A2CX7LUOHB2NDG	0321732944	5.0	1341100800
2	A2NWSAGRHCP8N5	0439886341	1.0	1367193600
3	A2WNBOD3WNDNKT	0439886341	3.0	1374451200
4	A1GI0U4ZRJA8WN	0439886341	1.0	1334707200
5	A1QGNMC6O1VW39	0511189877	5.0	1397433600
6	A3J3BRHTDRFJ2G	0511189877	2.0	1397433600
7	A2TY0BTJOTENPG	0511189877	5.0	1395878400
8	A34ATBPOK6HCHY	0511189877	5.0	1395532800
9	A89DO69P0XZ27	0511189877	5.0	1395446400

The authors of this [18] particular paper deal with the problem of unidentified users of a commercial website. They have used an iterative algorithm to optimize the utility function. The output of each iteration and the values of relative frequencies of recommendations are recalculated at the next stage.

3 Data Collection

The data that has been used for testing different collaborative methods is taken from the amazon. The data is been collected from 1996 to July 2014. The actual data set contains product reviews and metadata. In this, case we have only used product review data. The data is open source and available at [19] (Fig. 1).

4 Methodology

For the Traditional Method:

The main idea for the work is to pre-process the collected data and find out the correlation between the users and the products. It then recommends N products to each user and stores the results in the rec_products dictionary having the user as key and a list of recommended products as values. We recommend products to users different from those not rated/interacted with by that particular user. First, we find similar users to the user using correlation, i.e., users correlating threshold value. Then we find a set of products for those similar users, say set1, and a set of products rated

by the user to whom we are recommending, say set2. Then we recommend products in set1–set2 set to the user, increasing the personalization.

Now for the graph-based Methods:

After the preprocessing of the data, the data is converted into a graph using various functions, then extracting the nearest nodes for each user. Represent this in an embedding. after this, a random walk function is used that takes NetworkX Graph and a Node and generates a random walk for a given length and returns the random walk (list of nodes traversed) **Note: The same node may occur more than once in a Random Walk.** Then the graphs are generated for both stellar graph and networkX objects, and both the models (Gensim and Word2vec)are trained, and they extract the user embeddings. After this, the same recommendation process is done as mentioned in the traditional method.

4.1 Models Used

In this study, we will investigate collaborative filtering, a customary and valuable asset for recommender frameworks. Collaborative filtering needs nothing [20] else besides clients' authentic inclination on a bunch of things. The verifiable information would invariably be concurred by clients, especially those who have done it in the past. As far as client inclination, it is customarily communicated by two classifications. Particular Rating recommends clients' inclinations in a roundabout way, for example, site visits, clicks, buying records, standing by listening to a music track, and more. On a sliding scale, the ratings given by clients indicate their liking for the product. For further understanding, refer to Fig. 2.

Word2vec: Gensim is a natural [21] processing package that does "Topic Modeling for Humans". However, it is practical way more than that. If you are unacquainted with the subject matter of modeling, it is a way to take out or draw out the required subjects from large volumes of text. Gensim offers algorithms like LDA and LSI and the critical sophistication to make tremendous topic models. Nevertheless, the width and scope of facilities to create and compare topic models are remarkable in gensim, plus extra convenient tools for text processing. It is a fantastic package while working with different models and building other topic models. Also, another enormous advantage of gensim is: that it facilitates you take care of huge textual content files while not having to load the complete circulate into reminiscence. For further knowledge, refer to Table 1.

GraphSAGE: It is an [22] iterative algorithm that learns graph embeddings in an exceedingly specific graph for each node. The USP of GraphSAGE is that it had been the primary algorithm to form inductive node embeddings in an unsupervised manner. Rather Like in NLP, creating embeddings is incredibly useful for downstream tasks. CNN uses these embeddings for various tasks. Before GraphSAGE, many node embedding models were not supported by spectral decomposition/matrix factorization methods. The problem is that Matrix Factorization methods are inherently

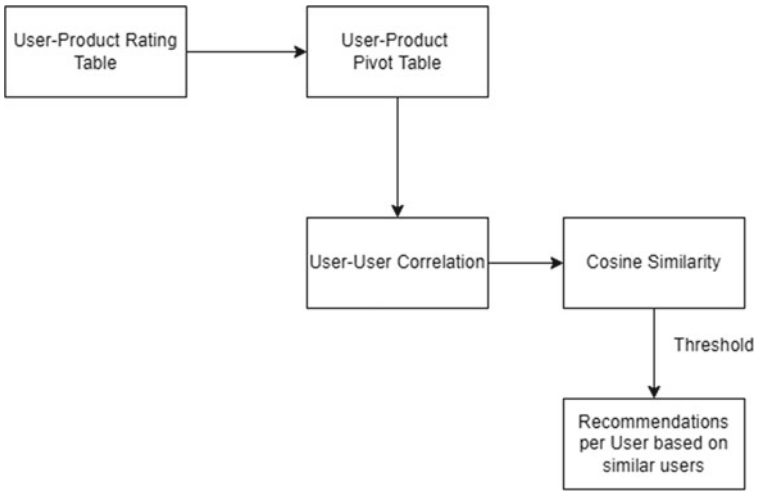
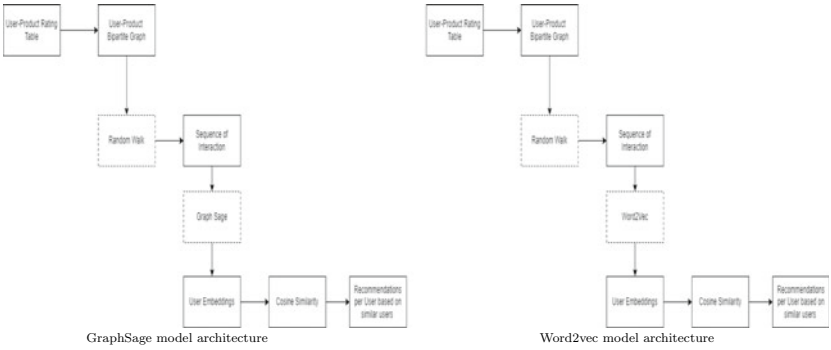


Fig. 2 Traditional model architecture

Table 1 Models used



transductive. The retraining of the model is recommended if a replacement node is added to the graph later. For further understanding, refer to Table 1.

4.2 Model Development Process

4.2.1 Data and Graph Structuring

In the actual world, maximum items around us are explicitly or implicitly related; in different words, we stay in a global of graphs. Such a feature is even extra prominent in RS, in which the objects considered, including users, items, attributes, and context,

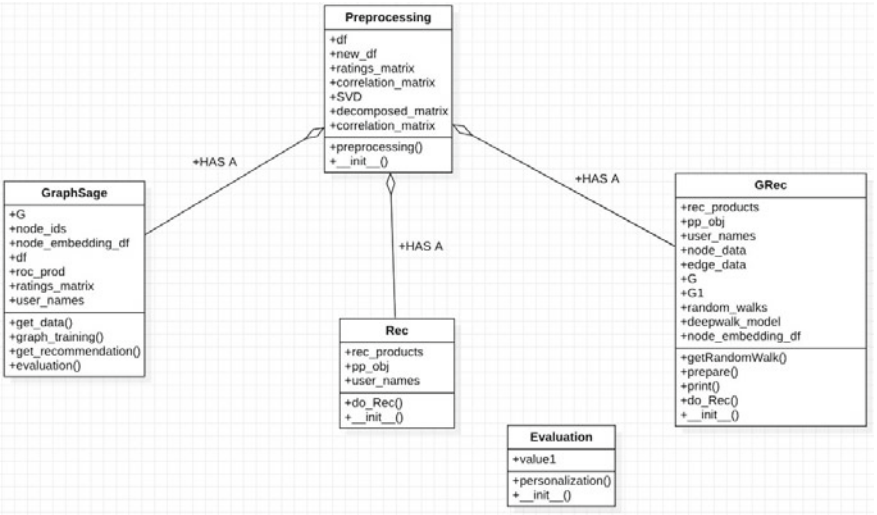


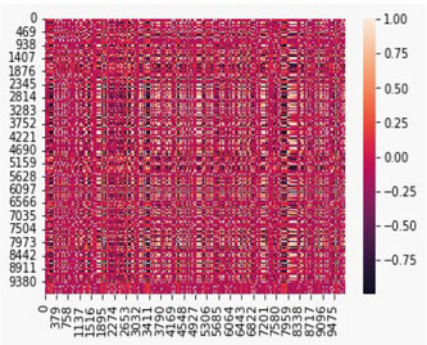
Fig. 3 Recommendation model architecture

are tightly connected and impact one other through various relations, as shown in Fig. 3. In practice, numerous styles of graphs arise from RS's statistics, which can drastically contribute to the high quality of the recommendations. Graph learning can learn complex relations as one of the most encouraging AI methods; GL has shown extraordinary potential in inferring information implanted in various charts. In particular, numerous GL strategies, like random walk and neural chart organizations, have been created to get familiar with the specific sort of relations displayed by charts and have exhibited to be very viable. Subsequently, utilizing GL to display different relations in RS is a characteristic and convincing decision create node data is a pivot table with rows as user Ids and columns as product Ids. The values filled in the pivot table are the ratings given by the products by the users, refer to Table 2 create edge data with the source as user id and target as product id showing the interaction between the user and product Building graphs using the edge data and node data created in the last steps.

4.2.2 Graph Traversal

Random walk: we traverse the graphs to understand their structure. The main idea is to start a traversal at a random element of graph G for a certain length M for N times, and the chances are high that the resultant vector for any other random walker object would be more or less similar compared to starting a random walker object that lies in a different community. Here a community refers to similar users based on their interaction with the products.

Table 2 Pivot table and correlation matrix used for models



Correlation matrix for collaorative filtering

Pivot table for collaorative filtering

A random walk implemented on a graph effectively computes the similarity between nodes and explores transitive associations between nodes. Assuming we gave two sets of nodes one represents users, and the other represents items. The links connecting nodes among those units constitute the transactions of customers. Then collaborative filtering is used as an insular recovery on the user-object bipartite graph and applies several activation techniques to create transitive relations between users and items.

4.2.3 Graph Learning

Get word embeddings from the word2vec model which uses the output of the random walk model [23]. Create node embeddings in which we have a corresponding embedding vector for each user using the word embeddings obtained in the last step. Create a correlation matrix among the users using the node embeddings procured. Select threshold T. Find all the users corresponding to each user having a correlation value more than equal to T. Create a set of all the products rated by those similar users, say set1, and create a set of products rated by that particular user, say set2. Calculate a list, L1 of all those products which are not in set2: L1 = set1–set2.

From this list, we select N products to recommend to that user

4.3 Evaluation Metrics

There are a few metrics for evaluating recommendation systems that can be used, [24] namely Intra-list Similarity, Personalization, Coverage, and a few others. To evaluate each of the methods used in this paper for the recommendations, the Per-

Table 3 Personalization scores for all the models

Algorithm used	Personalization score
Traditional collaborative filtering based model	0.8713
Graph based model word2vec	0.9976
Graph based model GraphSage	0.9725

sonalization score has been used. It is an excellent way to assess or judge any models that recommend itemsa to users different from those already rated by them. It is the dissimilarity or 1-cosine similarity between users' lists of recommendations. For this process, the personalization our recommendation system offers to the user in terms of products is measured in percentage; the higher the personalization score, the more the customized experience for every user, and the lesser the personalization score, the lesser the personalization score customization experience for the user.

5 Results

We have used 1,048,576 data points for applying different approaches to provide recommendations. We have used traditional collaborative filtering and two graph-based approaches, Word2Vec and Graph Sage. The result of each approach is a list of recommended products. For evaluating the recommendations of each model, we have used personalization as an evaluation metric. Personalization tells how many different products are recommended to the users, refer Table 3. A high personalization score indicates that user recommendations are different, meaning the model offers a personalized experience to each user.

Below is the personalized score of each approach model. As we can observe from the above results, the graph-based model provided a higher personalized experience to the user and performed better than the traditional collaborative filtering-based recommendation system.

6 Conclusion

Indicating that graph-based correlations have a better advantage in recommendation models. This project created recommendation models based on collaborative filtering using general user-product rating correlation and graph embedding-based correlation. Even though the general user-product rating gives a good personalization value, the graph-based recommendation model has a better personalization value. We have investigated this on the traditional collaborative filtering method using a pivot table and the correlation of the users to products, Word2vec (graph-based model) and

GraphSage (graph-based model) model. As per the results, the graph-based methods performed better than the traditional method, and between the two graph models, Word2vec gave us a better personalization score. In future work, we can investigate the effect of graph representation algorithms on the recommendation system for further study.

7 Future Work and Summary

We have investigated this on the traditional collaborative filtering method using a pivot table and the correlation of the users to products, Word2vec (graph-based model) and GraphSage (graph-based model) model. As per the results, the graph-based methods performed better than the traditional method, and Word2vec gave us a better personalization score between the two graph models. In future work, we can investigate the effect of graph representation algorithms on the recommendation system for further study.

References

1. Roberts, A. (2022). *The who, what, where, when, why (and how) of recommender systems*. Arize AI.
2. Shaikh, S., Rathi, S., & Janrao, P. (2017). Recommendation system in e-commerce websites: A graph based approached. In *2017 IEEE 7th International Advance Computing Conference (IACC)* (pp. 931–934). IEEE.
3. BluePi. (2015). *Classifying different types of recommender systems*. BluePi.
4. Wang, S., Hu, L., Wang, Y., He, X., Sheng, Q. Z., Orgun, M. A., Cao, L., Ricci, F., & Yu, P. S. (2021). Graph learning based recommender systems: A review. ArXiv preprint arXiv:2105.06339.
5. Cicekdag, M. R. (2021). *Recommendation systems: Content-based recommendation*. Python in Plain English.
6. Trudeau, R. J. (2021). *A beginner's guide to graph analytics and deep learning*. Pathmind.
7. Xia, F., Sun, K., Yu, S., Aziz, A., Wan, L., Pan, S., & Liu, H. (2021). Graph learning: A survey. *IEEE Transactions on Artificial Intelligence, 2*(2), 109–127.
8. SMITH, T. (2020). *Random walk theory*. Investopedia.
9. Zhang, Z., Zeng, D. D., Abbasi, A., Peng, J., & Zheng, X. (2013). A random walk model for item recommendation in social tagging systems. *ACM Transactions on Management Information Systems (TMIS), 4*(2), 1–24.
10. pawangfg. (2021). *Deepwalk algorithm*. Geeks for Geeks.
11. Wu, Z., Pan, S., Chen, F., Long, G., Zhang, C., & Philip, S. Y. (2020). A comprehensive survey on graph neural networks. *IEEE transactions on neural networks and learning systems, 32*(1), 4–24.
12. Huang, Z., Chung, W., Ong, T.-H., & Chen, H. (2002) . A graph-based recommender system for digital library. In *Proceedings of the 2nd ACM/IEEE-CS Joint Conference on Digital Libraries* (pp. 65–73)
13. Hu, L., Cao, J., Xu, G., Cao, L., Gu, Z., & Cao, W. (2014). Deep modeling of group preferences for group-based recommendation. In *Proceedings of the AAAI Conference on Artificial Intelligence*, vol. 28

14. Gipp, B., Beel, J., & Hentschel, C. (2009) Scienstein: A research paper recommender system. In *Proceedings of the International Conference on Emerging Trends in Computing (ICETiC'09)* (pp. 309–315)
15. Murali, M. V., Vishnu, T., & Victor, N. (2019). A collaborative filtering based recommender system for suggesting new trends in any domain of research. In *2019 5th International Conference on Advanced Computing and Communication Systems (ICACCS)* (pp. 550–553). IEEE.
16. Beel, J., Gipp, B., Langer, S., & Breitinger, C. (2016). Paper recommender systems: a literature survey. *International Journal on Digital Libraries, 17*(4), 305–338.
17. Mai, J., Fan, Y., & Shen, Y. (2009). A neural networks-based clustering collaborative filtering algorithm in e-commerce recommendation system. In *2009 International Conference on Web Information Systems and Mining* (pp. 616–619). IEEE
18. Gluhih, I. N., Karyakin, I. Y., & Sizova, L. V. (2016). Recommender system providing recommendations for unidentified users of a commerial website. In: *2016 IEEE 10th International Conference on Application of Information and Communication Technologies (AICT)* (pp. 1–3). IEEE.
19. Julian McAuley, U. (2014) *Amazon product data*. JMCAULEY UCSD.
20. Grover, P. (2017). Various implementations of collaborative filtering. *Towards Data Science*.
21. Karani, D. (2018). Introduction to word embedding and word2vec. *Towards Data Science*.
22. Özçelik, R. (2019). An intuitive explanation of graphsage. *Towards Data Science*.
23. Mikolov, T., Chen, K., Corrado, G., & Dean, J. (2013). Efficient estimation of word representations in vector space. Arxiv.
24. Longo, C. (2018). Evaluation metrics for recommender systems. *Towards Data Science*.

Movie Rating Prediction and Viewers' Sentiment Trend Analysis Using YouTube Trailer Comments

Sandipan Sahu, Raghvendra Kumar, and Pathan Mohd Shafi

Abstract Movie is one of the biggest industries in the world. It is one of the mainstream entertainment media. However, recent studies say only a few movies succeeded or satisfied viewers. Movie makers are desperate to know the viewers' reactions and sentiments to the movie. Maximum of the previous research works ware on movie hit prediction. Significantly, few works accurately predict the IMDb rating of an upcoming movie. Very few works analyse the viewers' sentiment before and after the movie's release. In our research work, we extract the YouTube comments of 80 selected movies. Then, we analyse the sentiment of each review comment using the VADER lexicon. Next, compute the overall sentiment and predict the IMDb rating of each movie. In the second part of our work, we investigate the viewers' sentiment trends pre- and post-release of the movie. We have achieved 0.4702 mean square error and 0.519 is R2-score. Our observed results proved that the forecasted rating of pre-released movies had the lowest error. Our analysis helps to support industry decisions.

Keywords Sentiment analysis · VADER lexicon · Rating prediction · Mean square error · R2-score

1 Introduction

Movie industries are one of the most fast-growing and most popular worldwide. The movie industry is enormous; a large amount of investment is spent on every box

S. Sahu (✉) · R. Kumar
Department of Computer Science and Engineering, GIET University, Gunupur, India
e-mail: sandipan.sahu@giet.edu

R. Kumar
e-mail: raghvendra@giet.edu

P. M. Shafi
Department of Computer Science and Engineering, MITADT University, Loni Kalbhor, India
e-mail: shafi.pathan@mituniversity.edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_12

office film. However, a few numbers the movies that achieved success. Uncertainty is one of the significant problems in this industry. Predicting the IMDb rating of an upcoming movie with significant accuracy is always beneficial for moviemakers and producers [1–5]. IMDb rating generally expresses the success or popularity of the movie. In the movie industry, promoting a movie is one of the essential parts. Sometimes, positive hypes created by the promotion activity like the release of a movie trailer could not persist after the movie's official release. In today's Internet-connected world, people are very fond to use social media networks like Facebook, Twitter, and YouTube to share their views on any recent topic [5–9]. YouTube is one of the most famous motion picture mediums. Almost every released movie uploads its trailer on the YouTube channel. YouTube review comments are one of the most reliable sources to analyse movies trend before and after the movie's release [10–12].

Significant research works have been done on movie hit prediction [13–15]. Most of the works classify the problem into a binary problem (hit/flop), and a few works classify the problem into a multiclass problem. However, minimal studies have been performed to predict the movie rating with significant accuracy. Furthermore, the viewer's reaction before and after the movie's release is also critical. Whether a movie fulfils the audience's expectations or not can be investigated by analysing the trend of review sentiment pre- and post-release of the movie.

In this study, we have proposed a framework to predict the rating of the forthcoming movies using sentiment analysis of YouTube trailer reviews. In addition, we have also analysed the trend of audience sentiment pre- and post-release of the movie.

To address the above problems, we extracted YouTube trailer reviews of 80 random movies released in 2020 and 2021. First, we have scraped all the reviews of each movie trailer. Next, we use the VADER lexicon as a sentiment analyser to extract the sentiment of each comment, then build a framework to compute the overall sentiment of each movie, and finally compute the predicted IMDb rating. After that, depending on the timing of the review comments (pre- or post-release), we have separated them into two clusters. Finally, we investigate and analyse the sentiment of pre- and post-release review comments and explore the trend of viewers' opinions.

Our study shows that the proposed movie rating prediction approach is effective and achieved a root mean square (RMS) error of less than 0.48. We also demonstrate how viewers' sentiment changes pre- and post-release of a movie.

- We offered a framework to predict the movie's IMDb rating by studying the sentiment of YouTube trailer review comments.
- We also proposed a novel method of computing the exhaustive sentiment of a movie.

The remaining part of this paper is organised as follows. Section 2 briefly reviews state-of-the-art approaches to film forecasting and sentiment analysis. Section 3 outlines our proposed framework and discuss about dataset. In Sect. 4, proposed method is described in detail. Section 5 presents the experimental results. Finally, in Sect. 6, we have discussed limitation and the future work of the research study.

2 Related Works

Movie success prediction is one of the challenging tasks. Since a massive amount of investment is associated with movie making and movie productions, movie success prediction is one of the critical research areas. The initial effort was performed by Litman [16] and examined the attributes and their impacts on the box office performance. The film industry keeps growing scenes Litman study. Due to the availability of a vast amount of movie data and social media data, the movie is one of the most important and rising search fields.

In movie success prediction, feature selection and use of attributes are the most critical part of the study. In one of the current works, authors try to find the influence of movie names on movie hits [17]. The most typical characteristic used for cast members is whether the film casts star artists. The star power of actors has been taken by actor incomes [18], previous award nominations [15], actor rankings [20], and the actor's number of Twitter followers [19]. Some past studies have analysed the director's success and tried to relate it with the movie's success [21]. Some earlier research has claimed that movies' economic performance is not influenced by star directors' appearance [15], and directors' power is not as significant as actors for movie success [22]. Many researchers conducted research work using some derived features related to key-rule performers and intrinsic movie features [23, 24].

Viewer-based features are about possible audiences' acceptance of a film. As the number of positive audiences for a movie increased, the likeliness of achieving success increased. Movie response can be recovered from several types of media, such as Twitter [25], trailer remarks [26], blogs [27], crowdsourced social media [28], and movie reviews [29]. Similarly, in [30], they applied social media, YouTube, and Twitter comment to predict potential audiences. Unfortunately, viewer-based features are available only for late prediction.

Sentiment analysis [31, 32] is a strategy for computationally specifying and classifying customers' sentiments into positive, negative, or neutral by analysing the review comments. Hui et al. [33] offered a model utilising social media data from a microblogging site. Using this information, the authors investigate the choice information and find the likeness between online movies and TV shows. Kumar et al. [34] apply sentiment analysis to user tweets and predict movie ratings. Dongjin et al. [35] proposed a model by combining users' review sentiment and rating scores to predict movie ratings. Abhishek et al. [36] proposed a sentiment analysis model to predict the movie rating by analysing tweeter review sentiment.

3 Methodology

Our research study aims to develop a model to predict movie IMDb ratings and find the viewers' opinion trends before and after the movie's release. Since we predict the rating (value) of a movie, it is evident that our problem is a regression problem.

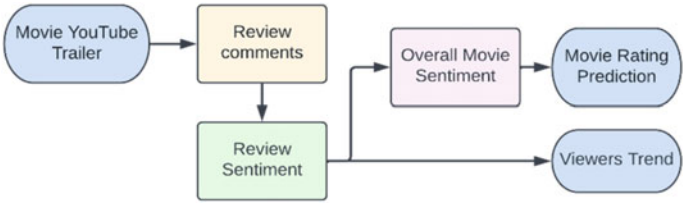


Fig. 1 Framework workflow

Therefore, our objective is to analyse the review sentiment and finally predict the movie's rating.

3.1 Framework

Generally, the movie's trailer is published well before the movie's release. Importantly, movie trailers are usually available on the YouTube channel. Viewers share their opinions and thoughts about the upcoming movie by writing comments on the trailer video. In our proposed work, we use these comments to predict the IMDb rating of the movie ultimately.

The framework for predicting movie rating has the following steps (Fig. 1).

1. Extracts the movie trailer comments from the official YouTube channel.
2. Computes the sentiment of each individual review comment.
3. Calculates the overall movie sentiment.
4. Predicts upcoming movie ratings from the overall sentiment.

3.2 Data Set Description

In this proposed work, we have created our data set. The data set comprises review comments on the YouTube movie trailer. At first, we selected 80 movies released between 2020 and 2021. Next, the official trailer of each movie was identified on the YouTube channel (https://www.youtube.com/). Then, we scraped all review comments of each movie by using google script. In this study, we have taken all comments chronologically from the beginning to the date of scraping. After extracting all review comments of each movie, we make a partition into two separate sets. One set consists of comments before the movie's release, and the other consists of all remaining comments until the day of the extraction. So for each movie, we have two sets of review comments; one consists of pre-released comments and the second consists of post-release comments. For each movie, we have extracted the IMDb

Table 1 Example of YouTube trailer review comments of the movie The Starling

Reviewer name	Comments	Time
Shinku Soul	Hey!!!!!!! Please make more series of tales of arcadia please!! We want more>>>>>	2021-03-21T17:15:49Z
Amar Ingole	I think > I must watch this show 👆	2021-03-20T01:39:13Z
Deadwing Nine	Wonder what happened to all that ' alleged' bribe money >…	2021-03-19T06:50:28Z
Devashish Sharma	😎Concepts these people bring are so awesome	2021-03-11T12:52:14Z

rating and official release date of the movie from the IMDb website (https://www.imdb.com/ accessed on 08 June 2022). Some examples of YouTube trailer review comments of the movie The Starling are given in Table 1.

4 Proposed Methods

In our proposed work, we scraped YouTube review comments using Google script. To predict the rating of a movie, we have used review comments only from the pre-released set of comments. Unfortunately, bring out comments contain an enormous amount of noise. We need to clean all the noise from the reviews. Our proposed methods have the following steps. Figure 2 shows the steps of movie rating prediction.

1. Extract YouTube review data from the selected movie reviews. Separate into two sets, pre-released and post-release movie reviews.
2. Take necessary action for cleaning and pre-processing the extracted review comments to make them machine-understandable.

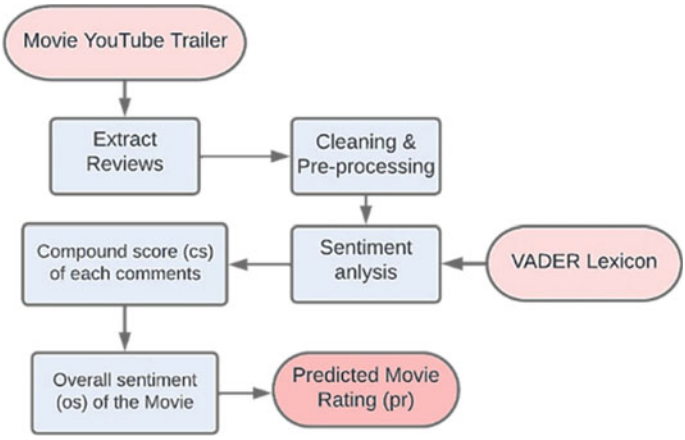


Fig. 2 Framework of proposed methods

3. Analyse the sentiment of each individual review by using the VEDAR lexicon. Then, find the compound score of each review comment.
4. Compute the overall sentiment using all effective review comments of each movie.
5. Finally, predict the IMDb rating of the movie.

Data cleaning and pre-processing is one of the most necessary steps to execute sentiment analysis accurately. In the data cleaning process, data is cleaned by deleting it. Data are corrected using several procedures like stemming, lemmatisation, etc., in the pre-processing step. We have performed both data cleaning and pre-processing in our review comments dataset to make the data ready for sentiment analysis. We have executed multiple steps to clean the data. Table 2 presents different types of noise that exist in the review comments such as, Stop words, repeating letters, weblink, special characters, and emojis. We removed all the noise present in the reviews. Next, lemmatisation is performed in the pre-process step. Table 3 gives some examples of reviews before and after pre-processing.

Table 2 Example of types of noise in the review comments

Type of noise	Example
Stop words	The, an, a, in, are, as, at, be
Words more than three same consecutive latter	2paccccccccccc is better periodddddddddddd baby baby stole pacs style babyyyyyyyyyyyyyyyyyy
Weblink	May I know the background music name from < ahref = "https://www.youtube.com/watch?v=n4Uv5VHRDZg&t=0m33s" > 0:33 < /a > ❤…I just love it!
Special characters	#, @, !, $, %, …**
Emojis	😊>❤👍❤

Table 3 Example of reviews before and after pre-processing steps

Review before pre-processing	Review after pre-processing
Is this Hunters Season2 😊 < br > Anyway, I am excited	This hunters season anyway excited
> I think this movie is a emotional + action movie 😎	Think this movie emotional action movie
< ahref = "https://www.youtube.com/watch?v=Fft5igeEIEM&t=1m23s">1:23 stunned	Href YouTube watch stunned

Table 4 Values of four parameters of some example comments

Cleaned comments	Positive	Neutral	Negative	Compound score
Looks really good hope movie trailer jitni acchi	0.515	0.485	0	0.7485
Waste your time this boring chaotic with a stupid ending	0	0.294	0.706	−0.9006
Basically, Netflix does not want people to sleep always binge-watching	0.14	0.86	0	0.0772

4.1 Sentiment Analysis

We analysed the sentiment using the VADER sentiment analyser from the nltk package in this proposed work. VADER is a lexicon and rule-based tool for sentiment analysis. It is a very useful tool for sentiment analysis. VADER considers every single word of a review, and by using its lexicon and rules, compute the overall sentiment intensity of the review. Each review returns four component values as positive, negative, neutral, and compound. The range of the first three components is between [0, 1]. The compound score represents the overall sentiment of the review, and the value is between [−1, 1]. It is a normalised value of the first three components. Compound score "−1" represents extreme negative comment; similarly " +1" represents extreme positive comment. A value near zero on either side of the number line characterised a comment as a neutral comment. Using VADER, we compute the sentiment score of each individual review comment. Table 4 presents the score of each component for some example comments.

4.2 Overall Movie Score and Rating Prediction

Our next objective is to determine the overall sentiment of a movie. At first, we compute the sentiment score of each pre-release review comment of the movie. Since the compound score (*cs*) is the normalised value of the other three components (positive, negative and neutral), we used the compound score as our deterministic parameter. We have considered the compound score of each review to calculate the overall movie sentiment (*ms*). Some comments do not carry any sentiments, like purely neutral comments or junk comments; in that case, the compound score value would be zero ($cs = 0$). We eliminate all the comments of a movie having $cs = 0$. Finally, we computed the overall movie score (ms) using Eq. (1).

$$ms_i = 1/p \sum_{j=1}^{n} cs\left(r_j^i\right) \tag{1}$$

Table 5 Examples of some overall scores, predicted ratings, and IMDb ratings

Movie name	Overall sentiment	Predicted rating	IMDb rating
The White Tiger	0.3404	5. 6.7	6. 7.1
BLACKPINK: Light Up the Sky	0.4085	7. 7	8. 7.5
Torbaaz	0.3474	9. 6.7	10. 6.9
Sentinelle	0.0838	11. 5.4	12. 4.7
Dance Dreams: Hot Chocolate Nutcracker	0.5858	13. 7.9	14. 7.1

where ms_i is the overall movie score of movie m_i, p is total number of movie with $cs\left(r_j^i\right) \neq 0$, and $cs\left(r_j^i\right)$ is the compound score of the j th review of movie m_i. Overall score ranges between $[-1, 1]$.

Finally, in the framework, we have computed predicted rating $pr(m_i)$ from the overall movie score ms_i of each movie m_i. The movie score is scaled in the range between $[1, 10]$. We have used Eq. (2) to calculate the predicted rating from the movie score. Table 5 presents some examples of the overall movie score and predicted rating.

$$pr(m_i) = \{1 + os(m_i)\} * 5 \tag{2}$$

5 Experimental Results and Analysis

In this research work, two separate modules are present to perform two different responsibilities. First, we present a framework to predict the IMDb rating of an upcoming movie by exploring the sentiment of the YouTube trailer review. Second, we analyse how viewers' opinion trends change before and after a movie's release. We have unsystematically selected eighty movies released in 2021–2022 and built our dataset.

5.1 Movie Rating Prediction

In our research study, we analyse the movie review sentiment using the VADER and TextBlob lexicon. Using both the lexicon, we performed the same process and predicted the movie rating of our selected movies. In Table 6, we have given ten examples of movies. In Table 6, IMDb rating, rating predicted by VADER, and rating predicted by TextBlob have been presented. The rating predicted by VADER is much more accurate than the TextBlob model.

Figure 3 shows the performance results of both the VADER and TextBlob models. We have considered our problem as a regression problem. Compute the value of the

Table 6 Comparative analysis of predicted ratings of VADER and TextBlob with IMDb rating

Sl. no.	Movie name	IMDb rating	Vader rating	TextBlob rating
1	Ajeeb Daastaans	6.7	6.9	6.6
2	Thunder Force	4.4	5.2	5.2
3	Squid Game	8	7.1	6.3
4	The Devil All The Time	7.1	6.7	6.6
5	Irul	5.8	5.9	6.2
6	Mosul	7.2	6.8	6.7
7	I Care a Lot	6.3	5.8	5.4
8	Ludo	7.6	7.7	7.5
9	Mank	6.9	6.7	6.3
10	The White Tiger	7.1	6.7	6.4

mean square error, R2-score, root mean square error, and mean absolute error. In all the parameters, VADER lexicon model performs better than TextBlob.

We have plotted IMDb rating, predicted rating using VADER, and TextBlob of all eighty movies in Fig. 4. IMDb ratings are plotted in increasing order, from a small value to a higher value. The plotted graph demonstrates that both the prototypes performed relatively well in general. However, both models perform weekly at the beginning when the IMDb ratings are low and at the end when the IMDb rating is high. Still, compared to TextBlob, our proposed VADER lexicon performs better. In addition, some specific movies, such as movies 17, 27, and 39, for which both models predict significantly higher values than the original IMDb rating. In the same

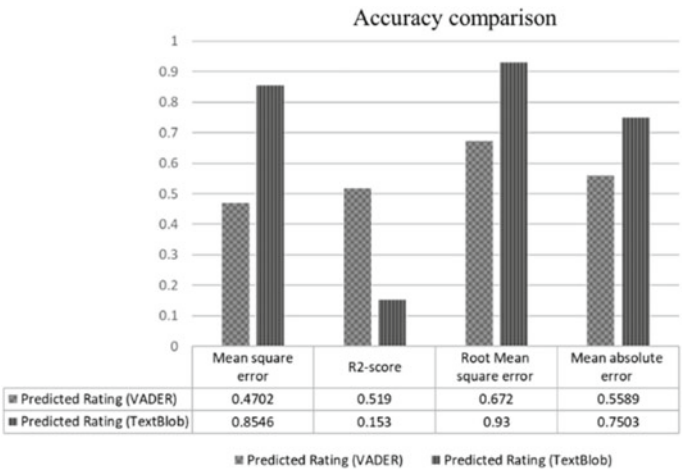


Fig. 3 Comparative analysis of prediction error between VADER and TextBlob lexicons

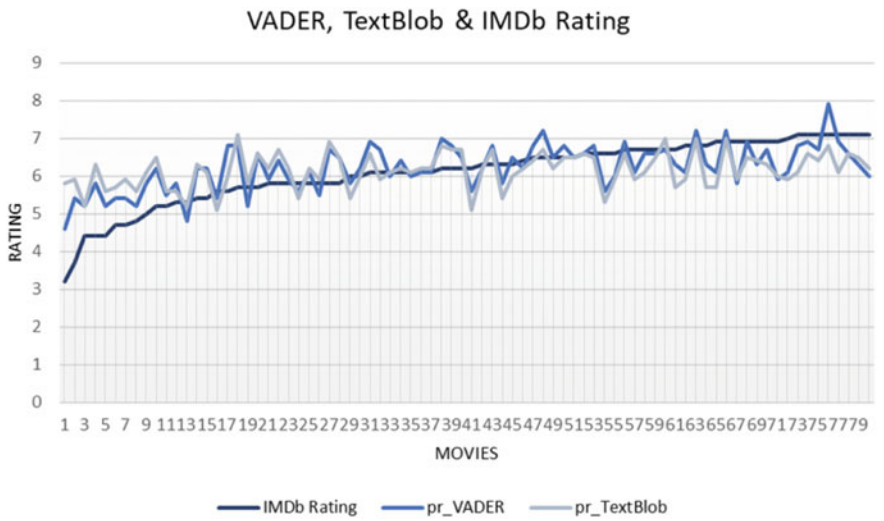


Fig. 4 Comparison between predicted rating by VADER and TextBlob and IMDb rating

way for movies like 41, 55, 63 and 66, our proposed models predict a significantly low value.

5.2 Movie Trend Analysis

We analyse the changes in the viewers' sentiments pre- and post-release of the movie. We observed that in our data set, out of 80 movies, in 30 movies, changes of positive sentiment are more than 10. Figure 5 plots the percentage of positive sentiment before releasing the movie (Pos_br) and the percentage of positive sentiment after releasing the movie (Pos_ar) of all 30 movies. The figure shows that only movies 1, 6, and 28 have a higher percentage of positive sentiment before the movie's release. All the other movies have a lower pre-release positive sentiment. On the other hand, movies 2 and 3 achieved a very high percentage of positive reviews after the movie release. Figure 6 plots the percentage of negative sentiment before and after releasing the same 30 movies. Expectedly, movies 2 and 3 have a low percentage of negative reviews. Movies 1, 15, and 20 had a significant negative sentiment trend. On the other hand, movies 26 and 27 were getting significant positive sentiment trends after the movie release.

In the movie industry, some movie creates hype about the pre-released movie with the help of the movie's trailer and also using promotional activities, creating a positive sentiment in the viewers' mind. But after release, they could not sustain the positive sentiment. Figure 7 presents five examples of movies where we observed a maximum drop in positive sentiment after the movie's release. For example, in the

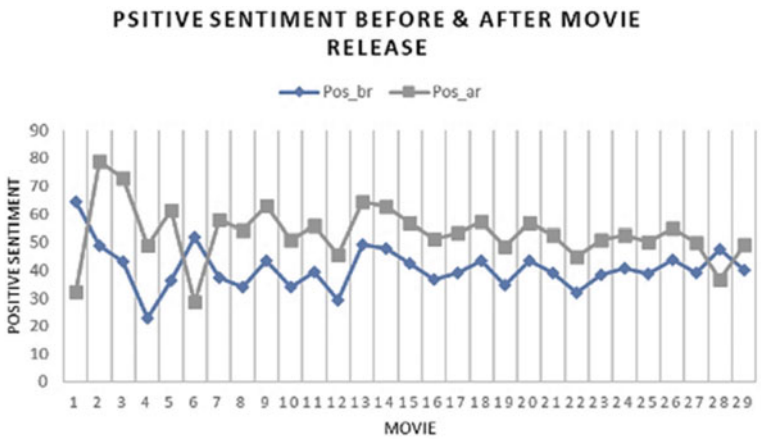


Fig. 5 Changes in positive sentiment before and after the release of the movie

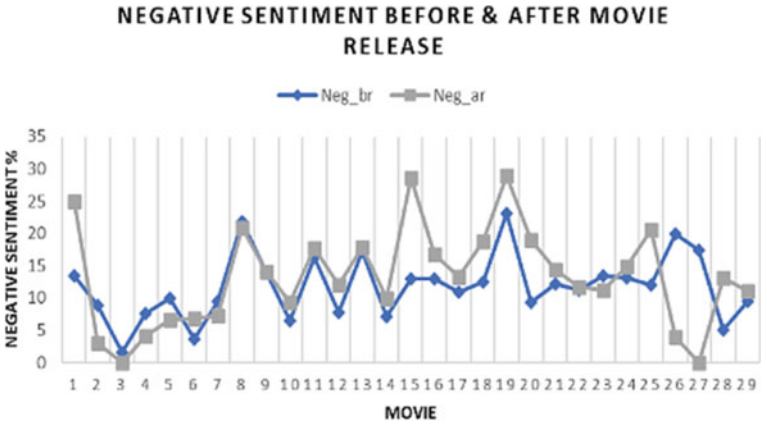


Fig. 6 Changes in negative sentiment before and after the release of the movie

case of the movie "The Match", viewers' positive sentiment percentage dropped by 32.04%. On the contrary, in some movies, viewers' responded much more positively after the movie's release. Figure 8 shows five movies where we observed a maximum increase in positive sentiment after the movie's release.

Figure 9 presents five movies for which negative sentiment reduces significantly after the movie's release. For example, the movie "Bombay Rose" received a 20% negative review, but after it was released, it reduced to only 3.92%. On the contrary, Fig. 10 presents five movies for which negative sentiment increases significantly after the movie's release. For example, in the movie "London Hughes: To Catch a Dick", negative sentiment increases by 22.13%. In the movie "The Midnight Sky", it increases by 17.48%.

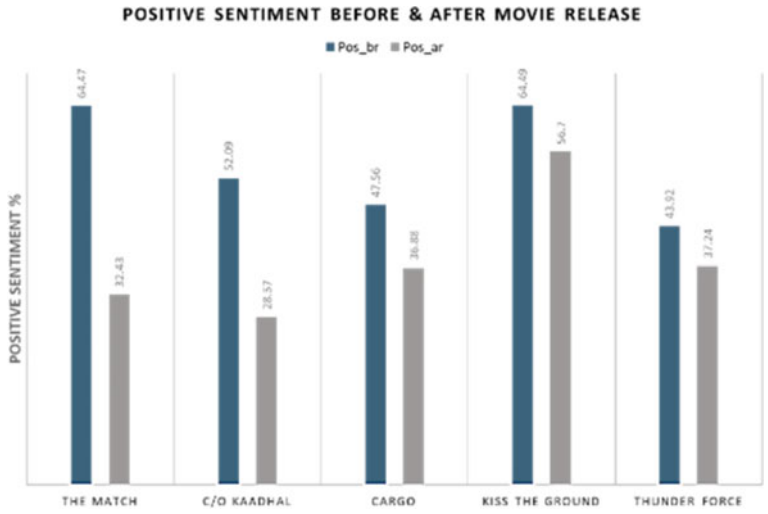


Fig. 7 Reducing the positive sentiment trend after the release of the movie

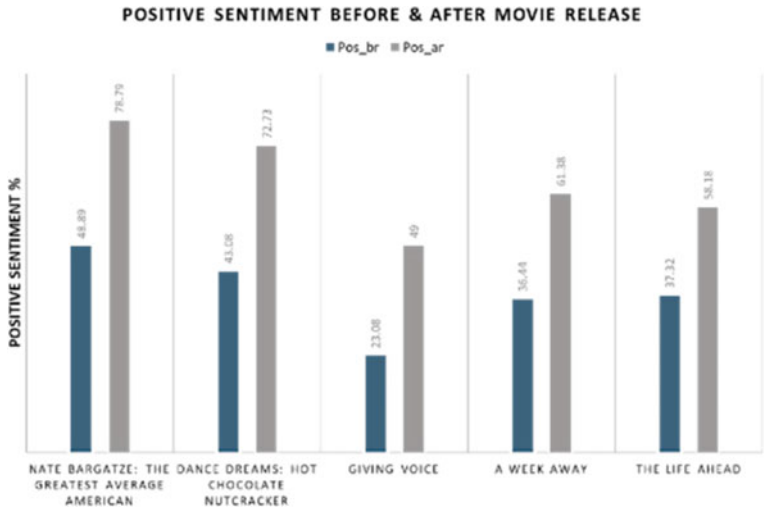


Fig. 8 Growing positive sentiment trend after the release of the movie

6 Conclusions and Future Works

A substantial amount of money and human effort is involved with each movie production. But in the end, only a few of the movies got successful. Therefore, predicting movie ratings is very important for moviemakers. In our research work, we analyse each review comment and compute the overall sentiment of the viewers. Then, from

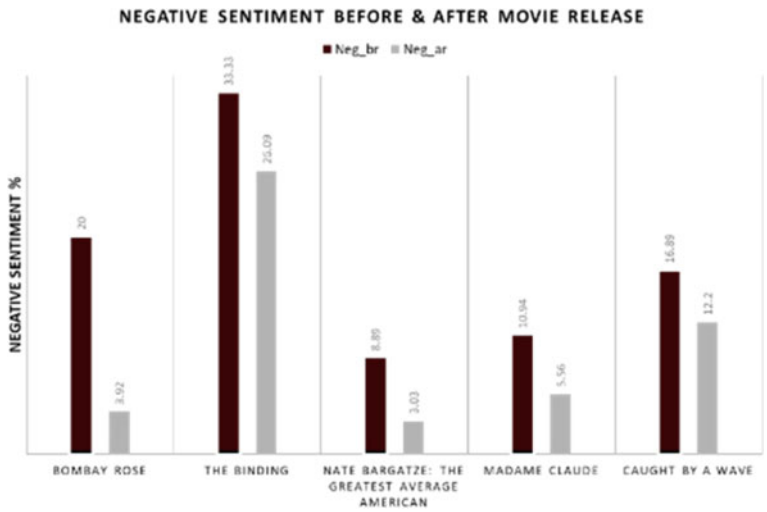


Fig. 9 Reducing the negative sentiment trend after the release of the movie

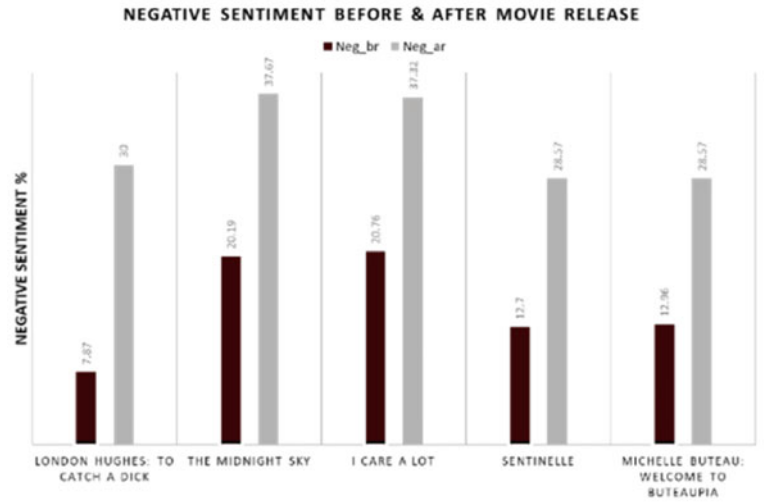


Fig. 10 Growing negative sentiment trend after the release of the movie

overall sentiment, we derived the predicted rating. Analysing the sentiment trend of viewers is also a critical aspect for movie makers. Sometimes, positives decrease after the release of the movie and at the same time may be negativity also increase. We also observed some low-profile movies get popular after their release. Observation and analysis of viewers' sentiment trends are essential for movie makers to learn from their mistakes and realise the positive gear.

Our proposed work predicts the movie rating of average movies with significant accuracy. But it fails to achieve good accuracy when the movie has a high IMDb rating or a very low IMDb rating. In future work, we plan to overcome these drawbacks and need to attain high accuracy for all types of movies. In the second part, we study viewers' sentiment trends pre and post-release of the movie. In future work, we plan to investigate and find the parameters responsible for movie success.

References

1. Lim, Y. J., & Teh, Y. W. (2007, August). Variational Bayesian approach to movie rating prediction. In *Proceedings of KDD cup and workshop* (Vol. 7, pp. 15–21).
2. Armstrong, N., & Yoon, K. (1995). *Movie rating prediction.* Technical Report, Carnegie Mellon University.
3. Fikir, O. B., Yaz, I. O., & Özyer, T. (2010, August). A movie rating prediction algorithm with collaborative filtering. In *2010 International conference on advances in social networks analysis and mining* (pp. 321–325). IEEE.
4. Li, X., Zhao, H., Wang, Z., & Yu, Z. (2020, May). Research on movie rating prediction algorithms. In *2020 5th IEEE international conference on big data analytics (ICBDA)* (pp. 121–125). IEEE.
5. Liu, C. L., Hsaio, W. H., Lee, C. H., Lu, G. C., & Jou, E. (2011). Movie rating and review summarization in mobile environment. *IEEE transactions on systems, man, and cybernetics, part C (applications and reviews), 42*(3), 397–407.
6. Zhuang, L., Jing, F., & Zhu, X. Y. (2006, November). Movie review mining and summarization. In *Proceedings of the 15th ACM international conference on Information and knowledge management* (pp. 43–50).
7. Yessenov, K., & Misailovic, S. (2009). Sentiment analysis of movie review comments. *Methodology, 17*, 1–7.
8. Topal, K., & Ozsoyoglu, G. (2016, August). Movie review analysis: Emotion analysis of IMDb movie reviews. In *2016 IEEE/ACM international conference on advances in social networks analysis and mining (ASONAM)* (pp. 1170–1176). IEEE.
9. Munjal, P., Narula, M., Kumar, S., & Banati, H. (2018). Twitter sentiments based suggestive framework to predict trends. *Journal of Statistics and Management Systems, 21*(4), 685–693.
10. Ji, S. W., & Waterman, D. (2010). *Production technology and trends in movie content: An empirical study.* Working Paper, Department of Telecommunications, Indiana University, Bloomington, IN. Retrieved from http://www.indiana.edu
11. Lee, K. S. (2020). A exploratory study of movie trends through simulation in movie. *The Journal of the Korea Contents Association, 20*(9), 424–429.
12. Horváth, A., & Balázs, G. (2021). Movie consumption related trends and countertrends in consumer behavior.
13. Eliashberg, J., Jonker, J. J., Sawhney, M. S., & Wierenga, B. (2000). MOVIEMOD: An implementable decision-support system for prerelease market evaluation of motion pictures. *Marketing Science, 19*(3), 226–243.
14. Meiseberg, B., & Ehrmann, T. (2013). Diversity in teams and the success of cultural products. *Journal of Cultural Economics, 37*(1), 61–86.
15. Boccardelli, P., Brunetta, F., & Vicentini, F. (2008). What is critical to success in the movie industry? A study on key success factors in the Italian motion picture industry.
16. Litman, B. R. (1983). Predicting success of theatrical movies: An empirical study. *Journal of popular culture, 16*(4), 159.
17. Bae, G., & Kim, H. J. (2019). The impact of movie titles on box office success. *Journal of Business Research, 103*, 100–109.

18. Parimi, R., & Caragea, D. (2013, July). Pre-release box-office success prediction for motion pictures. In *International workshop on machine learning and data mining in pattern recognition* (pp. 571–585). Springer, Berlin, Heidelberg.
19. Apala, K. R., Jose, M., Motnam, S., Chan, C. C., Liszka, K. J., & de Gregorio, F. (2013, August). Prediction of movies box office performance using social media. In *2013 IEEE/ACM international conference on advances in social networks analysis and mining (ASONAM 2013)* (pp. 1209–1214). IEEE.
20. Begam S, S., Selvachandran, G., Ngan, T. T., & Sharma, R. (2020). Similarity measure of lattice ordered multi-fuzzy soft sets based on set theoretic approach and its application in decision making. *Mathematics, 8*, 1255.
21. Vo, T., Sharma, R., Kumar, R., Son, L. H., Pham, B. T., Tien Bui, D., Priyadarshini, I., Sarkar, M., & Le, T. (2020). Crime rate detection using social media of different crime locations and twitter part-of-speech tagger with brown clustering. 4287–4299.
22. Nguyen, P. T., Ha, D. H., Avand, M., Jaafari, A., Nguyen, H. D., Al-Ansari, N., Van Phong, T., Sharma, R., Kumar, R., Le, H. V., Ho, L. S., Prakash, I., & Pham, B. T. (2020). Soft computing ensemble models based on logistic regression for groundwater potential mapping. *Applied Sciences, 10*, 2469.
23. Jha, S., et al. (2019). Deep learning approach for software maintainability metrics prediction. *IEEE Access, 7*, 61840–61855.
24. Sharma, R., Kumar, R., Sharma, D. K., Son, L. H., Priyadarshini, I., Pham, B. T., Tien Bui, D., & Rai, S. (2019). Inferring air pollution from air quality index by different geographical areas: Case study in India. *Air Quality Atmosphere Health, 12*, 1347–1357.
25. Sharma, R., Kumar, R., Singh, P. K., Raboaca, M. S., & Felseghi, R.-A. (2020). A systematic study on the analysis of the emission of CO, CO_2 and HC for four-wheelers and its impact on the sustainable ecosystem. *Sustainability, 12*, 6707.
26. Dansana, D., Kumar, R., Das Adhikari, J., Mohapatra, M., Sharma, R., Priyadarshini, I., & Le, D.-N. (2020). Global forecasting confirmed and fatal cases of COVID-19 outbreak using autoregressive integrated moving average model. *Frontiers in Public Health, 8*, 580327. https://doi.org/10.3389/fpubh.2020.580327
27. Malik, P. K., Sharma, R., Singh, R., Gehlot, A., Satapathy, S. C., Alnumay, W. S., Pelusi, D., Ghosh, U., & Nayak, J. (2021). Industrial internet of things and its applications in industry 4.0: State of the art. *Computer Communications, 166*, 125–139, ISSN 0140-3664. https://doi.org/10.1016/j.comcom.2020.11.016
28. Sharma, R., Kumar, R., Satapathy, S. C., Al-Ansari, N., Singh, K. K., Mahapatra, R. P., Agarwal, A. K., Le, H. V., & Pham, B. T. (2020). Analysis of water pollution using different physico-chemical parameters: A study of Yamuna river. *Frontiers in Environmental Science, 8*, 581591. https://doi.org/10.3389/fenvs.2020.581591
29. Dansana, D., Kumar, R., Parida, A., Sharma, R., Adhikari, J. D., Le, H. V., Pham, B. T., Singh, K. K., & Pradhan, B. (2021). Using susceptible-exposed-infectious-recovered model to forecast coronavirus outbreak. *Computers, Materials & Continua, 67*(2), 1595–1612.
30. Oghina, A., Breuss, M., Tsagkias, M., & Rijke, M. D. (2012, April). Predicting IMDB movie ratings using social media. In *European conference on information retrieval* (pp. 503–507). Springer, Berlin, Heidelberg.
31. Medhat, W., Hassan, A., & Korashy, H. (2014). Sentiment analysis algorithms and applications: A survey. *Ain Shams Engineering Journal, 5*, 1093–1113.
32. Cambria, E., Das, D., Bandyopadhyay, S., Feraco, A. (2017). Affective computing and sentiment analysis. In *A practical guide to sentiment analysis* (pp. 1–10). Springer.
33. Li, H., Cui, J., Shen, B., & Ma, J. (2016). An intelligent movie recommendation system through group-level sentiment analysis in microblogs. *Neurocomputing, 210*, 164–173.
34. Kumar, S., De, K., & Roy, P. P. (2020). Movie recommendation system using sentiment analysis from microblogging data. *IEEE Transactions on Computational Social Systems, 7*, 915–923.

35. Yu, D., Mu, Y., & Jin, Y. (2017). Rating prediction using review texts with underlying sentiments. *Information Processing Letters, 117*, 10–18.
36. Kesharwani, A., & Bharti, R. (2017). *Movie rating prediction based on: twitter sentiment analysis*. LAP LAMBERT Academic Publishing.

Performance Evaluation of Hybrid FSO/RF Link Under NRZ Modulation Format

Shakshi and Himanshi Saini

Abstract NRZ is the dominant modulation method in commercial terrestrial FSO system. This is because of its simplicity and flexibility to the natural nonlinearities of the laser and the external modulator. In this paper, the performance of hybrid free space optics (FSO) and radio frequency (RF) has been analyzed by employing NRZ (non-return to zero) modulation format (non-chirped NRZ, chirped NRZ, alternate chirp NRZ, vestigial sideband (VSB) NRZ). All these have been modeled using optisystem software. The various performance matrices such as quality–factor (Q-factor), bit error rate (BER) and eye height have been evaluated with respect to bit rate and frequency. It has been observed that non-chirped NRZ gives best Q-factor and BER as compared to other modulation formats.

Keywords Alternate chirp NRZ · BER · Chirped NRZ · Modulation · Non-chirped NRZ · Q-factor · VSB NRZ

1 Introduction

Free space communication is the system, in which information is sent from transmitter to receiver through air. This type of communication is line of sight communication. FSO provides higher data rate as compared with optical fiber. FSO has wide range of application in cellular system, monitoring, security and broadcasting. It is the quickest method of communication but while transferring the data it might handle various weaknesses. There may be geometric loss, atmospheric loss due to fog, haze and rain, misalignment loss due to pointing errors and many more. One of the recent technologies to overcome the above loses is hybrid FSO and RF. In this, if FSO system performance is degraded than RF system will work as backup. The growing demand for high data rate and improvement in spectral efficiency has opened the door to new modulation format which not only carry information but also work on chromatic dispersion and nonlinearities. Modulation formats such as

Shakshi (✉) · H. Saini
Deenbandhu Chhotu Ram University of Science and Technology, Haryana, India
e-mail: shakshighatwal@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_13

duobinary, alternate mark inversion (AMI), return-to-zero (CRZ), carrier-suppressed return-to-zero (CSRZ) and NRZ belong to this advanced group. NRZ is the dominant modulation method in commercial terrestrial FSO system. This is because of its simplicity and flexibility to the natural nonlinearities of the laser and the external modulator. The paper is organized as follows: Sections 1 and 2 give the introduction and literature survey, respectively. In Sect. 3, simulation setup is described. Section 4 provides the result and discussion. Section 5 presents the conclusions and future scope of our study.

2 Literature Survey

For transmitting heavy amount of information, we use some modulation techniques like, non- chirped, chirped and alternate NRZ [1]. These formats are evaluated in Malaysia, and result shows that alternate chirped NRZ works better as compared with other techniques under different weather conditions [1]. Performance of various modulations formats work under some parameters like Q-factors, BER and eye height [2, 3]. For increase the quality, linear RoF (radio over fiber) system is proposed with low intermodulation distortion using single-drive dual parallel Mach-Zehnder modulator [4]. For high speed data transmission, modulators like push-pull MZ modulator are used [5].

3 Simulation Setup

The simulation setup shown in Figs. 1, 2, 3 and 4 is used to analyze and compare the performance of chirped NRZ, non-chirped NRZ, alternate NRZ, VSB modulation formats, respectively. Transmitter section consists of pseudo-random bit sequence generator (PRBS) which generates data signal that can be modulated by employing single-drive MZM. The modulated optical signal is transmitted over an optical fiber of length 10km. In the receiver section, optical signal is detected by PIN photo detector and analyzed by BER analyzer. Simulation parameters like layout, transmitter, Bessel filter and single-drive MZM and receiver have been given in Table 1.

4 Result and Discussion

In the NRZ format, the pulse remains on throughout the bit slot and its amplitude does not drop to zero between two or more successive 1 bit. Figure 5 shows the eye diagrams for various NRZ modulation formats. It is observed that eye is clearly opened for non-chirped modulation format. In Table 2, the results are summarized for all NRZ modulation format at the data rates of 10, 15 and 20 Gbps. Table 3 gives

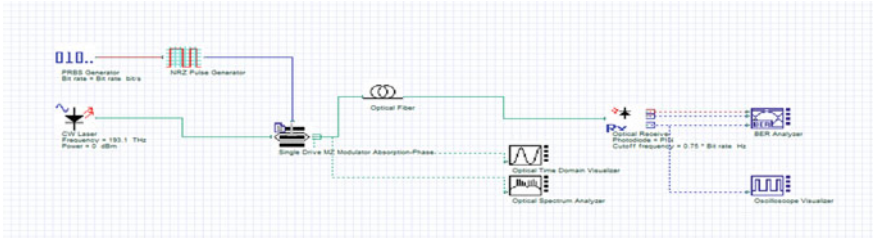


Fig. 1 Non-chirped NRZ

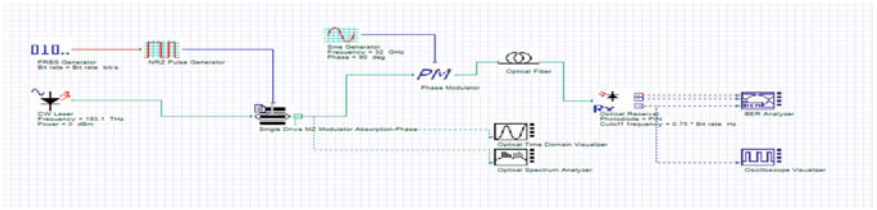


Fig. 2 Chirped NRZ

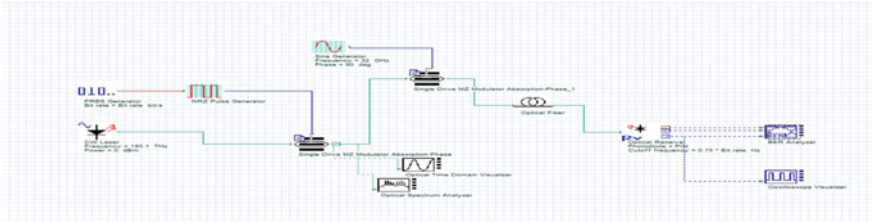


Fig. 3 Alternate chirped NRZ

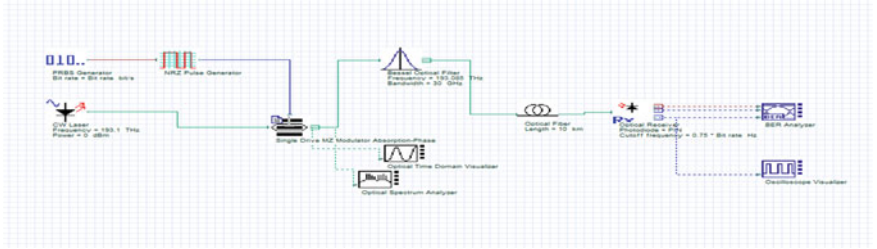


Fig. 4 Vestigial sideband

Table 1 Performance indices

Layout parameters	Values
Bit rate	10 Gbps,15 Gbps, 20 Gbps
Sequence length	128
Samples per bit	64
Number of samples	8192
Sensitivity	−100 dBm
Resolution	0.1 nm
Transmitter parameters	*Values*
PBRS bit rate	10 Gbps,15 Gbps, 20 Gbps
CW laser power	0 dBm
CW laser frequency	193.1, 193.3, 193.5, 193.7,193.9, 191.7, 196.1 THz
Single-drive MZM parameters	*Value*
Splitting ratio	1.3
Modulator type	Phase shift having voltage 1.5 V
Bias voltage1	−2.8 V
Bias voltage2	−1.1 V
Bessel filter parameter	*Values*
Frequency	193.085
Bandwidth	100 GHz
Depth	100 dB
Insertion loss	0 dB
Order	1
Receiver parameters	*Value*
Optical receiver photo diode	PIN
Cut off frequency	0.75* bit rate

the results of all NRZ modulation format at the data rates of 10, 15 and 20 Gbps. Table 4 given the results for all NRZ modulation format at the data rates of 10, 15 and 20 Gbps. And Table 5 analyzed the results for all NRZ modulation format at the data rates of 10, 15 and 20 Gbps.

Based on the result achieved in Table 2, it is seen that at 10 Gbps at frequency 196.1 and 193.1, the best values of Q-factor and less BER are obtained. At 10 Gbps, in case of non-chirped, the best value of Q-factor is 74.3756, at 15 Gbps, it is reduced to 35.9057, and at 20 Gbps, it is 12.0114. In case of chirped, alternate and VSB modulation formats the best values of Q-factors are 20.0828, 26.1193 and 57.5204, respectively. It is also observed from Table 2 that BER reduces more by using non-chirped NRZ modulation format at high bit rate for long transmission distance.

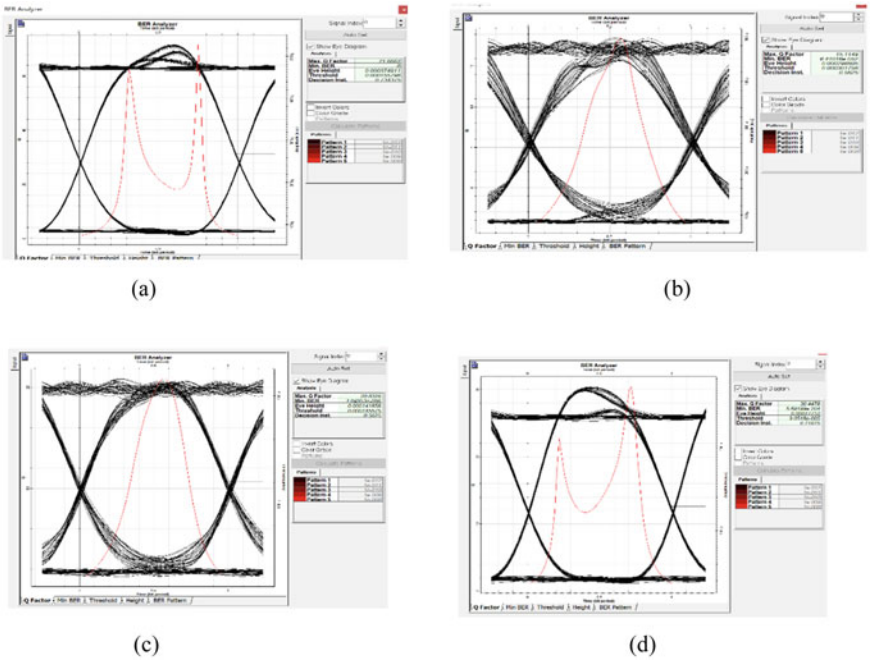


Fig. 5 Eye diagram of hybrid FSO/RF system with **a** Non-chirped NRZ, **b** chirped NRZ, **c** alternate chirped NRZ, VSB modulation formats at 10 km fiber length

Table 2 Performance of non-chirped NRZ modulation format (2a) 10 Gbps (2b) 15 Gbps (2c) 20 Gbps

(**a**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	63.2646	0	0.000371695
193.1	71.6662	0	0.00374911
193.3	66.6058	0	0.00373218
193.5	65.0382	0	0.00037291
193.7	62.8252	0	0.000373654
193.9	66.9874	0	0.000374813
196.1	74.3756	0	0.000374533

(**b**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	26.8391	5.63792e-159	0.000346755
193.1	33.3582	2.75045e-244	0.000352624
193.3	33.6562	1.23897e-248	0.000352976

(continued)

Table 2 (continued)

(**b**)

Frequency (THz)	Q-factor	Min BER	Eye height
193.5	32.8607	3.97627e-237	0.000353603
193.7	32.9443	2.54796e-238	0.000353675
193.9	35.9057	1.23984e-282	0.000355167

(**c**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	8.02401	4.23428e-016	0.00027382
193.1	9.0218	7.87658e-020	0.00025718
193.3	9.34258	4.0316e-021	0.000291068
193.5	9.41173	1.41829e-021	0.000291068
193.7	9.39667	2.43854e-021	0.000289085
193.9	9.69673	1.36338e-022	0.000289963
196.1	12.0114	1.444e-033	0.000308611

5 Conclusion and Future Scope

The performance of non-chirped NRZ, chirped NRZ, alternate chirp NRZ, VSB NRZ modulation formats has been analyzed in terms of the eye diagram, Q-factor and BER for hybrid FSO/RF system. Simulation results indicate that non-chirped modulation format works efficiently as it provides high Q-factor of 74.3756, less BER and maximum eye opening at different frequency ranges for longer transmission distance as compared to other NRZ modulation formats at 10 Gbps. With the rapid developments in technology and ever-increasing demand for higher speed and capacity, some more hybrid techniques, namely OOK, DPSK, QAM, QPSK can be involved for the better performance.

Table 3 Performance of chirped NRZ modulation format (3a) 10 Gbps (3b) 15 Gbps (3c) 20 Gbps

(**a**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	13.7459	2.66275e-043	0.00028615
193.1	15.1149	6.41016e-052	0.000296805
193.3	15.5295	1.08302e-064	0.00299925
193.5	15.9366	1.74912e-057	0.000302208
193.7	16.0346	2.64422e-058	0.000302613
193.9	16.7856	1.5406e-063	0.000306882
196.1	20.0828	5.19297e-090	0.000323731

(**b**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	6.39892	7.54326e-011	0.000178926
193.1	6.82538	4.29147e-012	0.000191761
193.3	6.90016	2.53966e-012	0.000192815
193.5	6.96498	1.6058e-012	0.000195429
193.7	7.04204	9.29554e-013	0.000196478
193.9	7.07773	7.54326e-011	0.000178926
196.1	8.52646	7.40952e-018	0.00023023

(**c**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	4.91355	4.40396e-007	0.000141073
193.1	6.29297	7.73163e-008	0.00015635
193.3	5.18631	1.04918e-006	0.000153532
193.5	5.41071	3.06162e-008	0.000163092
193.7	5.17928	1.08117e-007	0.000153335
193.9	5.34666	4.35985e-008	0.000160222
196.1	6.33314	1.17725e-010	0.000192977

Table 4 Performance of alternate chirped NRZ modulation format (4a) 10 Gbps (4b) 15 Gbps (4c) 20 Gbps

(**a**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	19.1569	3.91072e-097	0.000139113
193.1	20.8328	8.71693e-097	0.000141863
193.3	22.7291	1.08976e-114	0.000144486
193.5	22.3828	2.76906e-111	0.000144919
193.7	21.171	8.55208e-100	0.000143091
193.9	20.8068	1.85314e-096	0.000143414
196.1	26.1193	1.09607e-150	0.000149896

(**b**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	9.7658	7.65718e-023	0.00010958
193.1	9.80979	5.07093e-023	0.000110793
193.3	9.72243	1.20675e-022	0.00010994
193.5	10.0318	5.49687e-024	0.000112131
193.7	9.86873	2.82611e-023	0.000110758
193.9	9.91499	1.78699e-023	0.000110726
196.1	10.3089	3.20676e-025	0.000115006

(**c**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	6.509	3.639e-011	9.28962e-005
193.1	6.33244	1.13015e-010	9.18034e-005
193.3	6.09108	5.21241e-010	8.74875e-005
193.5	6.3102	1.29265e-010	9.12517e-005
193.7	6.01703	8.23028e-010	8.67559e-005
193.9	6.13215	4.0172e-010	8.80217e-005
196.1	5.92.95	1.39888e-009	8.55488e-005

Table 5 Performance of VSB NRZ modulation format (5a) 10 Gbps (5b) 15 Gbps (5c) 20 Gbps

(**a**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	0	1	0
193.1	57.5204	0	0.000339505
193.3	8.27415	6.41647e-017	1.29566e-005
193.5	1.93261	0.266423	−2.7844e-006
193.7	0	1	0
193.9	0	1	0
196.1	0	1	0

(**b**)

Frequency (THz)	Q-factor	Min BER	Eye height
193.1	30.4478	5.69199e-204	0.00017752
193.3	6.49393	4.17839e-011	1.14529e-005
193.5	0	1	0
193.7	0	1	0
193.9	0	1	0
196.1	0	1	0

(**c**)

Frequency (THz)	Q-factor	Min BER	Eye height
191.7	0	1	0
193.1	9.10645	3.74412e-020	0.000261574
193.3	4.93692	3.93161e-007	8.48395e-006
193.5	0	1	0
193.7	0	1	0
193.9	0	1	0
196.1	0	1	0

References

1. Arif, R. E., Othman, M. B., & Pramono, S. H. (2015). Investigation of non chirped NRZ, chirped NRZ and alternate-chirped NRZ modulation techniques for free space optic (FSO) systems. *ARPN Journal of Engineering and Application Sciences, 10*, 8731–8735.
2. Kathpal, N., & Garg, A. K. (2017). Simulative investigation of single-tone ROF system using various duobinary modulation formats. *International Optical and Lig. Wave: An International Journal, 1*, 28–33.
3. Liu,N.,. Zhong, W., He, Y., Heng, K. H., & Cheng, T. H. (2008). Comparison of NRZ and RZ modulations in laser intersatellite communication systems. In *Proceedings of the 2008 International Conference on Advanced Infocomm Technology* (Vol. 4).

4. Li, S., Zheng, X., Zhang, H., & Zhou, B. (2010). Highly linear radio-over-fiber system incorporating a single-drive dual-parallel Mach-Zehnder modulator. *IEEE Photonics Technology Letters, 22*, 1775–1777. https://doi.org/10.1109/LPT.2010.2082516
5. Djordjevic, I. B., Judy, R., & Siyuan, Y. (2004). Chirped NRZ modulation format for high speed transmission. *Journal of Optical Communications, 25*, 158–160.

An Adaptive Opposition Learning-Improved Slime Mould Algorithm-Based Optimization Routing for Guaranteeing Reliable Data Dissemination in FANETs

J. Sengathir, M. Deva Priya, A. Christy Jeba Malar, and Suma Sira Jacob

Abstract Flying Ad hoc NETwork (FANET) refers to a self-organizing wireless network that facilitates easy, flexible and inexpensive deployment of flying nodes termed as Unmanned Aerial Vehicles (UAVs). These UAVs communicate with one another without the presence of any fixed network infrastructure. The routing process is responsible for achieving reliable coordination and cooperation among flying nodes to establish reliable routes towards radio access infrastructure that corresponds to Base Station (BS) of FANET. Routing protocols in FANETs play an anchor role in preventing network partitions and link disconnections to guarantee prolonged route lifetime with minimized energy utilization rate. In this paper, an Adaptive Opposition Learning-Improved Slime Mould Algorithm (AOLISMA)-based optimization routing is proposed for ensuring reliable data dissemination among UAVs with extended network lifetime and minimized energy consumption. This AOLISMA routing approach utilizes two randomly selected search agents for determining feasible direction and displacement that aid in better routing process. It adopts random selection of search agents for restricting the limits of exploration and exploitation to establish better balance during the process of routing. It also helps in attaining a near-optimal or optimal route that prolongs network route lifetime. It specifically utilizes opposition learning for adaptive increase in the exploration rate for identifying feasible routes from which, optimal route can be selected based on an objective

J. Sengathir
Department of Information Technology, CVR College of Engineering, Mangalpally, Vastunagar, Hyderabad, Telangana, India
e-mail: j.sengathir@gmail.com

M. Deva Priya (✉)
Department of Computer Science and Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamil Nadu, India
e-mail: devapriya.m@sece.ac.in

A. Christy Jeba Malar · S. S. Jacob
Department of Information Technology, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India
e-mail: a.christyjebamalar@skct.edu.in

S. S. Jacob
e-mail: sumasarajacob@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_14

function for attaining reliable routing. The simulation experiments of the proposed AOLISMA scheme conducted based on throughput, control overhead, mean delay and energy consumption for varying mobility rates of UAVs confirm better performance on par with the baseline GAR, ACOAR and ABCAR approaches taken for comparison.

Keywords Flying Ad hoc NETworks (FANETs) · Improved slime mould algorithm · Opposition-Based Learning (OBL) · Unmanned Aerial Vehicles (UAVs) · Route lifetime

1 Introduction

Flying Ad hoc NETwork (FANET) is a kind of Mobile Ad hoc NETwork (MANET) that includes an aircraft which acts as a converter for sending or receiving data through wireless communication [1, 2]. In contrast to the traditional wireless network, FANET establishes communication by transmitting data among themselves. In contrast to MANET and Vehicular Ad hoc NETwork (VANET), it supports increased mobility, distant communication and scarce node-positioning that are highly challenging in designing routing protocols [3, 4]. It can be substituted at any time without support from any static facility. A network can be set at any place to facilitate highly efficient communication at the multi-aircraft system's network layer [5]. With the development of embedded systems and reduction of size of the electromechanical systems, Unmanned Aerial Vehicles (UAVs) are capable of monitoring air, identifying biological agents and targets, relaying communication owing to their reduced cost, offering robust scalability, easy concealment and handling the challenges in tracking [6]. FANET with micro-UAV acting as radar has drawn much attention from diverse areas including academic, industrial as well as military. They are extensively used in several military and civilian related applications.

Routing protocols play a dominant role in enhancing network performance and ensuring efficient communication. FANETs can be represented as undirected graphs with vertices representing nodes and edges representing links [7–9]. The nodes are the same, while the links change with the inclusion and exclusion of communication links [10]. An ideal route involves finding an appropriate set of vertices, such that the corresponding set of edges are the ones with reduced cost and increased stability [11, 12]. For a network containing 'n' nodes, there are n! permutations of nodes. Route direction in FANET is typically not limited, and hence, it is a pleasant combination [13]. The number of possible routes is n!/2n. In case exhaustive search is to be carried out, all the routes should be found and compared to determine the optimal route [14]. Determining an ideal route in a battery-powered FANET is challenging. Usually, a usable route is determined and not an enhanced one [15, 16]. When an intermediary node wants to communicate, the neighbouring nodes are regarded as the next hop nodes in the route. Determining a stable and optimized route in FANET

is NP-hard. Route determination in FANET is considered as a single-goal planning problem [17, 18]. Hence, it is feasible to employ heuristic algorithms for route planning in FANETs.

2 Related Work

Ma et al. [19] have propounded a Velocity-Aware and Stability-Estimation-based Multi-Path Routing Protocol that incorporates a route discovery and maintenance scheme. During routing discovery, it sends Route REQuest (RREQ) packets through trustworthy nodes based on the computation of co-direction degree, thus reducing the routing overhead. It removes the theoretical error in finding the path stability. The association of survival period amid neighbouring links plays a dominant role in establishing path stability. To deal with route maintenance, path similarity and residual survival period-based multiple path selection scheme are proposed. It forwards packets through chosen paths based on the multi-path selection scheme. The performance of the velocity and stability-estimation-based protocol is found to be better in contrast to the benchmarked protocols in terms of throughput, average delay, routing overhead and convergence time of route discovery.

Based on the features of increased mobility of nodes in FANETs combined with the characteristics of topology dependent class routing protocol, a Genetic Algorithm-based Routing (GAR) protocol is propounded by Wei et al. [20]. It depends on enhanced GA for route search by considering link stability, bandwidth and node energy. GAR enhances selection, crossover and variation operators for rapidly finding an enhanced route from source to destination by involving lesser cost. From the results, it is evident that the scheme offers better throughput, stability and reduced delay. GAR offers route stability, which in turn enhances network performance, lifetime and network availability.

Node mobility imposes an increased challenge in FANETs. Continuous Hopfield Neural Network (CHNN) is used with Dynamic Source Routing (DSR) for finding the route to support the movement of a node [10]. Owing to repeated topology fluctuations, the protocol considers the routes independent of their quality. It considers factors like hop count, link capacity and stability, energy, interference, etc. The node is mapped to CHNN, and an optimal route is found by dynamic growth of NN state. Search time is dynamically determined based on the time, and the state becomes stable. DSR is optimized to get a stable route, thus improving the stability and communication efficiency of the network.

Wei and Yang [21] have dealt with finding steady routes with increased efficiency using Ant Colony Optimization (ACO). In a network with proactive routing, the routes are constructed before data is sent. Proactive routing does not involve episodic broadcasts, intermittent identification of link states and neighbour nodes. It initializes pheromone along the edges in the network. Every ant arbitrarily chooses a node and path by repeatedly using transition rules. During route selection, if an ant dies before reaching the destination, it releases another ant to substitute the dead ant and

determines the path. When an ant finishes routing, it updates the pheromone along the chosen path based on local update. It determines the ant that finds the minimum cost path and stability limit and employs global update rules to update the pheromone along the paths.

AODV protocol does not focus on the cost, bandwidth and delay in the network, and hence, the routing table includes only one path. Guo and Lv [22] have attempted to enhance the AODV protocol by using Particle Swarm Optimization (PSO). PSO is enhanced based on inertia weight, shrinkage factor, linear decline and chaos. ACPSO determines ideal path and transmits data quickly, while Chaotic PSO (CACPSO) is designed to enhance AODV protocol. The performance is analysed in terms of network delay, packet delivery rate and route discovery frequency.

Hameed et al. [23] have addressed the dynamic issues by varying the choice of relay to establish the significance of cooperative diversity scheme. Grey Wolf Algorithm using Cooperative Diversity (GWCOOP) scheme is proposed for efficient routing in FANETs. It is based on Grey Wolf Optimizer (GWO) that includes social hierarchy as well as collaboration scheme. It implements grey wolves' natural posture to deal with flying node demands. It establishes cooperative diversity using 2 relays to withstand source to destination links. It outdoes BAT-COOP protocol based on transmission loss, link delay, energy consumption as well as Packet Loss Ratio (PLR).

Kaur et al. [24] have defined an approach which is based on FireFly Algorithm (FFA). It applies the concept of FFA on FANETs where Geographical Position Mobility-Oriented Routing (GPMOR) protocol aims to decrease the amount of hops depending on Gauss Markov (GM) mobility model. It facilitates efficient routing of packets.

As the nodes are highly mobile in FANETs, reducing the amount of delay in finding routes is challenging. Da Costa et al. [25] have focused on this problem by offering a routing mechanism called Q-FANET that is based on improved Q-Learning algorithm which deals with reducing network delay in networks with increased mobility. The proposed protocol involves reduced delay as well as jitter and offers increased Packet Delivery Ratio (PDR) in contrast to other reinforcement learning-based protocols.

3 Proposed Adaptive Opposition Learning-Improved Slime Mould Algorithm (AOLISMA)-Based Optimized Routing

In this section, the primitive details of the proposed Adaptive Opposition Learning-Improved Slime Mould Algorithm (AOLISMA), its objective and fitness function along with the process of routing and route maintenance in FANETs are presented.

3.1 Primitive Details of AOLISMA

The Slime Mould Algorithm (SMA) is one of the significant function optimization algorithms as it is capable of handling the balance between exploitation and exploration for reaching near-optimal solution or optimal solution. This traditional SMO algorithm uses two random search agents for limiting the rate of exploration and exploitation, such that the displacement of the estimated solutions from the best search agents can be possibly determined from the entire population. However, the degree of balance between exploration and exploitation is not maintained to sufficient level. Thus, an adaptive approach using Opposition-Based Learning (OBL) is used for sustaining the balance between exploration and exploitation. In specific, OBL is utilized for adaptive increase in the rate of exploration. It maximizes the exploitation rate by replacing a random search agent with the best solution during the process of position updation.

Consider that there are 'n' number of slime moulds in the search space with 'L_{TH}' and 'U_{TH}' as the lower and upper boundaries of searching. Then, the position of each slime mould (search agent) is determined based on Eq. (1)

$$\mathrm{SM}_i = L_{\mathrm{TH}} + \mathrm{Rand}\,(U_{\mathrm{TH}} - L_{\mathrm{TH}}) \text{ with } 1 \leq i \leq n \tag{1}$$

Then, the food approaching phenomenon of slime mould completely depends on the food smell in the air which is represented using Eq. (2).

$$\mathrm{SM}_{t+1} = \begin{cases} \mathrm{SM}_{\mathrm{HOC}} + \mathrm{SB}_1\left(W_{SA}\left(\mathrm{SM}_t^A - \mathrm{SM}_t^B\right)\right), & \mathrm{Rand}_{[0,1]} < S_{\mathrm{Prob}} \\ \mathrm{SB}_2.\mathrm{SM}_t, & \mathrm{Rand}_{[0,1]} \geq S_{\mathrm{Prob}} \end{cases} \tag{2}$$

where

SM_t^A and SM_t^B	2 slime mould search agents that are randomly selected during the process of exploration
t and $t+1$	Current and previous iterations
$\mathrm{SM}_{\mathrm{HOC}}$	Position of the slime mould search agent which possesses high odour concentration,
W_{SA}	Weight associated with the search agent
$\mathrm{S}_{\mathrm{Prob}}$	Selection probability

However, the slime mould selection characteristics of food completely depend on 'SB_1' and 'SB_2' which range between $[-a, a]$ and $[0, 1]$ respectively. 'S_{Prob}' is determined using Eq. (3).

$$S_{\mathrm{Prob}} = \tan \mathrm{h}\left(\mathrm{SM}_{\mathrm{fit}}^i - \mathrm{OP}_{\mathrm{Fit}}\right) \tag{3}$$

where,

$\mathrm{SM}_{\mathrm{fit}}^i$ and $\mathrm{OP}_{\mathrm{Fit}}$	Fitness value of the individual slime mould search agent and optimal fitness value determined in the current iterations

In particular, the value of SB_2 is computed using Eq. (4).

$$SB_2 = [-a, a] \text{ with a} = \text{arc tanh}\left(\frac{-2}{\text{Iter}_{\text{Max}}} + 1\right) \tag{4}$$

where

Iter_{Max} Maximized number of iterations

Moreover, 'W_{SA}' is calculated using Eq. (5).

$$W_{SA} = \begin{cases} 1 + \text{Rand}_{[0,1]} \log\left(\frac{B_{\text{Fit}} - \text{SM}_i}{B_{\text{Fit}} - W_{\text{Fit}}} + 1\right), & 1 \le i \le \frac{n}{2} \\ 1 - \text{Rand}_{[0,1]} \log\left(\frac{B_{\text{Fit}} - \text{SM}_i}{B_{\text{Fit}} - W_{\text{Fit}}} + 1\right), & \frac{n}{2} \le i \le n \end{cases} \tag{5}$$

where,

B_{Fit} and W_{Fit} Best and Worst fitness values possessed by slime mould search agent in the current iteration ($\text{Iter}_{\text{Curr}}$).

Finally, the smell index representing the fitness value associated with each slime mould search agent is sorted in ascending order as it is included into the minimum valued problem during path stability prediction.

Further, the wrapping food phenomenon of slime mould search agent exhibited during the searching process is used for updating its corresponding position as specified in Eq. (6).

$$\text{SM}_{t+1} = \begin{cases} L_{\text{TH}} + \text{Rand}\ (U_{\text{TH}} - L_{\text{TH}}), & \text{Rand}_{[0,1]} < \text{BP}[\text{expr},\ \text{expl}) \\ \text{SB}_s.\text{SM}_t, & \text{Rand}_{[0,1]} < S_{\text{Prob}} \\ \text{SM}_{\text{HOC}} + \text{SB}_1\left(W_{SA}\left(\text{SM}_t^A - \text{SM}_t^B\right)\right), & \text{Rand}_{[0,1]} \ge S_{\text{Prob}} \end{cases} \tag{6}$$

where

BP[expr, expl) balancing parameters considered for sustaining the balance between exploration and exploitation.

In this proposed AOLISMA, the value of BP[expr, expl) is assigned to 0.03.

3.2 Improved SMA using Opposition-Based Learning

Opposition-Based Learning is added to SMA as the current solution of routing determined during the present iteration possesses 50% of probability of being farther from the optimal solution when compared to the opposition solution. Thus, inclusion of OBL aids in selecting potential individual solution in the search space and focusses on accelerating the searching process towards potential convergence. It is

also identified to maximize the degree of diversity in the population. If the number of search agents in the population is 'n', then the population of SMA can be represented using $\mathrm{SM}_i = (\mathrm{SM}_1, \mathrm{SM}_2, \ldots, \mathrm{SM}_n)$. At this juncture, if the OBL algorithm can generate an opposite population say $\widehat{\mathrm{SM}_i} = \left(\widehat{\mathrm{SM}_1}, \widehat{\mathrm{SM}_2}, \ldots, \widehat{\mathrm{SM}_n}\right)$, then

$$\widehat{\mathrm{SM}_i} = L_{\mathrm{TH}} + \mathrm{U}_{\mathrm{TH}} - \mathrm{SM}_i \tag{7}$$

The fitness value corresponding to the current and opposition solution in the population is computed. If the total number of solutions in the search space is '2n', then the individual solution with better fitness values is chosen as the new population of the subsequent generation. Moreover, the OBL methodology mainly concentrates on the ability of exploration. Thus, an elite chaotic searching scheme is adopted for improving the rate of exploitation in the search space. In specific, the selection of elite solution has the potentiality of improving the algorithm towards better exploitation using chaotic mutation. The elite solutions are mapped in the search space within the interval that ranges between 0 and 1 for determining the chaotic solutions as shown in Eq. (8)

$$\mathrm{CH}_t^{\mathrm{Ind}_i} = \frac{\mathrm{ESM}_t^i - L_{\mathrm{TH}}}{U_{\mathrm{TH}} - L_{\mathrm{TH}}} \tag{8}$$

Finally, a greedy selection strategy is adopted for ranking elite and chaotic solutions such that the identified solutions with better fitness value are considered as the new population for successive generation.

3.3 Objective Function Used in AOLISMA

In the proposed AOLISMA, factors like nodes' energy, link bandwidth, link stability and route availability are considered as the constraints of optimization for determining the objective function. AOLISMA concentrates on establishing balanced node energy availability and good stability after optimization. The adopted objective function depends on the fitness value of functions associated with the parameters of residual energy (Res_E^n), available bandwidth link between nodes ($\mathrm{BW}_{\mathrm{Avail}}$) and link stability ($\mathrm{L}_{\mathrm{Stablility}}$) as represented in Eq. (9).

$$\mathrm{Obj}_{\mathrm{Fn}} = W_1 \times \mathrm{Res}_E^n + W_2 \times \mathrm{BW}_{\mathrm{Avail}} + W_3 \times L_{\mathrm{Stablility}} \tag{9}$$

where

W_1, W_2 and W_3 Weight Adaptive factor that satisfies the condition, $W_1 + W_2 + W_3 = 1$.

The value of '$L_{\text{Stablility}}$' is determined based on the strategy adopted in [12] and it is expressed in Eq. (10)

$$L_{\text{Stablility}} = \frac{-(xy + wz) + \sqrt{\left(x^2 + y^2\right)r^2 - (xz - yw)^2}}{x^2 + y^2} \tag{10}$$

where the parameters utilized for computing the value of link stability ($L_{\text{Stablility}}$) is determined based on [12]. Moreover, the route is determined to be optimized when it possesses better node energy balance, bandwidth balance and good stability. Thus, the objective function for optimized route (OP_{Route}) is defined using Eq. (11)

$$\text{OP}_{\text{Route}} = \sum_{i,j} W_1 \times \text{Res}^n_{E_{ij}} + W_2 \times \text{BW}_{\text{Avail}_{ij}} + W_3 \times \text{LK}_{\text{Stablility}_{ij}} \tag{11}$$

3.4 Fitness Function for AOLISMA

The adopted Improved Slime Mould Algorithm (ISMA) derives the fitness value of each solution (feasible number of routes that can be determined in the network) from the population for attaining an efficient search process. The fitness function selection is determined to directly impact the algorithmic convergence speed, such that optimal solution can be determined with accuracy. The fitness function for AOLISMA is a maximization problem as it considers maximized residual energy of nodes, maximum link bandwidth and highest network link stability during the formulation of the objective function. Thus, the fitness function for AOLISMA is defined based on Eq. (12)

$$\begin{aligned} \text{Fit}_{\text{Fn}}(f) &= \text{Max}(\text{OP}_{\text{Route}}) \\ &= \text{Max}\left(\sum_{i,j} W_1 \times \text{Res}^n_{E_{ij}} + W_2 \times \text{BW}_{\text{Avail}_{ij}} + W_3 \times \text{LK}_{\text{Stablility}_{ij}}\right) \end{aligned} \tag{12}$$

3.5 AOLISMA-based Route Searching Process

Initially, the source node S' broadcasts the RREQ packets to the possible number of paths in the network for initializing route discovery or route lookup process. The source node sends the RREQ as a single broadcast packet which is received by the complete set of nodes that are currently within the transmission range of 'S' at a point of time. The broadcasted RREQ can identify the originating source and destination

nodes for which route discovery is initiated. Whenever, another node receives this RREQ, it completely exchanges the information associated with energy of nodes, link bandwidth and link stability. When the node that receives the RREQ is identified as the destination during the process of route discovery, it replies to the source node with RREP packets. After the source node receives a RREP packet, the process of route establishment starts based on AOLISMA-based searching. If the node that received the RREQ packet is not the destination, then the process of route discovery continues through the method of local broadcast using neighbour node information.

The AOLISMA-based route searching process involves the following steps:

Step 1 Use network node IDentifier (ID) to initialize the number of slime moulds (number of UAVs in the network), dimensions considered for evaluating the optimal path determination, upper and lower thresholds, maximum and current iterations

Step 2 Determine the adaptation value of each node with respect to each solution based on OBL and elite chaotic methodology

Step 3 Use Equation (7) for computing the population depending on OBL and determine its fitness value for sorting them to determine the top solutions that possess higher fitness value

Step 4 Calculate the fitness value of each solution for identifying the worst and best among them until the condition '$\text{Iter}_{\text{Curr}} < \text{Iter}_{\text{Max}}$' is satisfied

Step 5 Update the maximized fitness value of each routing path as the optimized best fitness value using the weight updated through Equation (5)

Step 6 Update the opposition population using Eq. (7) depending on the parameters of 'S_{Prob}', 'SB_1' and 'SB_2' respectively

Step 7 Sort the fitness value of solution determined in the current iteration after the process of employing OBL such that elite chaotic searching methodology can be implemented using Eq. (8)

Step 8 $\text{Iter}_{\text{Curr}} = \text{Iter}_{\text{Curr}} + 1$

Step 9 If '$\text{Iter}_{\text{Curr}} < \text{Iter}_{\text{Max}}$' is satisfied, return to step 3

Step 10 Identify the optimal valued solution as the best fitness solution (optimal route used for data dissemination)

4 Simulation Results and Discussion

The performance of the proposed AOLISMA routing approach and baseline approaches is evaluated based on throughput, mean delay and control overhead with different nodes' mobility. The experimental validation of the proposed AOLISMA routing approach is conducted using NS-3 simulator which is an open source network simulator that runs over Linux environment. This implementation is achieved using a hierarchical model with 100 nodes distributed over the grid area of 2500 × 2500 m. This simulation is run for 1200 s with 500 m radius of communication. It is implemented using a free space model with maximum number of CBR connections set to

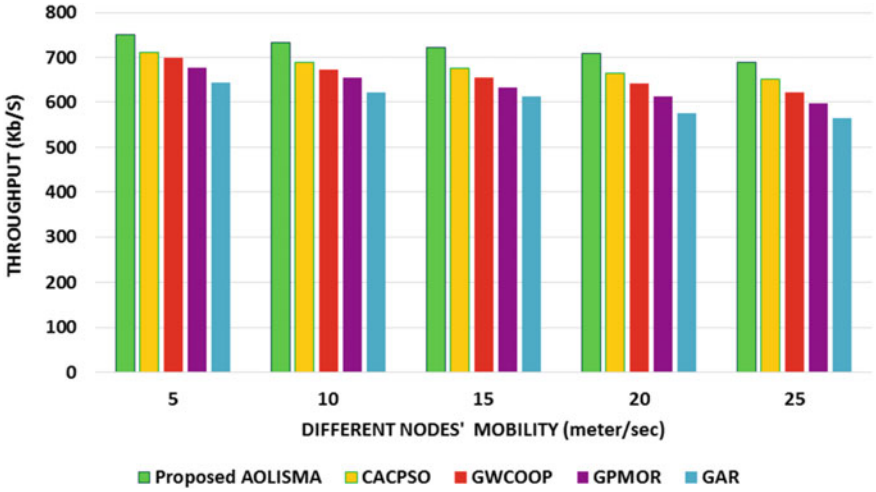


Fig. 1 Throughput of AOLISMA scheme for varying mobility of nodes

20. Moreover, Random Way Point (RWP) mobility and WaveLan are used as mobility and transfer models for implementation, respectively.

Initially, Fig. 1 depicts the throughput achieved by the proposed AOLISMA scheme and baseline CACPSO, GWCOOP, GPMOR and GAR scheme for varying node mobilities. Independent of node mobility, the proposed AOLISMA scheme is potential enough in determining optimized route using the objective function that adopts energy, bandwidth and link stability. This determination of optimal route by the proposed AOLISMA scheme maximizes throughput by delivering optimal number of data packets to the destination. Hence, the proposed AOLISMA scheme enhances throughput by 8.94%, 10.64%, 13.42% and 15.86% in contrast to the baseline CACPSO, GWCOOP, GPMOR and GAR schemes.

On the other hand, Fig. 2 portrays the mean delay incurred by the proposed AOLISMA and baseline CACPSO, GWCOOP, GPMOR and GAR schemes for varying node mobilities. The mean delay time involved by the proposed AOLISMA scheme is realized to be minimized as it adopts an optimized route between the source and the destination node in a rapid rate with least cost. In addition, the mean delay incurred by the proposed AOLISMA scheme is significantly reduced by 10.52%, 12.85%, 14.58% and 16.19% when compared to the baseline approaches.

Moreover, Fig. 3 demonstrates the performance of the proposed AOLISMA scheme and baseline CACPSO, GWCOOP, GPMOR and GAR scheme in terms of control overhead for varying node mobilities. The results prove that the proposed AOLISMA scheme independent of mobility of nodes facilitate minimized control overhead, since it adopts potential link stability factors during path determination and includes a route maintenance strategy which always keep the number of retransmissions of acknowledgement requests under control. Thus, the proposed AOLISMA

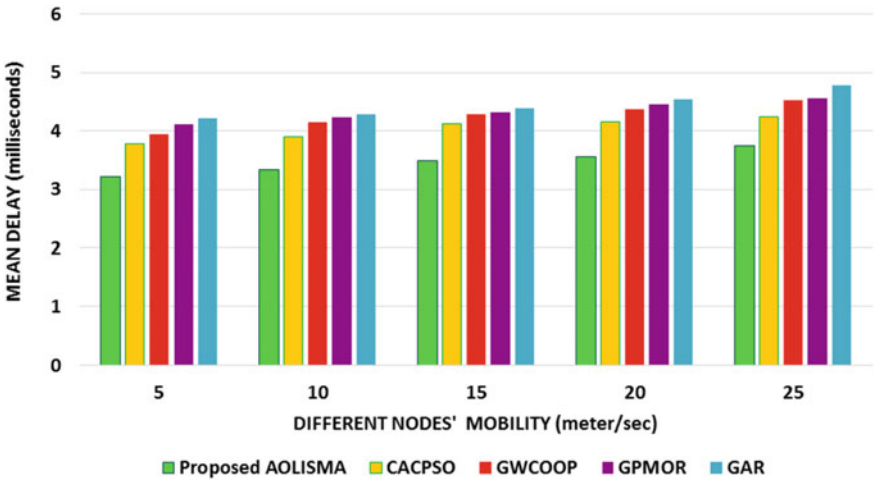


Fig. 2 Mean delay of AOLISMA scheme for varying mobility of nodes

scheme reduces the control overhead by 7.32%, 10.21%, 12.38% and 14.92% in contrast to the baseline CACPSO, GWCOOP, GPMOR and GAR schemes.

In addition, Fig. 4 depicts the energy consumption incurred by the nodes in the network during the implementation of the AOLISMA scheme and baseline approaches for varying node mobilites. The results clearly confirm that the proposed scheme consumes only a minimized amount of energy as it includes a path stability determination scheme that takes hop and bandwidth into account. Thus, the proposed

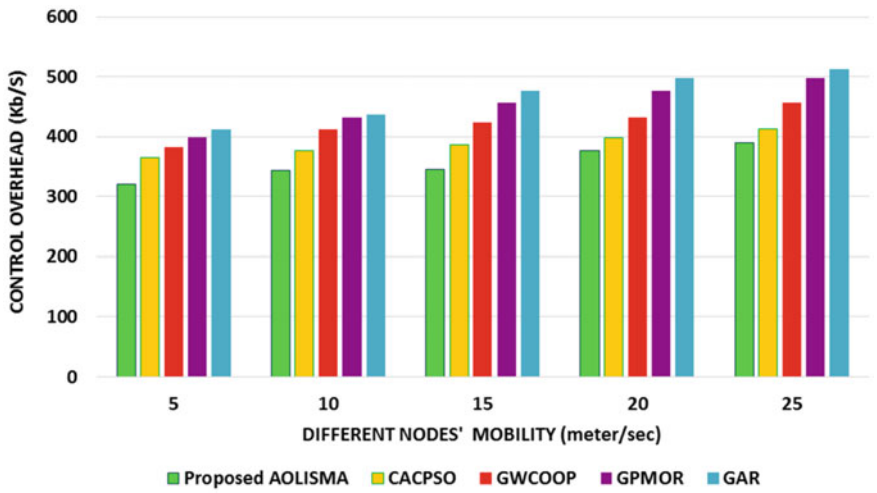


Fig. 3 Control overhead of AOLISMA scheme for varying mobility of nodes

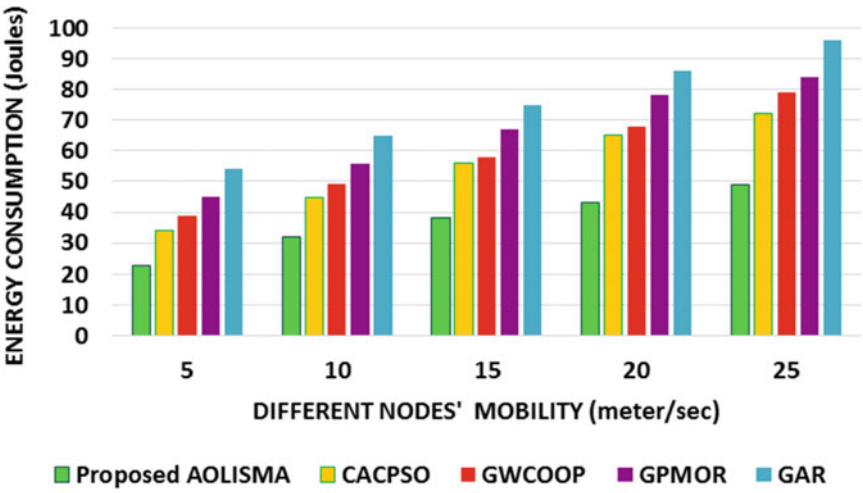


Fig. 4 Energy consumption of AOLISMA scheme for varying mobility of nodes

AOLISMA scheme reduces the utilization of energy by 9.32%, 11.86%, 14.29% and 17.91% in contrast to the benchmarked schemes taken for analysis.

5 Conclusion

The proposed AOLISMA scheme guarantees reliable data dissemination among UAVs with extended network lifetime and minimized energy consumption. It adopts two randomly selected search agents for determining feasible direction and displacement that aids in better routing. It utilizes OBL and confirms adaptive increase in the exploration rate by identifying feasible routes from which optimal route can be selected based on objective function for attaining reliable routing process. The experimental validation conducted using ns-3 simulator prove that the proposed AOLISMA scheme enhances the throughput by 8.94%, 10.64%, 13.42% and 15.86% in contrast to the baseline CACPSO, GWCOOP, GPMOR and GAR schemes. The results confirm that the AOLISMA scheme reduces the control overhead by 7.32%, 10.21%, 12.38% and 14.92% in contrast to comparable approaches. As part of future scope, it is decided to implement a sailfish optimization algorithm-based routing phenomenon for FANET environment and compare its performance with the proposed AOLISMA approach.

References

1. Khan, M. F., Yau, K. A., Noor, R. M., & Imran, M. A. (2019). Routing schemes in FANETs: A survey. *Sensors, 20*(1), 38.
2. Aadil, F., Raza, A., Khan, M., Maqsood, M., Mehmood, I., & Rho, S. (2018). Energy aware cluster-based routing in flying ad-hoc networks. *Sensors, 18*(5), 1413.
3. Mahmud, I., & Cho, Y. (2021). LECAR: Location estimation-based congestion-aware routing protocol for sparsely deployed energy-efficient UAVs. *Sensors, 21*(21), 7192.
4. Sahingoz, O. K. (2013). Networking models in flying ad-hoc networks (FANETs): Concepts and challenges. *Journal of Intelligent and Robotic Systems, 74*(1–2), 513–527.
5. Guillen-Perez, A., & Cano, M. (2018). Flying ad hoc networks: A new domain for network communications. *Sensors, 18*(10), 3571.
6. Souza, J., Jailton, J., Carvalho, T., Araújo, J., & Francês, R. (2019). A proposal for routing protocol for FANET: A fuzzy system approach with QoE/QoS guarantee. *Wireless Communications and Mobile Computing, 2019*(2), 1–10.
7. Shankar Subramaniyam, R., & Deva Priya, M. (2016) Black box detection using UAV in FANETs. *International Journal of Multidisciplinary Research and Development (IJMER), 3*(1), 69–72.
8. Balamurugan, A., Sengathir, J., Deva Priya, M., & Christy Jeba Malar, A. (2022) Hybrid marine predators optimization and improved particle swarm optimization-based optimal cluster routing in wireless sensor networks (WSNs). *China Communications, 19*(6), 219–247. https://doi.org/10.23919/JCC.2022.06.017
9. Sengathir, J., & Deva Priya, M. (2023) Selfish node detection scheme based on bates distribution inspired trust factor for MANETs. *EAI Endorsed Transactions on Energy Web, 9*(6). https://doi.org/10.4108/ew.v9i6.3065
10. Yang, H., & Liu, Z. (2019). An optimization routing protocol for FANETs. *EURASIP Journal on Wireless Communications and Networking, 2019*(1), 67–79.
11. Rosati, S., Kruzelecki, K., Heitz, G., Floreano, D., & Rimoldi, B. (2016). Dynamic routing for flying ad hoc networks. *IEEE Transactions on Vehicular Technology, 65*(3), 1690–1700.
12. Bhardwaj, V., & Kaur, N. (2020). An efficient routing protocol for FANET based on hybrid optimization algorithm. In: 2020 International Conference on Intelligent Engineering and Management (ICIEM), pp. 252–255
13. Liu, J., Huo, S., & Wang, Y. (2020). Throughput optimization for flying ad hoc network based on position control using genetic algorithm. *International Journal of Metrology and Quality Engineering, 11*(2), 11–21.
14. Oubbati, O. S., Atiquzzaman, M., Lorenz, P., Tareque, M. H., & Hossain, M. S. (2019). Routing in flying ad hoc networks: Survey, constraints, and future challenge perspectives. *IEEE Access, 7*(1), 81057
15. Sundar, K., & Rathinam, S. (2014). Algorithms for routing an unmanned aerial vehicle in the presence of refueling depots. *IEEE Transactions on Automation Science and Engineering, 11*(1), 287–294.
16. Maakar, S. K., Khurana, M., Chakraborty, C., Sinwar, D., & Srivastava, D. (2022). Performance evaluation of AODV and DSR routing protocols for flying ad hoc network using highway mobility model. *Journal of Circuits, Systems and Computers, 31*(01), 2250008.
17. Pandey, A., Shukla, P. K., & Agrawal, R. (2020). An adaptive flying ad-hoc network (FANET) for disaster response operations to improve quality of service (QoS). *Modern Physics Letters B, 34*(10), 2050010.
18. Naik, M. K., Panda, R., & Abraham, A. (2021). Adaptive opposition slime mould algorithm. *Soft Computing, 25*(3), 14297–14313.
19. Ma, Z., Guo, Q., Ma, J., Zhang, Z., Ma, H., Peng, L., & Li, Y. (2019). VaSe-MRP: Velocity-aware and stability-estimation–based multi-path routing protocol in flying ad hoc network. *International Journal of Distributed Sensor Networks, 15*(11), 155014771988312.
20. Wei, X., Yang, H., & Huang, W. (2021). A genetic-algorithm-Based optimization routing for FANETs. *Frontiers in Neurorobotics, 15*(2), 89–98.

21. Wei, X., & Yang, H. (2020). A routing optimization method based on ACA for FANETs. *International Journal of Pattern Recognition and Artificial Intelligence, 35*(05), 2159015.
22. Guo, K., & Lv, Y. (2020). Optimizing routing path selection method particle swarm optimization. *International Journal of Pattern Recognition and Artificial Intelligence, 34*(12), 2059042.
23. Hameed, S., Minhas, Q., Ahmed, S., Habib, S., Kamrul Hasan, M., Islam, M., & Khan, S. (2021). An improved iBAT-COOP protocol for cooperative diversity in FANETs. *Computers, Materials and Continua, 67*(2), 2527–2546.
24. Kaur, M., Singh, A., Verma, S., Kavita, Jhanjhi, N. Z., & Talib, M. N. (2021). FANET: Efficient routing in flying ad hoc networks (FANETs) using firefly algorithm. *Intelligent Computing and Innovation on Data Science, 3*(3), 483–490.
25. Da Costa, L. A., Kunst, R., & Pignaton de Freitas, E. (2021). Q-FANET: Improved Q-learning based routing protocol for FANETs. *Computer Networks, 198*(2), 108379.

COVID-19 Diagnosis Based on Deep Features Using Transfer Learning

P. Anantha Prabha, M. Deva Priya, R. Kiruthick, M. Nishith, and Prajish

Abstract Coronavirus is a highly contagious disease that infects humans. People's daily lives, their well-being and national economy are affected by this dangerous viral disease. Though Reverse Transcriptase Polymerase Chain Reaction (RTPCR) test is a commonly used technique for diagnosing COVID-19, it is costly and demands more time and effort to determine accurate results. Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-based tests are still time-consuming, and antigen/antibody tests can produce ineffective false-negative results. The motivation of this work is to develop a COVID-19 diagnostic system which can support medical personnel, especially in regions where there are very few trained medical personnel. Transfer learning (TL)-based COVID-19 diagnostic technique is proposed to automate COVID-19 diagnosis and support medical capabilities. Chest X-ray and Computer Tomography (CT) images are used to diagnose lung-related issues. First, a median filter is applied as a pre-processing method which is used to remove noise from the CT images. Image segmentation is done to extract areas of interest, and Convolutional Neural Network (CNN) is applied to CT images to extract deep features. The images are classified using TL-based Support Vector Machine (SVM) model. From the results, it is evident that the proposed system offers an accuracy of around 97.57%.

P. Anantha Prabha · R. Kiruthick · M. Nishith · Prajish
Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamil Nadu, India
e-mail: ap.prabha@gmail.com

R. Kiruthick
e-mail: r.kiruthick2192000@gmail.com

M. Nishith
e-mail: nishitm3011@gmail.com

Prajish
e-mail: prajishunnikrishnan@gmail.com

M. Deva Priya (✉)
Department of Computer Science and Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamil Nadu, India
e-mail: devapriya.m@sece.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_15

Keywords Coronavirus · COVID-19 · Deep Transfer Learning · CT images · Convolutional Neural Network (CNN)

1 Introduction

In the recent past, Coronavirus affected a huge lot of people, and many have lost their lives. Unexpectedly, there is a widespread of the disease around the globe. Over the last decade, several types of infectious diseases like SARS, MERS and influenza emerged and existed only for a few days or months. But this viral infections last for a prolonged period. Many researchers are working on this kind of viral infections, and many of them have not been successful as the necessary antibodies are unavailable. Due to the ineffectiveness of the system, more expectations are placed on images which include plasma processing, X-ray and CT images [1, 2]. As the mortality rate due to this disease is more, the burden of analysing this disease is increased.

The disease shows symptoms of throat illness, followed by respiratory problems. The patients infected with COVID-19 are expected to be quarantined, legally screened and kept away from healthy individuals. This contamination follows a chain cycle of getting transmitted from one person to another through interaction with people infected with the virus. Healthcare professionals play a dominant role in detecting this disease. Further, many techniques are applied to reduce the effects of COVID-19. Clinical imaging is also a strategy for studying and predicting the effects of coronavirus on the human body. Normal people and COVID-19 patients can be examined accordingly using CT and chest X-ray images [3]. During the COVID-19 investigation, a huge amount of information about CT images is collected from patients infected with the virus. CNN is applied to investigate the deep features of CT images [4]. The primary task is to acquire chest CT images of patients affected with COVID by using CNN model [5]. Median filter is a non-linear method which is used for removing unwanted noise from COVID-19 CT images. These images provide many features that are very useful for analysis. In a CT scan, X-rays are sent through the patient's chest at different angles around the patient's body, detected by a radiation locator and converted into a high-resolution clinical image. To train a Neural Network (NN) from the scratch, a large dataset is required. Restricted datasets are only available, and TL is applied to determine precise and concise deep features from the training dataset [6].

Artificial Intelligence (AI) is used in many medical applications and is most often adopted because of its predictive capabilities and accuracy. This allows researchers to make more informed decisions and improve their technical processes by increasing the speed and accuracy of the strategic decision-making processes. AI enables the automation of decision-making processes. It aids in revealing the deep features in CT images for diagnosing COVID-19 [7–9].

2 Related Work

The expenses, efforts and time required for regular RTPCR tests to identify COVID-19 are more. Scientists apply AI-based algorithms to clinical trials like X-rays and CT lung images and to diagnose the presence of the disease [10]. Some of the recently emerging AI-based models which can diagnose COVID-19 from clinical images show better performance [11, 12]. The datasets are examined, pre-processed and segmented, and features are extracted, classified and tested. The TL technique shows a substantial difference in the outcomes in contrast to traditional classification [13]. The proposed system does not demand the creation of a separate model to classify COVID-19 diseases as in the case of traditional classification. This simplifies the herculean task by determining COVID-19 in contrast to an existing model. Secondly, owing to noise, it is challenging to identify anomalous features in lesion and tissue images.

Liu et al. [14] have designed a 2D thin matrix profile density network scheme for detecting COVID-19 from chest CT images. COVID-19 is detected at two levels using matrix profile technology. In the first level, CT images are smoothed and transformed into one-dimensional images and then directly classified. Finally, the authors have used VGG19 CNN model for comparison. Wang et al. [15] have proposed a method that is applied on CT scan images related to pneumonia (with or without) to identify the type of pneumonia including normal, COVID-19, any other lung problems caused by viruses. Fan et al. [16] have designed a COVID-19 lung infection segmentation deep network (Inf-Net) to automatically detect infected areas from chest CT images. In contrast to X-rays, CT screening in this system is commonly preferred due to its benefits including 3D view of lungs [17].

Wang et al. [18] have designed a weakly supervised Deep Learning (DL) framework which uses a 3D CT scan image dataset for COVID-19 classification as well as lesion localization. Segmentation is carried out using a pre-trained UNet. The 3D lung image portion is sent to Deep Neural Network (DNN) which aids in predicting the likelihood of the presence of COVID-19. Horry et al. [19] have demonstrated the diagnosis of COVID-19 by applying TL on medical images including X-ray, ultrasound and CT scans. VGG19 CNN model is selected to experiment with the models that have very limited and complex COVID-19 datasets. An image pre-processing step is introduced to reduce noise in the image. The DL models emphasis diagnostics rather than specific features. Zheng et al. [20] have proposed a Multi-Scale Discriminative Network (MSD-Net) which provides multi-class segmentation of COVID-19 CT images.

Liu et al. [21] have proposed a combination of DL target identification and image classification schemes used to screen patients' COVID-19 CT images. It provides a COVID-19 identification model based on the spatio-temporal sequence convolution method. Li et al. [22] have proposed a training classification network using a few COVID-19 CT images and an archive of negative samples. The system uses a self-monitoring learning method to determine features from COVID-19 and negative samples. Babukarthik et al. [23] have proposed a method using genetic DL CNN

method. It is trained from scratch to extract features and classify them into COVID-19 and normal regular images. Meng et al. [24] have provided a high-density connection 3D-CNN (DeCovid19Net) to predict disease potential in COVID-19 patients. By combining CT scan images with clinical information, it is possible to forecast the risk range of COVID-19 patients.

3 Proposed Architecture

A combination of deep features obtained using CNN and SVM-based methodologies employed for classification is proposed for diagnosing COVID-19. The architecture is shown in Fig. 1. SVM is used for classification instead of a DL-based classifier because the latter requires a large dataset to train the model from scratch and perform testing. The proposed scheme performs image segmentation by focusing on the Region of Interest (RoI) of chest CT images.

The connected layers with deep features of the CNN model are determined and passed to SVM for classification. Chest CT imaging method is commonly used in medical and clinical practice for disease diagnosis, but image processing and review are challenging. Image pre-processing techniques are implemented for inconsistent detection which may include noise and scatters.

In this work, CNN is trained to detect inconsistencies in CT images. Initially, the CT image is smoothed and converted into a single layer vector. Secondly, they are passed to CNNs which are layered networks, where each layer produces a response. Each layer extricates the deep features of CT scan images and passes them to the

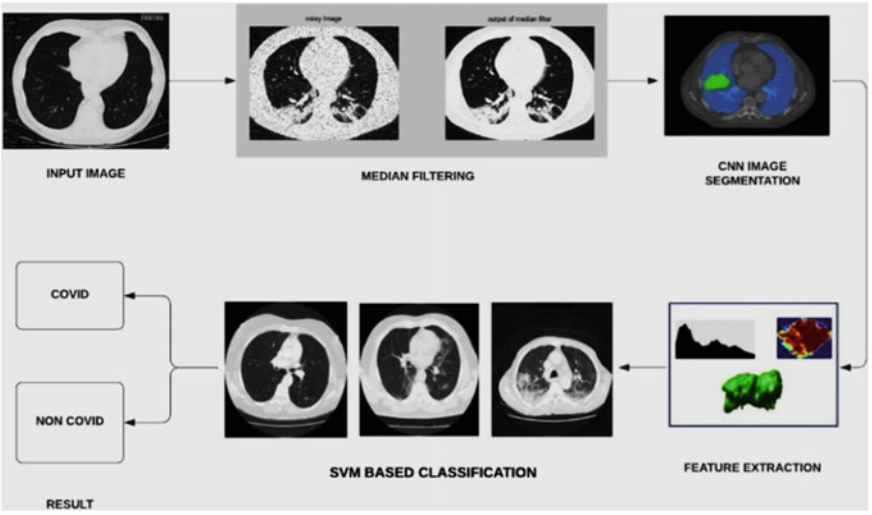


Fig. 1 Architecture of the proposed system

upcoming layer. Deep feature layers and vectors are obtained to assist in further diagnosis. Deep features are extracted and used in classification of images (COVID or non-COVID) by using SVM [25].

3.1 Pre-processing

CT scan images include artefacts and impurities like beam hardening, variations in image pixels, noise and scatter which have a greater impact on the accuracy of the model. To deal with this issue, a median filter is applied to remove unwanted noise and scatters from CT images, while preserving the edges. It is possible to enhance the quality of the image by replacing every value with the neighbouring median.

The images are analysed quantitatively and pre-processed with and without image registration which helps to align multiple CT images in both COVID and non-COVID cases. Image convolution is performed after pre-processing to split the colour image into channels. Channel images are used to create mask images which can separate sensitive areas of blood vessels.

3.2 Image Segmentation

Edge detection is used to determine the parts in the CT scan image where the brightness level present in the CT image changes abruptly [26]. From the observations, it is clear that an edge that is present in an image may have a significant change in the intensity of the image [27–29].

The abrupt changes of discontinuities that exist in the CT scan images are particularly known as edges. These problems in image intensity can happen because of step or line discontinuities. With a stepwise discontinuity, the intensity of image changes sharply from a value on one side of discontinuity to another on the other side of the image. With line jumps, the intensity value of the image changes abruptly, following which, it returns to the initial value over a short distance. However, in real-world actual images, the possibilities of step and line edges are very rare. Actual shape-related information of the image will be enclosed only on the edges.

3.3 Deep Feature Extraction

In a CNN model, the deep features from the connected layers are extricated and are utilized for training. The functionality obtained from each CNN-based network is used by the SVM classifier. Each pixel in the CT image is compared with its neighbour. Hence, it is possible to add or remove, lighten or darken a particular

pixel. This applies to the entire image, allowing to find, filter and adjust explicit shapes.

A segmented image is a binary image with selected pixels that are marked as '1' and non-selected pixels labelled as '0'. Morphological cleaning is used in the proposed system which removes isolated pixels such as zero-enclosed binary pixels seen in the segmented image.

Finally, the results of a CT scan image without pinholes have a selected pixel of '1' and a non-selected pixel of '0'. From the experimental observations, it is seen that the resulting image may contain non-selected pixels that can be filtered using morphological filtering. After morphological filtering, some discontinuities are seen among the selected pixels due to the presence of noise, and these broken segments can be connected by considering the morphological distance bridge.

3.4 Support Vector Machine (SVM)-Based Classification

Classification is carried out by using the SVM algorithm which is a supervised ML algorithm [30]. SVM based classification is applied on the deep features derived using CNN for diagnosing COVID-19. It works relatively well for classes with well-separated boundaries. Both linear and non-linear problems can be solved using this algorithm, and it is suitable for many practical classification and regression problems. This classifier is effective when the number of classes is greater than the number of samples that exist in the model. SVM creates a decision line called a hyperplane between two classes which decides the result from the separated line.

SVM is used in this proposed method instead of a DL-based classifier because the latter demands a huge dataset to train and test the model. Deep features from the CNN model are passed to the SVM classifier algorithm which creates a decision line to separate the classes. Various deep features determined during the feature extraction stage are used to classify images.

4 Experimental Setup and Results

The system is implemented using MATLAB 2014a DL Toolbox which has a MATLAB Simulink model that helps to design simulation circuit by using appropriate components to get the desired output.

4.1 Dataset

The dataset images are taken from the Italian Society of Medical and Interventional Radiology [31]. They provide open source and reliable COVID-19 CT and radiographic lung images (Fig. 2). Figure 3 shows the outcomes of each stage followed by classification with maximum accuracy.

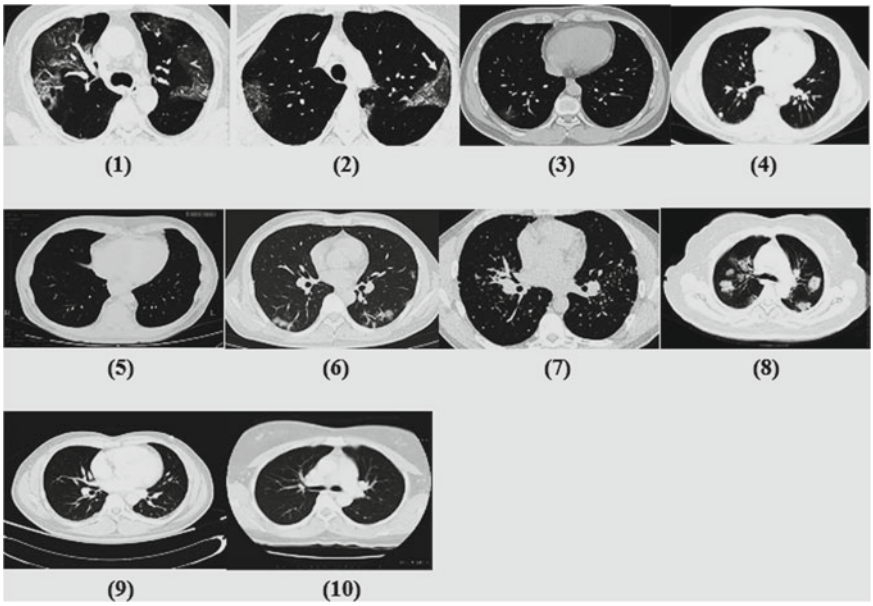


Fig. 2 Representative chest CT images of COVID-19

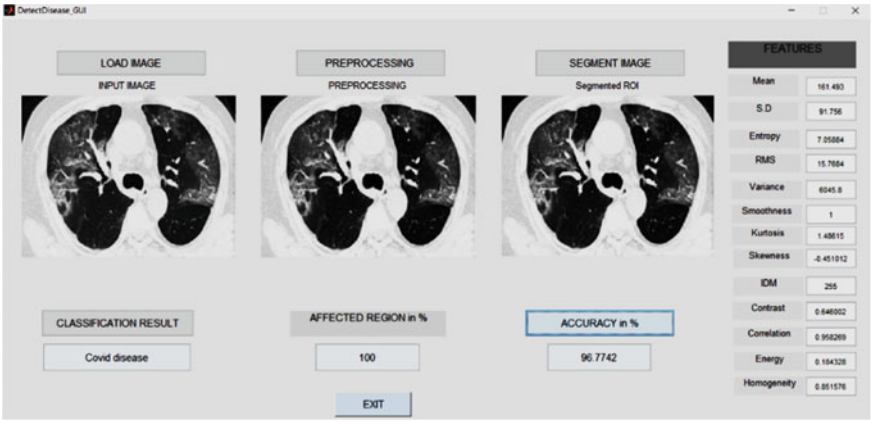


Fig. 3 Disease classification

Table 1 shows the ten COVID-19 images used as input images and the values of the deep features calculated using MATLAB functions. The resulting features are categorized into various properties such as mean, standard deviation, contrast, correlation, energy, homogeneity, entropy, RMS, variance, smoothness, kurtosis, skewness and ideal. These deep feature values can be used to categorize images as COVID or non-COVID by using SVM which is a binary classifier. The proposed system offers 97.57% average accuracy.

5 Conclusion

The experimental evaluation of TL and image classification approach is presented to detect COVID-19 positive cases and identify affected regions from chest CT scan images. Furthermore, a TL-based approach that can be applied to extract precise and concise deep features from training data is proposed. Techniques such as median filters, morphological filters and image segmentation are used . In addition, the importance of applying image pre-processing and image segmentation techniques on medical images is emphasized. SVM classifies CT images based on deep features. The proposed scheme addresses the challenges linked with the limited low quality of COVID-19 CT scan image data. Since ML-based system is widely used in other medical imaging works, this type of ML approach can be applied to the COVID-19 diagnostic process as well. The proposed approach can be improved by using the COVID-19 CT images in conjunction with CT images of other lung conditions.

Extensive experiments convey that the proposed approach offers improved performance with 97.% accuracy. From experimental observations, it is clear that the proposed approach will have a substantial influence on controlling the spread of COVID-19 by supporting rapid diagnosis. For now, some restrictions such as labelled data for other lung diseases and limited number of reliable CT input images are considered. Recently, image augmentation and feature-level fusion are shown to dramatically enhance the performance of machine learning models. It is planned to use these concepts in the future.

Table 1 Summary of experimental results

Image	1	2	3	4	5	6	7	8	9	10
Mean	161.49	118.73	118.09	156.68	127.49	129.84	126.39	156.57	89.593	133.14
SD	91.75	104.1	88.35	98.71	92.46	91.58	96.59	99.99	97.97	91.09
Entropy	7.058	6.53	7.116	6.538	6.784	6.844	6.919	6.808	5.918	6.891
RMS	15.76	15.32	15.58	15.15	15.74	15.76	15.29	14.64	14.85	15.73
Variance	6045.8	6747.29	6295.66	7798.36	5885.43	7047.05	6568.4	8071.32	8411.82	7556.88
Smoothness	1	1	1	1	1	1	1	1	1	1
Kurtosis	1.486	1.242	1.2	1.387	1.229	1.198	1.167	1.478	1.714	1.272
Skewness	−0.451	0.277	0.022	−0.365	0.262	−0.002	−0.081	−0.49	0.747	−0.055
Ideal	255	255	255	255	255	255	255	255	255	255
Contrast	0.64	0.77	0.86	0.38	0.81	1.08	0.8	0.54	0.43	0.55
Correlation	0.958	0.96	0.941	0.977	0.949	0.934	0.955	0.969	0.975	0.966
Energy	0.184	0.209	0.12	0.282	0.217	0.102	0.151	0.288	0.309	0.15
Homogeneity	0.851	0.859	0.821	0.908	0.863	0.794	0.819	0.887	0.917	0.908
Classification result	COVID	COVID	COVID	COVID	COVID	COVID	COVID	COVID	COVID	COVID
Affected region in %	100	99.9	99.9	100	99.9	99.9	99.9	99.7	99.9	99.9
Accuracy in %	98.387	96.677	98.387	98.387	98.387	96.774	96.774	96.774	98.387	96.774

References

1. Hu, S., Gao, Y., Niu, Z., Jiang, Y., Li, L., Xiao, X., & Yang, G. (2020). Weakly supervised deep learning for covid-19 infection detection and classification from CT images. *IEEE Access, 8*, 118869–118883.
2. Fang, Z., Ren, J., MacLellan, C., Li, H., Zhao, H., Hussain, A., & Fortino, G. (2021). A novel multi-stage residual feature fusion network for detection of Covid-19 in chest X-ray images. *IEEE Transactions on Molecular, Biological and Multi-Scale Communications, 8*(1), 17–27.
3. Ohata, E. F., Bezerra, G. M., das Chagas, J. V. S., Neto, A. V. L., Albuquerque, A. B., de Albuquerque, V. H. C., & Reboucas Filho, P. P. (2020). Automatic detection of Covid-19 infection using chest X-ray images through transfer learning. *IEEE/CAA Journal of Automatica Sinica*, *8*(1), 239–248.
4. Castiglione, A., Vijayakumar, P., Nappi, M., Sadiq, S., & Umer, M. (2021). Covid-19: Automatic detection of the novel coronavirus disease from CT images using an optimized convolutional neural network. *IEEE Transactions on Industrial Informatics, 17*(9), 6480–6488.
5. Carvalho, E. D., Silva, R. R., Araújo, F. H., de AL Rabelo, R., & de Carvalho Filho, A. O. (2021). An approach to the classification of Covid-19 based on CT scans using convolutional features and genetic algorithms. *Computers in Biology and Medicine*, *136*, 104744.
6. Oh, Y., Park, S., & Ye, J. C. (2020). Deep learning Covid-19 features on CXR using limited training data sets. *IEEE Transactions on Medical Imaging, 39*(8), 2688–2700.
7. Deva Priya M., Saranya M., Sharaha N., Tamizharasi S. (2022). Classification of COVID-19 tweets using deep learning classifiers. In *International Conference on Recent Trends in Computing (ICRTC 2021)* (Vol. 341, pp. 213–225). Organized by SRM Institute of Science and Technology, Delhi-NCR Campus, Ghaziabad (U.P.) on 04th–05th, June 2021. The paper is published in Lecture Notes in Networks and Systems, Springer, ISBN: 978-981-33-4500-3.
8. Mugilan, A., Kanmani, R., Deva Priya, M., Christy Jeba Malar, A., Suganya, R. (2021) Smart sentimental analysis of the impact of social media on COVID-19. In *4th International Conference on Micro-Electronics and Telecommunication Engineering* (Vol. 179, pp. 437–446), SRM Institute of Science and Technology, Delhi NCR Campus, Ghaziabad during 26th–27th September 2020. The paper is published in Micro-Electronics and Telecommunication Engineering, Lecture Notes in Networks and Systems, Springer, ISBN: 978-981-33-4687-1.
9. Anantha Prabha, P., Deva Priya, M., Christy Jeba Malar, A., Karthik, S., Dakshin, G., & Dinesh Kumar, S. (2021). Improved ResNet based Image classification technique for Malaria detection. In *6th International Conference on Recent Trends in Computing (ICRTC 2020)* (Vol. 177, pp. 795-803). Organized by SRM Institute of Science and Technology, Delhi-NCR Campus, Ghaziabad (U.P.) on 03rd–04th July 2020. The paper is published in Lecture Notes in Networks and Systems, Springer, ISBN: 978-981-33-4500-3. https://doi.org/10.1007/978-981-33-4501-0_73
10. Abbas, A., Abdelsamea, M. M., & Gaber, M. M. (2021). Classification of Covid-19 in chest X-ray images using DeTraC deep convolutional neural network. *Applied Intelligence, 51*(2), 854–864.
11. Mohammed, A., Wang, C., Zhao, M., Ullah, M., Naseem, R., Wang, H., et al. (2020). Weakly-supervised network for detection of Covid-19 in chest CT scans. *IEEE Access*, *8*, 155987–156000.
12. Ozturk, T., Talo, M., Yildirim, E. A., Baloglu, U. B., Yildirim, O., & Acharya, U. R. (2020). Automated detection of Covid-19 cases using deep neural networks with X-ray images. *Computers in Biology and Medicine, 121*, 103792.
13. Shamsi, A., Asgharnezhad, H., Jokandan, S. S., Khosravi, A., Kebria, P. M., Nahavandi, D., & Srinivasan, D. (2021). An uncertainty-aware transfer learning-based framework for Covid-19 diagnosis. *IEEE Transactions on Neural Networks and Learning Systems, 32*(4), 1408–1417.
14. Liu, Q., Leung, C. K., & Hu, P. (2020). A two-dimensional sparse matrix profile DenseNet for Covid-19 diagnosis using chest CT images. *IEEE Access, 8*, 213718–213728.

15. Wang, J., Bao, Y., Wen, Y., Lu, H., Luo, H., Xiang, Y., et al. (2020). Prior-attention residual learning for more discriminative Covid-19 screening in CT images. *IEEE Transactions on Medical Imaging*, *39*(8), 2572–2583.
16. Fan, D. P., Zhou, T., Ji, G. P., Zhou, Y., Chen, G., Fu, H., et al. (2020). Inf-net: Automatic covid-19 lung infection segmentation from CT images. *IEEE Transactions on Medical Imaging*, *39*(8), 2626–2637.
17. Apostolopoulos, I. D., & Mpesiana, T. A. (2020). Covid-19: Automatic detection from X-ray images utilizing transfer learning with convolutional neural networks. *Physical and Engineering Sciences in Medicine, 43*(2), 635–640.
18. Wang, X., Deng, X., Fu, Q., Zhou, Q., Feng, J., Ma, H., et al. (2020). A weakly-supervised framework for Covid-19 classification and lesion localization from chest CT. *IEEE Transactions on Medical Imaging*, *39*(8), 2615–2625.
19. Horry, M. J., Chakraborty, S., Paul, M., Ulhaq, A., Pradhan, B., Saha, M., & Shukla, N. (2020). Covid-19 detection through transfer learning using multimodal imaging data. *IEEE Access, 8*, 149808–149824.
20. Zheng, B., Liu, Y., Zhu, Y., Yu, F., Jiang, T., Yang, D., & Xu, T. (2020). MSD-Net: Multi-scale discriminative network for Covid-19 lung infection segmentation on CT. *IEEE Access, 8*, 185786–185795.
21. Liu, J., Zhang, Z., Zu, L., Wang, H., & Zhong, Y. (2020, October). Intelligent detection for CT image of Covid-19 using deep learning. In *2020 13th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI)* (pp. 76–81). IEEE.
22. Li, Y., Wei, D., Chen, J., Cao, S., Zhou, H., Zhu, Y., et al. (2020). Efficient and effective training of Covid-19 classification networks with self-supervised dual-track learning to rank. *IEEE Journal of Biomedical and Health Informatics*, *24*(10), 2787–2797.
23. Babukarthik, R. G., Adiga, V. A. K., Sambasivam, G., Chandramohan, D., & Amudhavel, J. (2020). Prediction of Covid-19 using genetic deep learning convolutional neural network (GDCNN). *IEEE Access, 8*, 177647–177666.
24. Meng, L., Dong, D., Li, L., Niu, M., Bai, Y., Wang, M., et al. (2020). A deep learning prognosis model help alert for Covid-19 patients at high-risk of death: A multi-center study. *IEEE Journal of Biomedical and Health Informatics*, *24*(12), 3576–3584.
25. Kaur, T., Gandhi, T. K., & Panigrahi, B. K. (2021). Automated diagnosis of Covid-19 using deep features and parameter free BAT optimization. *IEEE Journal of Translational Engineering in Health and Medicine, 9*, 1–9.
26. Pei, H. Y., Yang, D., Liu, G. R., & Lu, T. (2021). MPS-net: Multi-point supervised network for CT image segmentation of covid-19. *IEEE Access, 9*, 47144–47153.
27. Haldorai, A., & Anandakumar, S. (2020). Image segmentation and the projections of graphic centered approaches in medical image processing. *Journal Medical Image Computing,* 74-81.
28. Arulmurugan, R., & Anandakumar, H. (2018). Region-based seed point cell segmentation and detection for biomedical image analysis. *International Journal of Biomedical Engineering and Technology, 27*(4), 273–289.
29. Prabha, P. A., Suchitra, G., & Saravanan, R. (2023). Cephalopods classification using fine tuned lightweight transfer learning models. *Intelligent Automation & Soft Computing, 35*(3).
30. Zhou, C., Song, J., Zhou, S., Zhang, Z., & Xing, J. (2021). Covid-19 detection based on image regrouping and ResNet-SVM using chest X-ray images. *IEEE Access, 9*, 81902–81912.
31. Italian Society of Medical and Interventional Radiology. https://sirm.org/covid-19/

Honey Badger Optimization Algorithm-Based RSU Deployment for Improving Network Coverage in VANETs

J. Sengathir, M. Deva Priya, A. Christy Jeba Malar, and S. Sam Peter

Abstract Road Side Units (RSUs) installed in roadside, and intersections in Vehicular Ad hoc NETwork (VANET) play an anchor role in aggregating and exploring intelligent data associated with vehicle traffic. These RSUs help in exchanging information among vehicles and obtaining early warning messages to ensure safety driving of vehicles. However, determining the number of RSUs and position over which they must be deployed are vital due to high cost incurred in implementing and maintaining them in the network. This problem of determining the number of RSUs along with their positions of deployment is a multi-objective problem, since it necessitates maximized coverage of network with minimized number of RSUs in the network. In this paper, Honey Badger Optimization Algorithm-based RSU Deployment (HBOA-RSUD) scheme is proposed with a multi-objective fitness function for improving network coverage in VANETs. This HBOA-RSUD initially establishes a static model for determining the complexity involved during the deployment of RSUs in the urban road. Then, a multi-objective HBOA algorithm with sigmoid function is applied over individual discrete values of fitness for identifying the position of RSU deployment. It determines the new positions of RSUs for enhancing the performance of the population and convergence speed. Experimental results of

J. Sengathir
Department of Information Technology, CVR College of Engineering, Mangalpally, Vastunagar, Hyderabad, Telangana, India
e-mail: j.sengathir@gmail.com

M. Deva Priya (✉)
Department of Computer Science and Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamilnadu, India
e-mail: devapriya.m@sece.ac.in

A. Christy Jeba Malar
Department of Information Technology, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India
e-mail: a.christyjebamalar@skct.edu.in

S. Sam Peter
Department of Computer Science and Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India
e-mail: sampeter.s@skct.edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_16

HBOA-RSUD confirm a maximized throughput by 21.38%, maximized network coverage by 28.95%, minimized delay by 19.42% and reduced energy consumption by 21.98% for varying number of RSUs in contrast to the existing intelligent RSU deployment approaches.

Keywords Road Side Units (RSUs) · Vehicular Ad hoc NETwork (VANET) · Honey Badger Optimization Algorithm (HBOA) · Network coverage · Vehicle traffic

1 Introduction

Vehicular Ad hoc NETwork (VANET) is a form of Mobile Ad hoc NETwork (MANET), wherein vehicles are considered as nodes. Research in VANETs is booming due to its efficiency [1, 2]. It is a promising technology with the greatest challenge of ensuring cost effectiveness by efficient deployment of Road Side Units (RSUs). Developing efficient Intelligent Transportation Systems (ITSs) by establishing communication among vehicles is an important area of research [3]. ITS supports by providing traffic safety, accident and danger cautions, and navigation guidance. To gather and investigate traffic information, On-Board Units (OBUs) and RSUs are the essential infrastructural components for VANETs [4]. The vehicles in motion communicate with their nearest RSUs [5]. In vehicular infrastructures, RSUs are the main components that gather and distribute information among vehicles connecting them to the infrastructure. The RSUs communicate among themselves and with the back-bone network including hospital, police station, traffic control division or fire-brigade. VANET supports two types of communication namely, Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications [6].

Deployment of RSUs is expensive, and it plays a predominant role in sustaining network connectivity. Design of an effectual RSU deployment approach that offers high coverage and low deployment cost is of great significance. Positioning RSUs play a dominant role in V2I communications [7]. To improve the accessibility of RSUs, they should be closely deployed. Else, blind spots may occur wherein, vehicles lose communication with the infrastructure. Substantial positioning of RSUs to impeccably cover a larger area like a massive metropolitan is very pricy. To offer better network coverage, the RSUs must be mounted at right places. The immobile RSUs positioned along the roadside act as gateways or Access Points (APs) [8]. Designing an accurate coverage protocol for positioning RSUs in VANETs is challenging due to diverse service areas, multifarious mobility forms and resource limitations. RSUs are positioned such that each OBU is capable of directly communicating with at least one RSU and there is no region without coverage. The region where the RSU is to be positioned may not always be geometric in shape but may be convex. Another significant challenge is reducing the communication delay involved in V2I [9].

Further, as network topology changes often, the irregular links among the vehicles affect message propagation. RSUs help in extending vehicle coverage and enhancing network performance. Nevertheless, non-optimal positioning of RSUs lead to increase in power consumption and decrease in quality of network performance [10, 11].

In this paper, Honey Badger Optimization Algorithm-based RSU Deployment (HBOA-RSUD) scheme is proposed with the multi-objective fitness function for improving network coverage in VANETs. This HBOA-RSUD initially establishes a static model for determining the complexity involved during the deployment of RSUs in the urban road. Then, a multi-objective HBOA algorithm with sigmoid function is applied over individual discrete values of fitness for identifying the position of RSU deployment. It determines the new positions of RSUs for enhancing the performance of population and convergence speed.

2 Related Work

Lin [12] have dealt with the positioning of RSUs in V2I communications, where the problem is framed as a controlled optimization problem with an aim to diminish the positioning cost under a constraint that all areas are covered. The RSU positioning problem is taken as a binary integer programming problem. It is solved using branch and bound technique. Initially, the road map is converted to a new graph which includes numerous nodes. Throughout the process of conversion, some positions may not demand coverage for vehicular communications or may not be appropriate for RSU positioning. The positions of these nodes signify the candidates of RSU positioning and it is ensured that all the locations are enclosed. Filippini et al. [13] have used game theoretic tools to issue contents to vehicles through RSU-based infrastructure. The changing aspects are analyzed using a strategic game, wherein the operators accomplish their positioning decisions simultaneously, while a wide-ranging game is employed with one operator as the deployment leader. The symmetries of the games are then evaluated as a function of parameters like capacity of nominal infrastructure, interference and vehicle flows. They have focused on both simultaneous and leader–follower deployment and have measured the incompetence of equilibrium placements in contrast to the social optimum. This model predicts the accessible equilibria as a function of the amount of traffic.

Tao et al. [14] have dealt with message propagation in VANET which depends on efficient data forwarding. Cluster-based RSU Deployment (CRD) scheme with the Traffic-Aware Power Control (TAPC) method is proposed by considering the features of vehicle mobility along the highway to improve performance as well as reduce energy involved in the RSUs. A data dissemination algorithm called Data-Driven Message Propagation (DDMP) is also propounded. It is found that the proposed scheme supports improved message propagation by involving less propagation latency and energy.

Cheng et al. [15] have dealt with the coverage problem prevalent in the positioning of RSUs by proposing a geometry-based sparse coverage protocol called Geocover. It considers the geometrical features of road networks, mobility patterns of vehicles and resource restrictions. It takes the dimensions of road segments and performs buffering to suit diverse kinds of road topologies. It finds the hotspots from trace files to portray the mobility patterns and determine the valued road area that is to be covered. Two different versions of sparse coverage are provided which consider budget and quality limitations correspondingly. Genetic and greedy algorithms are used to deal with the coverage problem. It is seen that the proposed scheme is dependable and scalable for urban VANETs. Sarubbi et al. [16] have proposed a genetic algorithm called Delta-GA for dealing with the distribution of RSUs in a vehicular network. They have focused on minimizing the number of RSUs along with communication from the infrastructure supporting the network. It deals with QoS-based classification for deployment in VANET. Delta-GA is a genetic algorithm for instances in contrast to former algorithms. It is a deviation of Delta-R algorithm that forms the original population and offers a specific behavior. The algorithm finds a solution with more number of vehicles and then decreases the number of RSUs.

Kim et al. [17] have dealt with the reduction of cost of deployment of RSUs by focusing on the spatio-temporal coverage. The mechanism focusses on organizing RSUs on fixed locations, public transportation and wholly governable vehicles maintained by the government. A new approach is introduced to map the city into a grid graph. The problem is formulated as an optimization problem, and an approximation algorithm with polynomial running time is designed for the problem. The performance ratio is seen to be half the possible ratio.

Wang et al. [18] have dealt with positioning of RSUs in 2-D urban or suburban roadways. The centrality seen in a social network is applied to the problem of RSU positioning based on which the significance of RSU position candidate is measured. This centrality-based RSU positioning scheme is framed as a linear programming problem with a goal of improving the complete centrality for a given budget. The problem is portrayed as a 0/1 Knapsack problem, wherein the budget corresponds to the capacity of the sack, the cost of positioning an RSU resembles the weight of the item, and the candidate's centrality is similar to the value of the item. From the results, it is found that the proposed scheme yields better coverage time ratio. Yeferny and Allani [19] have proposed a spatio-temporal coverage scheme for non-safe VANET applications called Minimal Mobility Patterns Coverage (MPC). It deals with illustrating the mobility patterns of vehicles from trace files and finding the acceptable RSU locations so as to cover the mined mobility patterns by less likely number of RSUs. This technique illustrates the mobility patterns of vehicles by mining the correlations between the connections of vehicle paths against intersected junctions. Acceptable RSU positions are found involving nominal transversals in a hypergraph.

Gao et al. [20] have dealt with the One Dimensional RSU Deployment (D1RD) problem involving uneven profit densities by designing optimal algorithms. The features of optimal solutions comprise of RSU(s). Dynamic Limiting (DynLim) deals with reducing the search space significantly by dynamically regulating search

space bounds. OptDynLim based on DynLim scheme is proposed. Gao et al. [21] have also proposed a scheme for dealing with profit involving limited number of RSUs in road-network systems. They have developed a powerful RSU Deployment Problem Model (RDPM) using Genetic Algorithm (GA) including road-network and profit models. The road-network model deals with complex road shapes taking key significant factors like lane number and popularity.

Patil and Ragha [22] have dealt with traffic evaluation, emergency distribution and route finding. A decentralized identity managing protocol is propounded for emergency vehicles. They have focused on deployment of VANET by ensuring identity management to guard against exploitation of priority-based services. The trustworthiness of the OBUs is ensured against reply attack, message integrity and Denial of Service (DoS) attacks. Protecting against impersonation and preserving privacy plays a substantial role.

As Long Term Evolution for Vehicle (LTE-V) involves less delay, more data rate and offers more reliability, they are used in VANETs. Nevertheless, RSUs in LTE-V offer less coverage consuming more amount of energy for attaining long-distance communication. Yang et al. [23] have designed Energy Harvest Road Side Units (EH-RSUs) for low frequency areas instead of BSs which are fixed RSUs to lessen the positioning and upkeep costs. EH-RSUs are self-powered and service time is influenced by the battery capacity, speed of charging, service range and communication load. The EH-RSUs model structure is based on communication load. An optimization problem that reduces the cost of EH-RSUs and BSs is designed by considering the radius of EH-RSUs as optimization variable. The pre-positioning algorithm solves the optimization problem. Mahmood and Horváth [24] have considered message dissemination speed on the highway, wherein messages are shared between vehicles and also between the RSUs and vehicles. The optimum distance between RSUs and the influence of speed on message dissemination are dealt with. Alert messages are produced from a static source continuously. Based on the Markov renewal process, the message passing process between RSUs is formulated and the speed of message dissemination is found, thus providing a transient delivery of distance where the message is accessible.

3 Proposed Honey Badger Optimization Algorithm-Based RSU Deployment (HBOA-RSUD) Scheme

This proposed Honey Badger Optimization Algorithm-based RSU Deployment (HBOA-RSUD) scheme completely concentrates on the process of deploying RSUs in the intersections of urban road for attaining optimal network area coverage. It typically focusses on the deployment of RSUs to minimize the number of traffic intersections on the road. It aims at achieving maximized intersection coverage by

deploying less number of RSUs, enhancing the potentiality of vehicles to determine traffic information in a timely manner, confirming smooth roads and guaranteeing vehicular safety. In specific, the proposed HBOA-RSUD scheme targets on the process of deploying RSUs at road intersections as it can significantly reduce the radius of communication and improve the rate of RSU utilization. However, only some intersections possess RSUs as the problem under consideration targets on joint communication mode.

3.1 Plan of Deployment

Consider an urban area within the city 'C_x^i' which is the research object and then establish a static model for investigating the deployment of RSUs in the network. The mathematical model associated with the above stated problem is presented using Eq. (1)

$$\begin{aligned} \text{Min } f_x^1 &= \sum_{i=1}^{n} x_i \\ \text{Min } f_x^2 &= \frac{1 - |C_k|}{r} \end{aligned} \tag{1}$$

such that $x_i \in \{0, 1\}, 1 \leq i \leq n, 0 \leq \sum_{i=1}^{n} x_i \leq n$

where

n—total number of RSU deployed in the scenario

At this juncture, the value of the sigmoid function (S_{MF}^i) is used for checking whether a specific RSU need to be deployed in a specified position or not. The specific RSU in deployed in the intersection when the value of 'S_{MF}^i' is equal to or greater than 0.5. Otherwise, they are deployed in the road segment under study. In particular, $|C_k|$ and 'r' indicate the number of intersections enveloped by the communication radius and transmission distance of deployed RSUs respectively. Moreover, '$d_{i,j}$' is the total number of intersections with 'f_x^2' as the streets' percentage that are not covered. In this context, the deployment matrix and the estimated distance between two RSUs (i and j) in a specific urban road traffic can be visualized using

$$P_{\text{Dl}}(n \times n) = \begin{bmatrix} d_{(1,1)} & \cdots & d_{(1,s)} \\ \vdots & \ddots & \vdots \\ d_{(1,n)} & \cdots & d_{(n,s)} \end{bmatrix} \tag{2}$$

$$d_{i,j} = \begin{cases} \omega, \ i \text{ and } j \text{ are on the same road segments} \\ -1, \ i \text{ and } j \text{ are on different road segments} \\ 0, \ i = j \end{cases} \tag{3}$$

From Eq. 3, it is clear that the adjacency matrix determined for RSUs deployment in a specific context possesses the value of 'ω', -1 and 0, respectively. In specific, the value of the element associated with the adjacency matrix '$d_{i,j}$' is 'ω', when the RSUs say, 'i' and 'j' exist on the same road segment. On the other hand, the element of the adjacency matrix '$d_{i,j}$' is '-1', when they exist on the same road segment. Otherwise, the distance is computed to be '0'.

Further, the problem of RSU deployment on urban roads that should be handled as specified in Eq. (3) consists of two objective functions, 'f_x^1' and 'f_x^2' which are discontinuous in their characteristics. But both the functions are contradictory in nature, since the first function, 'f_x^1' concentrates on maximizing the coverage area enveloped by transforming it into a problem of minimization. But the second function 'f_x^2' completely concentrates on minimizing the deployment of RSUs on the road segment. Hence, the objective function adopts the above-mentioned integrated fitness values together to form a bi-objective optimization problem. This problem of two-objective optimization can be ideally solved using a swarm intelligent multi-objective meta-heuristic algorithm. Such classical algorithm always has the capability of solving the continuous problem in which the values of the initial and new populations are real numbers. In the proposed scheme, the value of RSU deployment is set to 1, when they are placed at the point of road intersection. On the other hand, they have a value 0, when the RSUs are not deployed. In addition, this strategy of RSU deployment is achieved using Eqs. (4) and (5)

$$x_{ij} = \begin{cases} 0 \ S_{\text{MF}}^i < 0.5 \\ 1 \ S_{\text{MF}}^i \geq 0.5 \end{cases} \tag{4}$$

$$S_{\text{MF}}^i = \frac{1}{1 + e^{-x}} \text{ with } x_{ij} \in R \tag{5}$$

As per Eq. (4), the RSU is not deployed at the intersection when the value of 'S_{MF}^i' is less than 0.5.

3.2 *HBOA-Based RSUs Selection for Achieving Reliable Data Delivery*

Once the RSUs are deployed over the optimized points of the road segment, HBOA is utilized for selecting potential RSUs that aids in attaining reliable data delivery between the source and destination vehicular nodes. This HBOA algorithm used for

selecting RSUs is proposed based on the inspiration derived from the foraging characteristics of honey badger contributed by Hashem et al. [25]. The HBOA algorithm comprises of two modes namely digging mode (it smells the food source) and honey mode (just follows the honeyguide bird). These modes are analogical to the process of selecting potential vehicular RSU nodes based on the factors of delay, RSUs cost, bandwidth and packet forwarding capability (digging mode) and the honey mode (selection of RSUs which are already utilized during previous transmission of data packets). Thus, these modes are adopted in the proposed HBOA-RSUD scheme for the selection of RSUs during the process of delivering packets to the destination nodes. Mathematically, the steps incorporated into the adopted HBOA algorithm is presented using the phases of exploration and exploitation as follows.

Initially, the candidate solutions (the feasible selection of RSU set) that could be determined in the network are represented as shown in Eq. (6).

$$C_{\text{Sol}} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1\text{d}} \\ h_{21} & h_{22} & \cdots & \text{v}_{2\text{d}} \\ \cdots & \cdots & \cdots & \cdots \\ h_{\text{q}1} & h_{\text{q}2} & \cdots & h_{\text{qd}} \end{bmatrix} \tag{6}$$

where

h_{ij}—'q' number of search agents that select optimized RSUs between the source and the destination nodes with respect to 'd' dimensions

Step 1: In the phase of initialization, the positions of the honey badger search agents (size of q population) are determined based on Eq. (7).

$$h_i = L^i_{\text{TH}} + \text{Rand}_1 \times \left(U^i_{\text{TH}} - L^i_{\text{TH}}\right) \text{Rand}_1 \tag{7}$$

where

h_i—i - th honey badger search agents' position

Rand_1—Random number which varies between 0 and 1

U^i_{TH}, L^i_{TH}—Upper and lower threshold to be explored in the search space

Step 2: After the process of initialization, the intensity associated with the concentration strength of the food source and its distance to the i - th honey badger search agents' position is determined using Eq. (8).

$$I^i_{\text{FS}} = \text{Rand}_2 \times \frac{S_{\text{ST}}}{4\pi d_{\text{FS}-\text{HB}}} \tag{8}$$

where

S_{ST}—Strength of food source (optimal RSUs)

$d_{\text{FS}-\text{HB}}$—Distance between the food source and the i - th honey badger search agent

In this case, Inverse Square Law is used as the motion of the i - th honey badger search agent completely depends on the degree of smell realized by the food source. In specific, the value of 'S_{ST}' and 'd_{FS-HB}' is determined based on Eqs. (9) and (10)

$$S_{ST} = h_i - h_{i+1} \tag{9}$$

$$d_{FS-HB} = \left(h_{FS} - h_{HB}^{i}\right) \tag{10}$$

Step 3: In this phase of density factor updating, a parameters (DF_{Up}) presented in Eq. (11) is used for controlling time varying randomization that attributes toward better transition from exploration to exploitation.

$$DF_{Up} = C_{ST}^{2} e^{\left(\frac{-Iter_{Curr}}{Iter_{Max}}\right)} \tag{11}$$

where

C_{ST}^{2}—Constant which is set to default value of 2

In addition, '$Iter_{Curr}$' and '$Iter_{Max}$' indicate the current iteration and maximum number of iterations, respectively.

Step 4: In this local optimum escaping process, a flag (FL_{Expl}) (presented in Eq. 12) is used for changing the direction of search in a more rigorous manner for determining the high opportunities of solutions in the search space.

$$FL_{Expl} = \begin{cases} 1, \text{ If } Rand_3 \leq 0.5 \\ -1, \text{ Otherwise} \end{cases} \tag{12}$$

Step 5: This process of updation of search agents' positions comprises of digging and honey phases. In the digging phase, the Cardioid motions are utilized for determining the better updating process of search agent with respect to the food source (optimal RSUs under selection) as specified in Equation (13).

$$\begin{aligned} h_{New} = {} & h_{FS} + FL_{Expl} \times HB_{Ability} \times I_{FS} + FL_{Expl} \times Rand_4 \times DF_{Up} \times d_{FS-HB} \\ & \times \left|(\text{Cos}\ (2\pi \cdot Rand_5)) \times (1 - \text{Cos}(Rand_6))\right| \end{aligned} \tag{13}$$

where

h_{FS}—Food source position

$HB_{Ability}$—Ability of the search agent during the process of exploration

$Rand_4$, $Rand_5$, $Rand_6$—Random numbers which ranges between 0 and 1

In this case, the value of '$HB_{Ability}$' in default is assigned the value of 6. The random numbers are used for confirming better exploration.

In the honey phase of HBOA, the updation of search agents' positions is achieved using Eq. (14)

$$h_{\text{New}} = h_{\text{FS}} + \text{FL}_{\text{Expl}} \times \text{Rand}_7 \times \text{DF}_{\text{Up}} \times d_{\text{FS-HB}} \tag{14}$$

However, this search process is impacted by the time variant search properties incorporated by the HBOA search agent in the search space.

Finally, the application of HBOA aids in determining the optimal number of RSUs through which data can be forwarded from the source to the destination nodes in the network.

4 Simulation Results and Discussion

The experimental validation of the proposed HBOA-RSUD scheme and the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches are conducted using EstiNet simulator for varying number of vehicular nodes and RSUs in the network. The simulation environment comprises of 100 vehicular nodes with number of RSUs ranging from 4 to 20 depending on the requirements of data dissemination.

Initially, Figs. 1 and 2 present the throughput and network coverage facilitated by the proposed HBOA-RSUD scheme and the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches for varying number of vehicular nodes. The throughput in the network is realized to be significantly higher as it adopts HBOA algorithm for selecting optimal RSUs from the network during data delivery. It also adopts sigmoid function for achieving the deployment of RSUs in specified road intersections for maximizing network area coverage. Thus, the proposed HBOA-RSUD scheme improves throughput under different vehicular nodes by 11.86%, 14.59%, 17.16% and 19.81% in contrast to the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches respectively. Moreover, the network coverage guaranteed by the proposed HBOA-RSUD scheme for varying number of vehicular nodes is improved by 12.72%, 15.84%, 18.28% and 21.21% in contrast to the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches.

Further, Figs. 3 and 4 demonstrate the performance of the proposed HBOA-RSUD scheme and competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches in terms of mean delay and average energy consumption for varying number of vehicular nodes. The proposed HBOA-RSUD scheme incorporates the benefits of Cardioid movement during the digging phase which prevents the delay of packets from source to destination nodes. It also adopts different smell intensities and random coefficients which help in selecting only energy efficient RSUs during the process of reliable packet delivery, thereby minimizing the consumption of energy in the network. Hence, the proposed HBOA-RSUD scheme reduces the mean delay by 14.28%, 17.22%, 19.84% and 22.39% in contrast to the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches for varying number of vehicular nodes. In addition, the proposed HBOA-RSUD scheme with varying number of vehicular nodes involves reduced average energy consumption by 16.56%, 18.94%, 21.52% and 24.84% when compared to the competitive approaches taken for investigation.

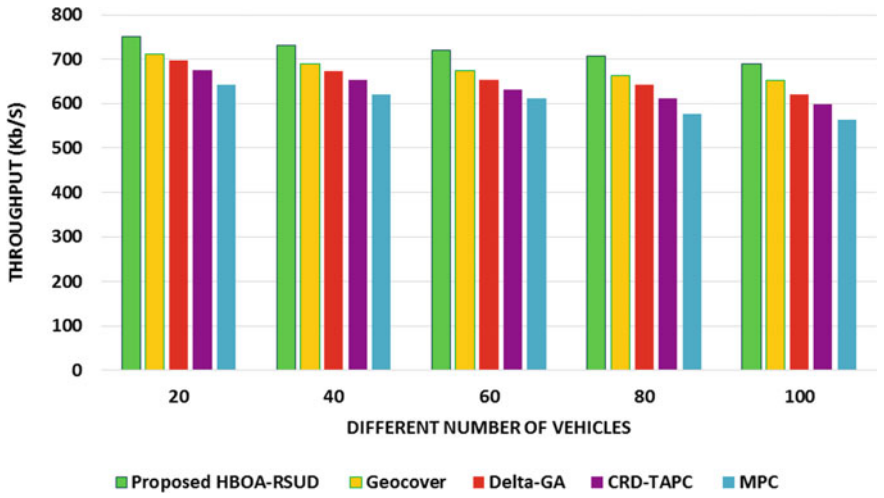


Fig. 1 Throughput of the proposed HBOA-RSUD scheme for varying number of vehicular nodes

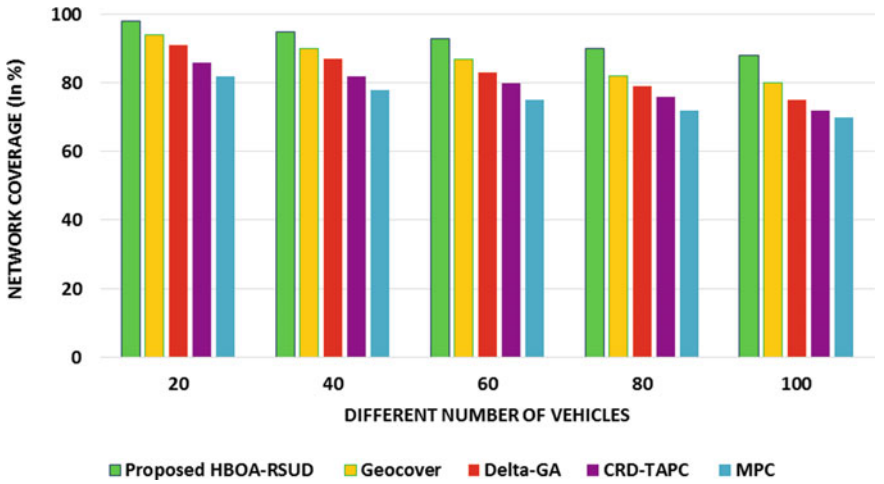


Fig. 2 Network coverage of the proposed HBOA-RSUD scheme for varying number of vehicular nodes

In addition, Fig. 5 depicts the network coverage attained by the proposed HBOA-RSUD scheme and the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches for varying number of RSUs. The network coverage is identified to be maximized by the proposed HBOA-RSUD approach as it selects only RSUs with high bandwidth offering capability and low installation cost during data transmission process. Thus, the proposed HBOA-RSUD scheme involving varying number of RSUs maximizes the network coverage by 23.29%, 26.84%, 29.12% and 32.16%

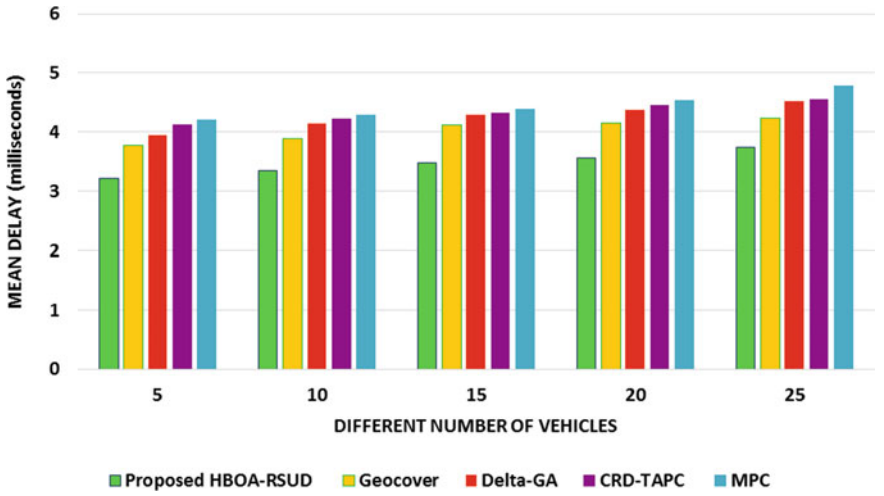


Fig. 3 Mean delay of the proposed HBOA-RSUD scheme for varying number of vehicular nodes

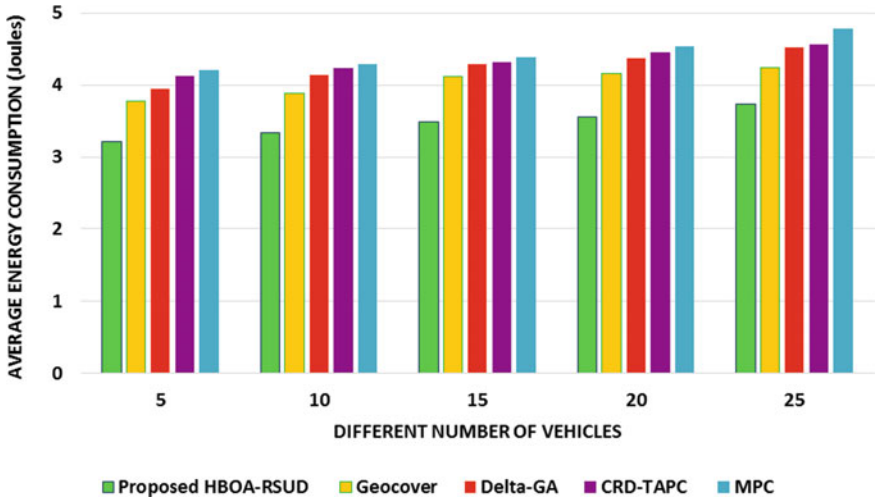


Fig. 4 Average energy consumption of the proposed HBOA-RSUD scheme for varying number of vehicular nodes

in contrast to the competitive Geocover, Delta-GA, CRD-TAPC and MPC approaches taken for investigation.

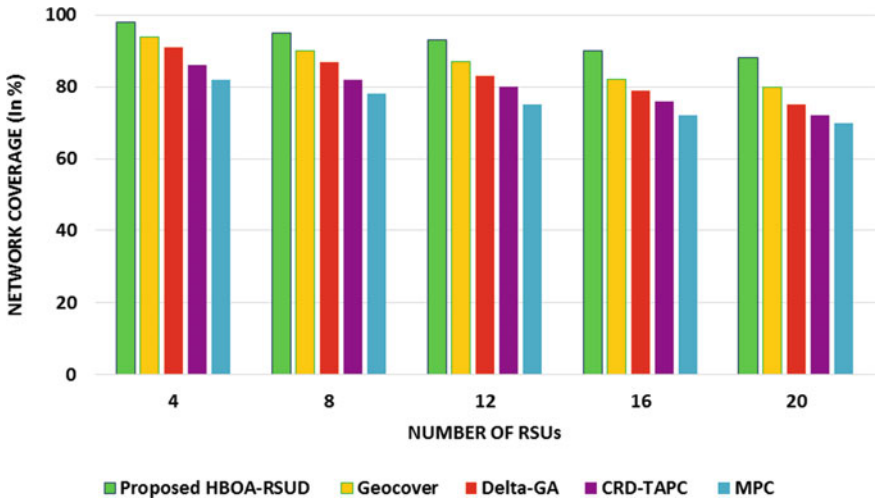


Fig. 5 Network coverage of the proposed HBOA-RSUD scheme for varying number of RSUs

5 Conclusion

The proposed HBOA-RSUD scheme confirms better network coverage with minimized number of RSUs deployed in the network for minimizing the cost of deployment and maintenance. It establishes a static model and estimates the complexity involved during the deployment of RSUs in the urban road. It further uses multi-objective HBOA algorithm with sigmoid function and determines the position of the urban road over which RSUs can be optimally deployed. The experimental results of HBOA-RSUD involving different vehicular nodes confirm 21.28% improved throughput, 28.95% better network coverage, 19.42% minimized delay and 21.98% reduced energy consumption. Moreover, the proposed HBOA-RSUD scheme involving under varying number of RSUs also confirms a maximized network coverage on par with the baseline RSUs deployment approaches. As part of future, it is planned to develop a pity beetle algorithm and compare its performance with the proposed HBOA-RSUD scheme in heterogeneous and homogeneous environments.

References

1. Anandakumar, H., & Arulmurugan, R. (2019). Next generation wireless communication challenges and issues. In *2019 Third International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)* (pp. 270–274). IEEE.
2. Murugan, S., & Anandakumar, H. (2019). Study of efficient hybrid wireless networks using QoS-oriented distributed routing protocol: QoS-oriented distributed routing protocol. In

Cognitive Social Mining Applications in Data Analytics and Forensics (pp. 213–235). IGI Global.
3. Outay, F., Kammoun, F., Kaisser, F., & Atiquzzaman, M. (2017, March). Towards safer roads through cooperative hazard awareness and avoidance in connected vehicles. In *2017 31st International Conference on Advanced Information Networking and Applications Workshops (WAINA)* (pp. 208–215). IEEE.
4. Ghorai, C., & Banerjee, I. (2017, January). A multi-objective data dissemination protocol for intelligent transportation systems. In *2017 IEEE 7th International Advance Computing Conference (IACC)* (pp. 144–149). IEEE.
5. Ali, G. M. N., Chong, P. H. J., Samantha, S. K., & Chan, E. (2016). Efficient data dissemination in cooperative multi-RSU vehicular ad hoc networks (VANETs). *Journal of Systems and Software, 117*, 508–527.
6. Abbas, F., & Fan, P. (2018). Clustering-based reliable low-latency routing scheme using ACO method for vehicular networks. *Vehicular Communications, 12*, 66–74.
7. Silva, C. M., Silva, F. A., Sarubbi, J. F., Oliveira, T. R., Meira, W., Jr., & Nogueira, J. M. S. (2017). Designing mobile content delivery networks for the internet of vehicles. *Vehicular communications, 8*, 45–55.
8. Song, C., Wu, J., Liu, M., & Zheng, H. (2017). Efficient routing through discretization of overlapped road segments in VANETs. *Journal of Parallel and Distributed Computing, 102*, 57–70.
9. Balamurugan, A., Deva Priya, M., Christy Jeba Malar, A., & Janakiraman, S. (2021). Raccoon optimization algorithm-based accurate positioning scheme for reliable emergency data dissemination under NLOS situations in VANETs. *Journal of Ambient Intelligence and Humanized Computing (AIHC), 12*, 10405–10424.
10. Christy Jeba Malar, A., Deva Priya, M., & Sengathir, J. (2020). A hybrid crow search and grey wolf optimization algorithm-based reliable NLOS Node Positioning Scheme for VANETs. *International Journal of Communication Systems, 34*(3), 1099–1131
11. Christy Jeba Malar, A., Deva Priya, M., & Sengathir, J. (2020) Harris hawk optimization algorithm based Non-Line-of-Sight (NLOS) nodes effective localization for reliable data dissemination in VANETs. *International Journal of Communication Systems, 34*(1), 1099–1131
12. Lin, P. C. (2012, November). Optimal roadside unit deployment in vehicle-to-infrastructure communications. In *2012 12th International Conference on ITS Telecommunications* (pp. 796–800). IEEE.
13. Filippini, I., Malandrino, F., Dán, G., Cesana, M., Casetti, C., & Marsh, I. (2012, January). Non-cooperative RSU deployment in vehicular networks. In *2012 9th Annual Conference on Wireless On-Demand Network Systems and Services (WONS)* (pp. 79–82). IEEE.
14. Tao, J., Zhu, L., Wang, X., He, J., & Liu, Y. (2014, December). RSU deployment scheme with power control for highway message propagation in VANETs. In *2014 IEEE Global Communications Conference* (pp. 169–174). IEEE.
15. Cheng, H., Fei, X., Boukerche, A., & Almulla, M. (2015). GeoCover: An efficient sparse coverage protocol for RSU deployment over urban VANETs. *Ad Hoc Networks, 24*, 85–102.
16. Sarubbi, J. F., Martins, F. V., & Silva, C. M. (2016, July). A genetic algorithm for deploying roadside units in vanets. In *2016 IEEE Congress on Evolutionary Computation (CEC)* (pp. 2090–2097). IEEE.
17. Kim, D., Velasco, Y., Wang, W., Uma, R. N., Hussain, R., & Lee, S. (2016). A new comprehensive RSU installation strategy for cost-efficient VANET deployment. *IEEE Transactions on Vehicular Technology, 66*(5), 4200–4211.
18. Wang, Z., Zheng, J., Wu, Y., & Mitton, N. (2017, May). A centrality-based RSU deployment approach for vehicular ad hoc networks. In *2017 IEEE International Conference on Communications (ICC)* (pp. 1–5). IEEE.
19. Yeferny, T., & Allani, S. (2018). Mpc: A rsus deployment strategy for vanet. *International Journal of Communication Systems, 31*(12), e3712.

20. Gao, Z., Chen, D., Cai, S., & Wu, H. C. (2018). Optdynlim: An optimal algorithm for the one-dimensional rsu deployment problem with nonuniform profit density. *IEEE Transactions on Industrial Informatics, 15*(2), 1052–1061.
21. Gao, Z., Chen, D., Yao, N., Lu, Z., & Chen, B. (2018). A novel problem model and solution scheme for roadside unit deployment problem in VANETs. *Wireless Personal Communications, 98*(1), 651–663.
22. Patil, S., & Ragha, L. (2020, February). Deployment and decentralized identity management for VANETs. In *2020 3rd International Conference on Emerging Technologies in Computer Engineering: Machine Learning and Internet of Things (ICETCE)* (pp. 202–209). IEEE.
23. Yang, F., Zhao, C., Ding, X., & Han, J. (2020). An analytical model for energy harvest road side units deployment with dynamic service radius in Vehicular Ad-Hoc networks. *IEEE Access, 8*, 122589–122598.
24. Mahmood, D. A., & Horváth, G. (2020). Analysis of the message propagation speed in VANET with disconnected RSUs. *Mathematics, 8*(5), 782.
25. Hashim, F. A., Houssein, E. H., Hussain, K., Mabrouk, M. S., & Al-Atabany, W. (2022). Honey badger algorithm: New metaheuristic algorithm for solving optimization problems. *Mathematics and Computers in Simulation, 192*(4), 84–110.

Map Drawing Approach for Airport Connectivity Using Coloring Algorithm

Neha Singh and Jyoti Srivastava

Abstract Graph theory is one of the most significant ideas. It has wide applications in our daily lives. Graph coloring is one of the concepts of graph theory. On the basis of the basics of requirements, different coloring methods are used. In deconstructing avionics, airport connectivity is the most important and crucial component. It has been used in various studies to see how showcase development affects air terminal improvement and how to arrange change so that it is recognized with showcase development. Several graph coloring methods have been developed in graph theory. In this paper, through the use of graph coloring shows the connectivity between domestic and international airports in India. In India, the total number of airports is 134, and 64 have domestic status, while 22 others have international status. This paper proposes an algorithm that connects the domestic and international airports. This paper uses the real-world graph and maps as well as a case study to set up its adequacy and constraints. This paper examines many academics' publications and methodologies for map design and airport connection networks.

Keywords Graph theory · Graph coloring · Airport connectivity · Domestic airport · International airport

1 Introduction

One of the most important, well-known, and studied subfields of graph theory is graph coloring. Various studies and books in which coloration is explored, as well as the issues and conjectures linked with it, provide evidence of this. Various fields of study are being described and solved [1]. Graph coloring is described as using the fewest colors possible to color the nodes of a graph while ensuring that no two neighboring nodes have the same color. One of the most helpful models in graph theory is graph coloring. It is been used to tackle issues with school schedules, computer register allocation, e-bandwidth allocation, and a slew of additional issues and more

N. Singh (✉) · J. Srivastava
Madan Mohan Malviya University of Technology, Gorakhpur, India
e-mail: nehaps2703@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_17

applications [2]. Graphs are commonly recycled to represent interrelationship data surrounded by entities [3].

Graphs have been used to represent a variety of situations, including references in scientific articles, movement between public relations switches, and aviation passes between urban areas. The resulting visual representation can encompass tens of thousands of knobs and margins, as these challenges grow in size [4]. Many strategies for displaying abstract datasets have been proposed by researchers. They frequently utilize graphs with nodes and links to represent item relationships, and graph drawing allows us to see these relationships [5].

In both rich and developing countries, air travel has become increasingly important as a form of transportation. Air travel is often safer and faster than other modes of transportation, despite its comparatively high cost [6]. The runway is analyzed and measured on a regular basis in terms of traveler and movement volume, as well as operational performance. These metrics are useful, but they do not provide quick insight into the amount of air convenience or airport competition in air transportation networks. An acceptable connectivity statistic is necessary to assist policymakers and airport management in measuring and monitoring network performance against that of other airports [7].

Competition encompassed by runways is heating up on a universal and local level, and several are aggressively elaborating their scope or updating their apparatus in order to position themselves as hub runways [8]. At the turn of the twentieth century, the aviation sector began to actively compete with one another. Not only the airline company, but even the airport itself seeks to outsmart the competition in order to stay afloat. Airports are in the business of connecting their region to the rest of the globe, working with airlines to do so. The stronger the airport's international connections are, the more appealing it becomes to its consumers and, more importantly, the more competitive it gets [9].

The air shipping system has a major brunt on economies, collective change, and national progress at the regional, domestic, and global levels. This is supported by policymakers' and the media's focus on issues related to its efficiency and safety. As a result, it is fun to look into and analyze distant airfield networks in terms of functionality and relatedness. Furthermore, the industry's rapid development has been fueled by the continued growth and liberalization of air transportation networks around the world [10]. Air transportation connections promote worldwide engagement, stimulating globalization, and encouraging social and economic progress [11].

Graph theory is used in a lot of the work on airport network connectivity. This method has been used on a variety of networks, including social, communications, neural, transportation, and so on. Any network can be defined as a collection of nodes connected by links [12]. One of the most important measures of a country's economic growth is its transportation infrastructure [13]. The necessity of timetable coordination for network airlines and airline alliances managing hubs cannot be overstated [14].

One of the most significant services provided by air traffic control agencies is traffic management. The following are the departments that make up Air Traffic Control: civil/military coordination, operations, standards, airspace planning, and

technical evaluation in search and rescue [15]. Fuzzy logic is used to forecast weather due to a certain weather state as part of the airport's daily routine work. Engineers and air traffic controllers could profit from the ability of the developed fuzzy solution to predict weather in real time. The function forecasting approach establishes an airport's current weather conditions, so the air movement authority may create a closing output that is one of two relevant or unsuitable for flight operations [16].

The remaining paper is categorized into several parts: Part 2 contains the literature review. Part 3 defines the problem statement, methodology for the airport connectivity approach and also defines the designing algorithm and procedure for the proposed algorithm. Part 4 discusses the result of the approach. Part 5 brings the paper to a close. Part 6 defines future scope.

2 Related Work

Hu et al. [3] proposed a calculation process for a close to ideal color task of a double impact graph, utilizing a novel branch, and bound technique enforced to an area disintegration of the coloring array. They allow models to show the methodology in genuine charts and pictures, just as a client consideration to set up its viability and conditions.

Cui et al. [4] describe a peculiar geometry-based edge grouping structure that can gather corners into packs to minimize general corner intersections, their technique utilizes control work to direct the edge grouping operation; corner groups can be shaped by constraining all corners to go over a few authority focuses on work.

Zhang et al. [7] presented a network approaches connect various components, such as speed and also restricted disciplines, too directly for an association's idea. They discovered that over the assessment period, Chinese air terminals had a mind-boggling increase in air arranged.

Usami et al. [8] provide opinions on air terminal prime and departure availability surrounded by private and universal travelers benefiting from knowledge gained from traveler development research. They detail an in-depth analysis of air terminal decisions and traveler development on international flights departing from adjacent cities. They employ a random utility econometric model.

Suwanwong et al. [9], they outline the process of evaluating airport connections. They now use the NETSCAN Connectivity Index to assess network units. This allows the NETSCAN model to be used to evaluate the Don Mueang International Airport's availability. The reason for choosing this model is that it is both mainstream and reliable.

Bagler et al. [10], they advocated looking into India's air terminal system as a complicated weighted system. They study India's airport system, which is a mind-boggling system that talks to India's local common avionics framework. They analyze India's airport network as a complex system, comparing and contrasting its many equity and topological partners.

The different types of airport connectivity and coloring approach are shown in Table 1.

The results of all of the following studies are utilized to determine the various coloring and connecting methods used for airport connectivity. The results of the preceding surveys, as well as other types of connectedness and coloring approaches, are shown in Table 1. The goal of this study is to find an air terminal building that

Table 1 Different types of airport connectivity and coloring approach

Ref. No	Method	Result
[10]	Time-dependent minimum path technique	Their findings demonstrate that the fastest links have similar routing parameters and circuits times
[12]	Time-dependent minimum path approach	It gives result to be leveraged to enable a new traveler approach known as self-help hubbing
[17]	Force directed, spring-embedding approach	In this, both methods produce nearly Lombardi design with exceptional at produce near excellent angular decision and the balancing boundary placements
[18]	Multilevel agglomerative edge bundling algorithm	In this, the proposed technique is far faster than previous methods
[19]	Gradient descent algorithm	The results demonstrate that apply Lab color administered in improved color choice and similarly good color assignment to the apex of the region chart
[20]	Collins–Stephenson circle packing algorithm	Their findings contribute significantly to our understanding of planar Lombardi drawings
[21]	Edge distance and color embedding	They provide the following findings: a graph edge distance metric, a graph edge coloring method, and graph edge study
[22]	Shortest path length and quickest time approach	According to the study, there are great logic to operation relatedness measurements instead of typical amount-based approaches for both accessibility and centrality evaluations
[23]	Fuzzy multi-criteria decision-making techniques	The fuzzy MCDM technique is a promising and realistic ruling formulation mechanism for gauging runway utility aspect, according to the research
[24]	Fuzzy-based procedure	The fuzzy bunch approach defines the uncertainty in runway membership
[25]	Fuzzy logic	In comparison with the values determined by expert judgment, good outcomes were attained

can be customized. This study demonstrates an important method for improving the dynamic and creation of a manner of discovering's arranging activity.

3 Problem Statement and Methodology

The connectivity between India's domestic and international airports is being developed using the graph colouring technique. An arrangement to investigate a better beginning colouring strategy for connecting international and domestic airports in India. This paper proposes the use of colours to help distinguish between domestic and international airports. In this paper, used method that establishes connectivity with colors. The proposed approach connects the every domestic and international airports of India using the graph coloring and airports connectivity methods. The model implemented in Eclipse IDE.

3.1 The Approach for Designing Algorithm

Figure 1 depicts the method to designing an algorithm.

3.2 Procedure for Proposed Algorithm

This phase gives the source place and destination place of airports. In case, if the source and destination flight is not match, then display message no any flight is available, if match, then show message path is available and color the direct and indirect flight path between sources to destination. We show the multiple path routs from source to destination and select the best path rout. This process is repeated until reach the destination. The steps involve are as follows:

Step1: First step selects the source place and destination place of flights.

Step 2: The second step matches the both places—

I. If match both places is false, then show message no flight is available.
II. If match both places is yes, then generating multiple path and find the best path from source to destination flights.

Step 3: Third step shows the multiple path from source to destination.

Step 4: Fourth step connects direct flight from source to destination and also connects the indirect flight from source to destination.

Step 5: Fifth step shows the direct flight from green color path and shows indirect flight from red color path.

Step 6: Six and final step shows all direct and indirect flights routes in table form.

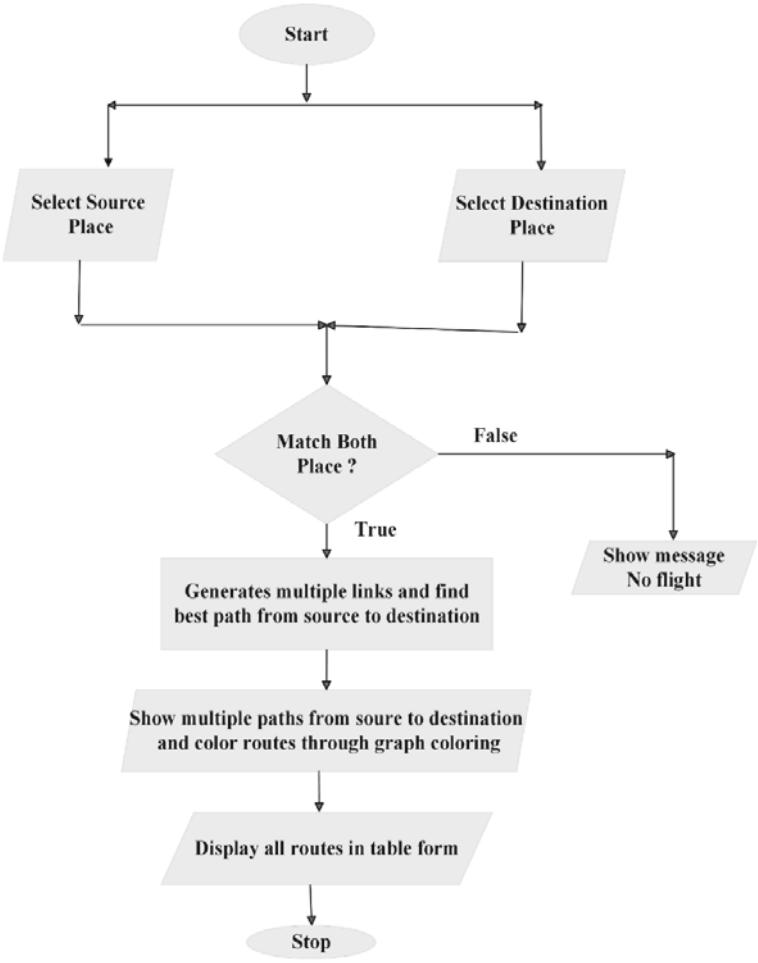


Fig. 1 Proposed approach

4 Results

In given result, we show the connectivity between the domestic and international airports in India through graph coloring method. In result, we show that direct and indirect connectivity of domestic and international airports flights and connectivity flights places show in table form.

Figures 2, 3, 4, and 5 show which green line shows the direct connectivity between sources to destination flights, red line shows the indirect connectivity between sources to destination flights, and table shows which places where direct and indirect flight connectivity will be indicated and all the flights data store in database.

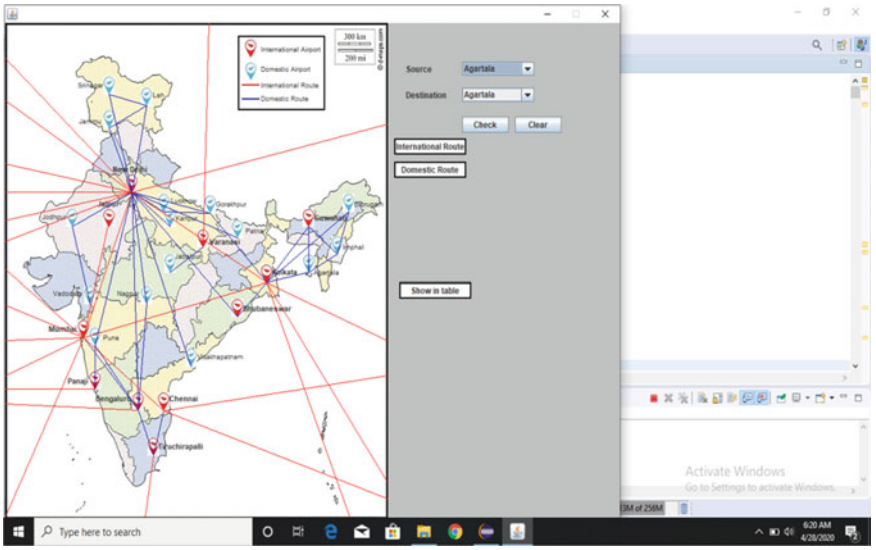


Fig. 2 Domestic and international airport connectivity

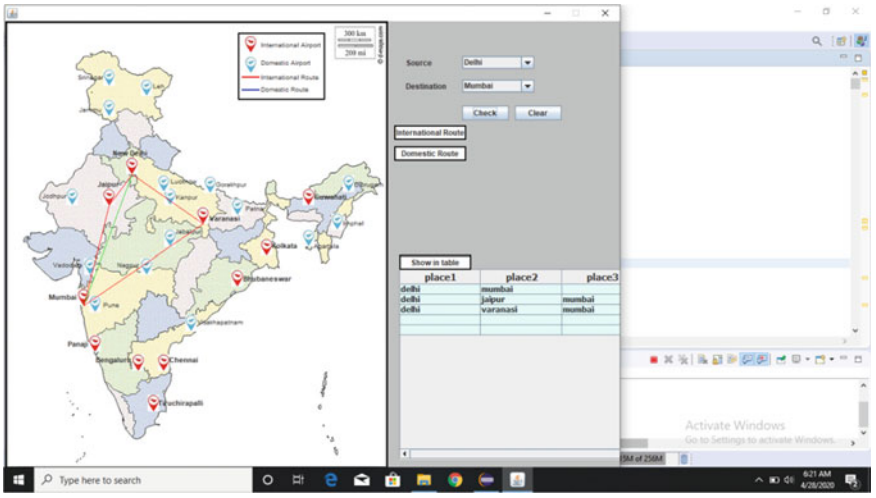


Fig. 3 Connectivity between Delhi and Mumbai flights

5 Conclusion

The work aims to design better initial coloring methods for finding total number of airports in India so that the connectivity between domestic and international airports should be established. Our aim would be to design and develop a method for coloring

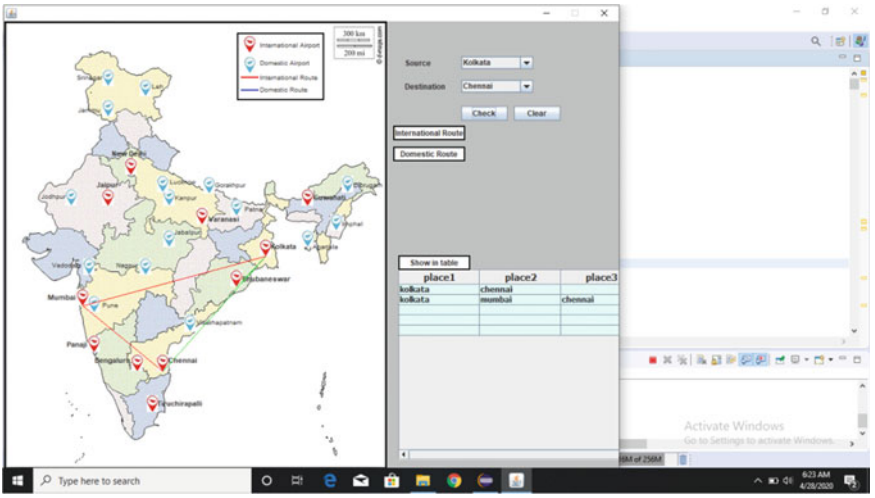


Fig. 4 Connectivity between Kolkata and Chennai flight

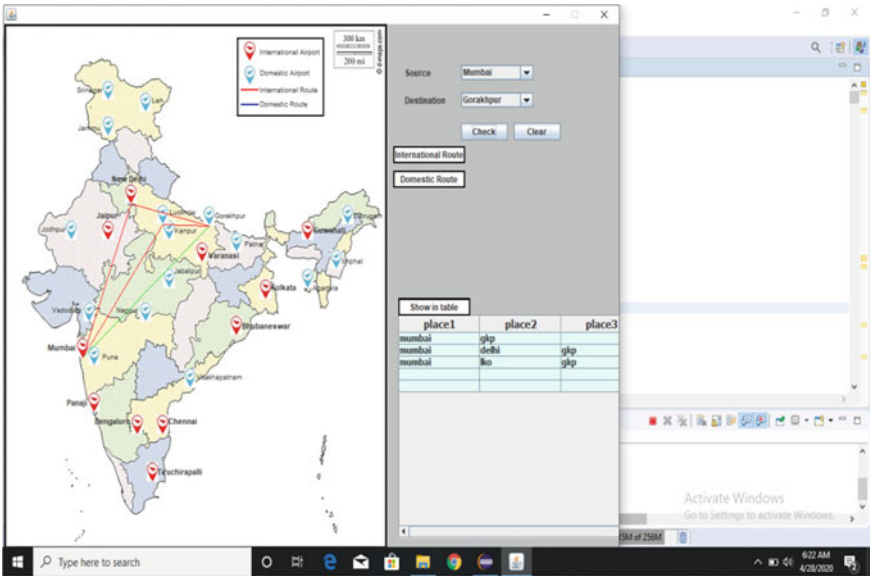


Fig. 5 Connectivity between Mumbai and Gorakhpur flights

connectivity between domestic and international airports. It is more essential to color neighboring airports with more specific color. We explained the better initial coloring methods for finding total number of airports in India. It gives fundamental network on a national, territorial, and global scale. This work creates alternative design of airport.

6 Future Scope

In the future, this research also can be deal with some following points:

- The connectivity method can also be used to increase the number of connectivity exchanges.
- Connectivity of airport can also be updated by researchers.
- In the future, the algorithms can be derived for the hard and soft deadline coloring also.
- We can improve the coloring and connectivity approach.

References

1. Formanowicz, P., & Tana, K. (2012). A survey of graph coloring—Its types, methods and applications. *Foundations of Computing and Decision Sciences, 37*.
2. Al-Omari, H., & Sabri, K. E. (2006). New graph coloring algorithms. *American Journal of Mathematics and Statistics, 2*(4), 739–741.
3. Hu, Y., Shi, L., & Liu, Q. (2018). A coloring algorithm for disambiguating graph and map drawings. *IEEE Transactions on Visualization and Computer Graphics, 25*(2), 1321–1335.
4. Cui, W., Zhou, H., Qu, H., Wong, P. C., & Li, X. (2008). Geometry-based edge clustering for graph visualization. *IEEE Transactions on Visualization and Computer Graphics, 14*(6), 1277–1284.
5. Hu, Y., Gansner, E. R., & Kobourov, S. (2010). Visualizing graphs and clusters as maps. *IEEE Computer Graphics and Applications, 30*(6).
6. Rocha, L. E. (2017). Dynamics of air transport networks: A review from a complex systems perspective. *Chinese Journal of Aeronautics, 30*(2), 469–478.
7. Zhang, Y., Zhang, A., Zhu, Z., & Wang, K. (2017). Connectivity at Chinese airports: The evolution and drivers. *Transportation Research Part A: Policy and Practice, 103*, 490–508.
8. Usami, M., Manabe, M., & Kimura, S. (2017). Airport choice and flight connectivity among domestic and international passengers—Empirical analysis using passenger movement survey data in Japan. *Journal of Air Transport Management, 58*, 15–20.
9. Sopadang, A., & Suwanwong, T. (2016). Airport connectivity evaluation: The study of Thailand. In *International conference on industrial engineering and operations management* (pp. 188–195).
10. Paleari, S., Redondi, R., & Malighetti, P. (2010). A comparative study of airport connectivity in China, Europe and US: Which network provides the best service to passengers? *Transportation Research Part E: Logistics and Transportation Review, 46*(2), 198–210.
11. Allroggen, F., Pittman, M. D., & Malin, R. (2015). How air transport connects the world—A new metric of air connectivity and its evolution between 1990 and 2012. *Transportation Research Part E: Logistics and Transportation Review, 80*, 184–201.
12. Malighetti, P., Paleari, S., & Redondi, R. (2016). Connectivity of the European airport network: Self-help hubbing and business implications. *Journal of Air Transport Management, 14*(2), 53–65.
13. Bagler, G. (2008). Analysis of the airport network of India as a complex weighted network. *Physica A: Statistical Mechanics and its Applications, 387*(12), 2972–2980.
14. Budde, A., De Wit, J., & Burghouwt, G. (2008). Borrowing from behavioral science: a novel method for the analysis of indirect temporal connectivity at airport hubs. In *Air transport research society conference.*

15. Idika, N., & Baridam, B. B. (2018). An intelligent air traffic control system using fuzzy logic model. *Int. J. Appl. Inf. Syst*.
16. Ramli, A. A., Islam, M. R., Fudzee, M. F., Salamat, M. A., Kasim, S. (2014). A practical weather forecasting for air traffic control system using fuzzy hierarchical technique. In *Recent advances on soft computing and data mining 2014* (pp. 99–109). Springer.
17. Chernobelskiy, R., Cunningham, K. I., Goodrich, M. T., Kobourov, S. G., & Trott, L. (2011). Force-directed Lombardi-style graph drawing. In *International symposium on graph drawing* (pp. 320–331). Springer.
18. Gansner, E. R., Hu, Y., North, S., & Scheidegger, C. (2011). Multilevel agglomerative edge bundling for visualizing large graph. *IEEE Pacific Visualization Symposium, 2011*, 187–194.
19. Dillencourt, M. B., Eppstein, D., & Goodrich, M. T. (2006). Choosing colors for geometric graphs via color space embeddings. In *International symposium on graph drawing* (pp. 294–305). Springer.
20. Eppstein, D. (2012). Planar Lombardi drawings for subcubic graphs. In *International symposium on graph drawing* (pp. 126–137). Springer.
21. Jianu, R., Rusu, A., Fabian, A. J., & Laidlaw, D. H. (2009). A coloring solution to the edge crossing problem. In *13th international conference information visualization* (pp. 691–696). IEEE.
22. Burghouwt, G., & Redondi, R. (2013). Connectivity in air transport networks: An assessment of models and applications. *Journal of Transport Economics and Policy (JTEP), 47*(1), 35–53.
23. Pandey, M. M. (2016). Evaluating the service quality of airports in Thailand using fuzzy multi-criteria decision making method. *Journal of Air Transport Management, 57*, 241–249.
24. Postorino, M. N., & Versaci, M. (2014). A geometric fuzzy-based approach for airport clustering. In *Advances in Fuzzy Systems*.
25. Kalić, M., Dožić, S., & Babić, D. (2012). *Predicting air travel demand using soft computing: Belgrade airport case study*. Compendium of. https://www.researchgate.net/profile/Slavica-Dozic/publication/267559799_Predicting_Air_Travel_Demand_Using_Soft_Computing_Belgrade_Airport_Case_Study/links/545a025d0cf2bccc4912f710/Predicting-Air-Travel-Demand-Using-Soft-Computing-Belgrade-Airport-Case-Study.pdf

L2 Teachers' Strategies and Students' Engagement in Virtual Classrooms: A Multidimensional Perspective

Hung Phu Bui

Abstract Student engagement refers to students' attention and involvement in affective, social, cognitive, and metacognitive processes. Student engagement can be influenced by social factors, the learning environment, and pedagogical strategies and is closely related to the learning outcomes. This study investigates (1) the strategies employed by Vietnamese EFL teachers in online classrooms, (2) the extent to which these strategies influence student engagement, and (3) students' preferences. A set of three questionnaires was administered to 442 participants (200 teachers and 242 students). Data cleaning showed that responses from 22 participants (7 teachers and 15 students) were invalid and therefore excluded from data analysis. The remaining data were projected to SPSS 26 for analysis. Results show that the Vietnamese EFL teachers used a wide range of strategies to engage students in online learning. Strategies to engage students emotionally and cognitively were found to have the strongest effects. Students preferred the strategies employed by their teachers which engaged them affectively, socially, and cognitively.. The findings suggest implications for online classroom practices.

Keywords Affective · Cognitive · L2 student engagement · Social · Teacher's strategies · Virtual learning

1 Introduction

1.1 Rationale for the Study

Student engagement is defined as "the adhesive, or mediation, that connects significant contexts-home, classroom, classmates, and children's society, in turn, to factors that contribute" [1, p. 3]. It is a heightened state of attention and involvement in

H. P. Bui (✉)
University of Economics Ho Chi Minh City, Ho Chi Minh City 700000, Vietnam
e-mail: hungbp@ueh.edu.vn

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_18

which participation is reflected in cognitive, social, behavioral, and emotional dimensions [2]. Student engagement is believed to be influenced directly or indirectly by the family background, school, and the classroom learning atmosphere and has direct effects on student outcomes. Because the learning and teaching environment influences students, teachers' support intention to engage students in learning are considered critical to students' success in school [1, 2].

In language education, an increasing body of research is interested the effects of student engagement in learning. Engagement can help students actively commit effort and attention to second language acquisition and learning [3]. The main factors for second language development are learners' interest and desire to engage with learning opportunities and the expenditure of effort while learning. Student participation has grown into a goal-oriented learning process and a measure of personal accountability.

Teachers are considered to have an essential role in student engagement. Different groups of students may need to be engaged in the learning process differently. Teachers should understand students' psychological development, needs, expectations, and desire to apply appropriate techniques to engage students in learning properly. Teachers' techniques to inspire pupils and assist learning are crucial markers of effective learning environments.

The current literature shows that online learning exhibits to be problematic in Asia. Asian students do not get engaged in public talks as their face can be threatened, which can obstruct their interaction with teachers and peers [4]. Their engagement in classroom interaction is, therefore, passive; they usually hesitate until they are asked to do [5]. To increase interaction between the teacher and students and between students and students, most, if not all, schools employ computer-mediated communication [6]. However, to a certain extent, a lack of interactivity is found in the current literature on online learning, which may lead to boredom in the classroom. Also, it is inadequate training for online pedagogy that might make teachers unaware of strategies to engage students in learning in the classroom [7].

1.2 Research Aims

This study explores the strategies used by Vietnamese L2 teachers to engage students in virtual learning and students' preferences for their teachers' strategies. It seeks to address the following research questions (RQs): RQ1. What strategies do Vietnamese EFL teachers employ to engage students in online learning? RQ2. To what extent do Vietnamese EFL teachers' strategies engage students in online learning? RQ3. Which strategies (involved in the questionnaire) do Vietnamese EFL students prefer?

1.3 L2 Students' Engagement in Virtual Learning

In second language (L2) education, student engagement is referred to as "a state of heightened attention and involvement, in which participation is reflected not only in the cognitive dimension but in social, behavioral and affective dimensions" [2, p. 51] putting forward the importance of task-based interaction, which can promote affective engagement. Accordingly, interactional behaviors can generate students' positive emotions. Interaction is a negotiation of meanings in which interlocutors exchange their knowledge and experience, which can provide opportunities for language production. During the interaction, students can clarify, elaborate, and exchange their opinions [8, 9], resulting in students' academic achievements and knowledge development [10].

Student engagement is not restricted to learning in the classroom. Students can learn both inside and outside the classroom [11]. While in-class engagement in learning usually refers mainly to the teacher's pedagogical techniques to promote students' participation in a controlled manner, out-of-class engagement in learning gives students autonomy and flexibility to complete their assigned works [11].

Student engagement is a multidimensional concept, with three main dimensions: affective, behavioral, and cognitive [3]. Affective engagement refers to students' emotions generated from classroom activities. Interest in learning can be an indicator of students' positive emotions. Behavioral engagement, generated during the learning process, can be detected through observations. It is of two main subtypes: passive and active [12]. A typical example of passive engagement is students' attention to activities. Activities, such as asking questions and making effort, are instances of the active type. Students' awareness of their responsibility by setting goals is an example of cognitive engagement. These types of engagement are interconnected because students can behave positively when they are interested in classroom activities [12].

However, interaction is not confined to social interaction. According to sociocultural theory, external mediation (from interaction with the outside world) serves as the means by which internal mediation is achieved. "Mediation involves (1) mediation by others in social interaction, (2) mediation by self through private speech, and (3) mediation by" artifacts (tasks and technology) [13]. Therefore, interaction includes interpersonal and intramental activities. The three processes of mediation result in knowledge development. From interaction with the outside world, people receive input which is then mentally processed through private speech to develop personal knowledge.

The arguments above distinguish social engagement from interactive engagement. Social interaction and interaction with tasks and artifacts (tasks and technology) should be classified into behavioral engagement, but the intramental process should be categorized into cognitive engagement. In mediation by artifacts, people may interact with tasks and technology. Regarding online learning, artifacts can refer to learners' interaction with a task assigned by the teacher or with technology. This interaction can be facilitated by synchronous and/or asynchronous computer-mediated communication [6].

Hiver et al. [14] suggested that student engagement can consist of three main dimensions but can be extended to have more than four. A literature survey shows that metacognition, regulation of one's thinking, is an essential factor in second language acquisition and learning. It may mediate the learning process [15]. According to Haukås [16], metacognition, a dynamic system, can contribute to language learning achievements.

To engage students in learning, teachers can employ diverse strategies. Teachers may turn the classroom into a social context in which teachers and students can exchange knowledge and experience to foster "interactiveness and the relationship between learners in interaction, as reflected in learners' mutuality and reciprocity, affiliation, willingness to interact with peers, supportiveness, scaffolding, and assistance" [3]. Helme and Clarke [17] suggested the use of self-regulation strategies to engage students cognitively and the use of collaborative tasks, "completing peer utterances; exchanging ideas; making evaluative comments; giving directions, explanations, or information; justifying an argument; and making gestures and facial expressions" as effective strategies to engage students in learning. As dimensions of engagement are interdependent, one strategy can be used to increase different types of student engagement.

To sum up, a survey of the literature indicates that little is known about strategies employed by English as a foreign language (EFL) teachers to engage students in the online language classroom and students' preferences for their teachers' strategies in Asian contexts. As there has been a growing interest in online teaching and learning worldwide in recent decades, investigations into these concerns would help enrich the literature in student engagement and contribute to effective online teaching and learning.

2 Research Methods

The current quantitative study employed questionnaires to collect data. First, the researcher sent an email invitation to L2 teachers to delve into the strategies they employed to engage students in learning in the classroom. Second, the pool of strategies revealed by the teachers was used to develop questionnaires administered to students to explore effects of these strategies on their engagement and their beliefs of the strategies.

This study employed the purposeful sampling strategy. With the approvals of the administrations of three universities in Vietnam, 442 participants (200 teachers and 242 students) were involved. They all experienced online teaching and learning during the COVID-19 pandemic. The student participants were taught by the teachers involved in this study.

The current study employed a set of three questionnaires corresponding to three research questions (RQs). They were designed on a Likert scale of 1–5 and were based on the proposals and research by Philp and Duchesne [2]. Questionnaire 1 investigated the strategies employed by L2 teachers to engage students in learning

(see Table 1). This questionnaire, on a Likert scale (1 = least frequently used and 5 = most frequently used), was administered to the teachers (n = 200). Questionnaire 2, in a Likert scale (1 = engaged the least and 5 = engaged the most), investigated the degree to which the teachers' strategies engaged students in learning (see Table 2). Questionnaire 3, on a Likert scale (1 = least liked and 5 = most liked), was about students' preferences for teachers' strategies (see Table 3). Questionnaires 2 and 3 were administered to students ($n = 242$). Before the main study, the questionnaires were first tested with 100 participants (50 teachers and 50 students) who were not involved in the main study. The results from the pilot testing showed that all the items were rated greater than 3 out of 5 in the Likert scale. In the main study, all of these questionnaires were administered online during the COVID-19 pandemic lockdown.

The researcher first cleaned the data collected from the questionnaire [4]. Responses from 22 participants (7 teachers and 15 students) were excluded as they were invalid (choosing two options for one item and leaving items unanswered). The remaining data ($n = 420$), collected from 193 teachers and 227 students, were projected to SPSS 26 for analysis. Regarding the objectives of the study, descriptive

Table 1 Vietnamese EFL teachers' strategies to engage students in online learning

Category ($n = 193$)	Mean	SD	Reliability
Affective engagement strategies	3.91	0.69	0.76
Social engagement strategies	4.81	0.53	0.83
Cognitive engagement strategies	4.70	0.59	0.87
Metacognitive engagement strategies	4.41	0.79	0.73

Author source

Table 2 Vietnamese EFL students' engagement in online learning

Category ($n = 227$)	Mean	SD	Reliability
Affective engagement strategies	4.76	0.62	0.81
Social engagement strategies	4.74	0.63	0.78
Cognitive engagement strategies	4.34	0.73	0.83
Metacognitive engagement strategies	4.35	0.67	0.75

Author source

Table 3 Vietnamese EFL students' preferences for strategies

Category ($n = 227$)	Mean	SD	Reliability
Affective engagement strategies	4.64	0.70	0.79
Social engagement strategies	4.61	0.69	0.84
Cognitive engagement strategies	4.67	0.70	0.82
Metacognitive engagement strategies	4.28	0.71	0.73

Author source

statistics were examined to answer the RQs. Reliability (internal coefficient consistency) was also used. The results show that the reliability of the whole questionnaire and each category was greater than 0.7.

3 Results

3.1 RQ1. What Strategies Do Vietnamese EFL Teachers Employ to Engage Students in Learning in the Online Classroom?

The results showed that Vietnamese EFL teachers used a wide range of techniques to engage students in online learning (see Table 1). They engaged students in socializing activities the most frequently ($M = 4.81$; SD = 0.53), followed by cognitive strategies ($M = 4.70$; SD = 0.59), and metacognitive strategies ($M = 4.41$; SD = 0.79). They engaged students emotionally the least frequently ($M = 3.91$, SD = 0.69). Strategies used for affective engagement were inclined to reducing anxiety rather than increasing students' excitement.

3.2 RQ2. To What Extent Do Vietnamese EFL Teachers' Strategies Engage Students in Learning?

Analysis of data collected from Questionnaire 2 showed the effects of the strategies on students' engagement in online learning (see Table 2). In general, students engaged in emotional activities the most ($M = 4.76$, SD = 0.62), followed by social engagement strategies ($M = 4.74$, SD = 0.62). They engaged in the activities that required cognitive processes ($M = 4.34$, SD = 0.73) and metacognitive processes ($M = 4.35$, SD = 0.67) the least.

Comparisons of results in Tables 1 and 2 showed that students engaged cognitively least often, although their teachers employed strategies for cognitive engagement the second most frequently. Also, although the teachers employed strategies to engage students emotionally the least often, these strategies engaged students more than the other strategy group.

3.3 RQ3. Which Strategies (Involved in the Questionnaire) Do Vietnamese EFL Students Prefer?

Analysis of data collected from Questionnaire 3 showed students' preferences for teachers' engagement strategies (see Table 3). Overall, the students liked the activities that engaged them in cognitive processes ($M = 4.61$, SD = 0.70), generated positive feelings ($M = 4.64$, SD = 70), and required socializing ($M = 4.61$, SD = 0.69) the most. They liked activities that required metacognitive processes the least ($M = 4.28$, SD = 0.71).

4 Discussion and Conclusions

The current study investigated the strategies used by L2 teachers to engage students in online learning, the extent to which these strategies affected their engagement, and their preferences for the teachers' strategies in the context of Vietnam during school closures from the COVID-19 pandemic. Inspired from the perspective that L2 student engagement is a multidimensional construct, including affective, social, cognitive, and metacognitive engagement, this study provided results about strategies employed by L2 teachers, effects of teachers' strategies, and students' preferences. Learner engagement should be a key concern in second language acquisition and learning, enhancing students' academic achievements.

Results showed that Vietnamese EFL teachers used a wide variety of techniques to engage students in online learning. They engaged students in socializing activities and cognitive processes most frequently. Several studies also found that L2 teachers seemed to engage students socially and cognitively more often than in other processes. However, L2 teachers should not disregard students' emotional and metacognitive engagement [2]. It might not be a good idea to separate these dimensions as they intersect; one type of engagement can affect others [3]. Teachers can use corrective feedback [18] and formative assessment strategies [19] to facilitate L2 learning.

Also, strategies used by L2 teachers were found to influence students' affective and cognitive engagement the most. During the cognitive and social processes of interaction in which negotiation of meanings occur [3], affective engagement may take place at the beginning, and students focus more on social and cognitive engagement in which they exchange information, pay attention, and are conscious of knowledge transformation [20]. Emotional engagement can affect L2 production and socializing; they can hesitate to communicate with peers and teachers if they experience negative feelings [3]. Regarding the relationship between interaction, input, and output, social engagement functions to facilitate the learning process [15]. It might be possible for teachers to engage students in L2 learning by using scaffolding strategies in online classrooms [21] and facilitating interaction between peers [6].

The third research question asked about students' preferences for teachers' strategies. They preferred affective and cognitive engagement strategies. Their preferences may have influenced their engagement to a certain extent. It can be seen from Tables 2 and 3 that they preferred teachers' strategies to engage them in emotions the second most, and they also rated their affective engagement the most often. According to Dao et al. [3], "positive emotions can create conditions for learners to attend to other aspects of interaction". Engagement can foster students' concentration on tasks and peer socialization [20].

This study shows two main limitations. First, employing a quantitative approach, this study mainly depended on questionnaires to collect data. The absence of qualitative data shows a lack of in-depth analysis. Further, research can collect data from interviews with teachers and students to delve into their beliefs. Second, data analysis mainly focused on descriptive statistics. Further, research can validate the questionnaires with a larger sample size.

References

1. Dunne, E., & Owen, D. (2013). *The student engagement handbook—Practice in higher education*. Emerald Publishing.
2. Philp, J., & Duchesne, S. (2016). Exploring engagement in tasks in the language classroom. *Annual Review of Applied Linguistics, 36*, 50–72.
3. Dao, P., Nguyen, M. X. N. C., & Iwashita, N. (2019). Teachers' perceptions of learner engagement in L2 classroom task-based interaction. *The Language Learning Journal, 49*(6), 711–724.
4. Hung, B. P., Khoa, B. T., & Hejsalembrahmi, M. (2022). Qualitative research in social sciences: Data collection, data analysis, and report writing. *International Journal of Public Sector Performance Management, 9*(4), 1–20.
5. Park, C. C. (2000). Learning style preferences of Southeast Asian students. *Urban Education, 35*(3), 245–268.
6. Bui, H. P., Anh, D. P. T., & Purohit, P. (2022). Computer-mediated communication and second language education. In R. Sharma & D. Sharma (Eds.), *New trends and applications in Internet of things (IoT) and big data analytics* (pp. 109–122). Springer.
7. Anderman, E. M., & Patrick, H. (2012). Achievement goal theory, conceptualization of ability/intelligence, and classroom climate. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 173–191). Springer.
8. Bygate, M., & Samuda, V. (2009). Creating pressure in task pedagogy: The joint roles of field, purpose, and engagement within the interaction approach. In A. Mackey & C. Polio (Eds.), *Multiple perspectives on interaction* (pp. 90–116). Routledge.
9. Baralt, M., Gurzynski-Weiss, L., & Kim. Y. (2016). Engagement with language: how examining learners' affective and social engagement explains successful learner-generated attention to form. In M. Sato & S. Ballinger (Eds.), *Peer interaction and second language learning. Pedagogical potential and research agenda* (pp. 209–240). John Benjamins.
10. Finn, J. D., & Zimmer, K. S. (2012). Student engagement: What is it? Why does it matter? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 97–132). Springer.
11. Nguyen, T., Cannata, M., & Miller. J. (2018). Understanding student behavioral engagement: Importance of student interaction with peers and teachers. *The Journal of Educational Research, 111*(2), 163–174.

12. Hung, B. P. (2019). Impacts of cooperative learning: A qualitative study with EFL students and teachers in Vietnamese colleges. *Issues in Educational Research, 29*(4), 1223–1240.
13. Hiver, P., Al-Hoorie, A. H., Vitta, J. P., & Wu, J. (2021). Engagement in language learning: A systematic review of 20 years of research methods and definitions. In *Language Teaching Research.*
14. Huong, L. P. H., & Hung, B. P. (2021). Mediation of digital tools in language learning. *LEARN Journal of Language Education and Acquisition Research Network, 14*(2), 452–471.
15. Ellis, R. (2015). *The study of second language acquisition.* Oxford University Press.
16. Haukås, Å. (2018). Metacognition in language learning and teaching: An overview. In Å. Haukås, C. Bjørke, & M. Dypedahl (Eds.), *Metacognition in language learning and teaching.* Routledge.
17. Helme, S., & Clarke, D. (2001). Identifying cognitive engagement in the mathematics classroom. *Mathematics. Education Research Journal, 13*(1), 133–153.
18. Lambert, C., & Zhang, G. (2019). Engagement in the use of English and Chinese as foreign languages: The role of learner-generated content in instructional task design. *The Modern Language Journal, 103*, 391–411.
19. MacIntyre, P. D., Gregersen, T., & Mercer, S. (2016). *Positive psychology in SLA*. Multilingual Matters.
20. Bui, H. P., & Nguyen, T. T. T. (2022). L2 classroom assessment and learning motivation: Insights from secondary school EFL classrooms. In *IRAL: International Review of Applied Linguistics in Language Teaching.*
21. Bui, H. P., & Nguyen, L. T. (2022). Scaffolding language learning in the online classroom. In R. Sharma, & D. Sharma (Eds.), *New trends and applications in Internet of things (IoT) and big data analytics* (pp. 45–60). Springer.

A Performance Comparison of State-of-the-Art Imputation and Classification Strategies on Insurance Fraud Detection

M. Shanthini and Bhuvana Sanmugam

Abstract Annually, around one trillion in premiums are gathered by the insurance market, which engages over a thousand enterprises globally. Insurance fraud is when a person or group presents bogus insurance claims to receive compensation or privileges that they are not obligated to, and it costs the insurance business tens of billions. As a corollary, the insurance industry faces a challenging burden in detecting insurance fraud. Examining and identifying fraudulent elements is a common existing approach to detecting fraud, but it requires a long time and is tedious since it might lead to inaccurate results. The focus of this research is to develop an automated machine learning classification framework with the best imputation technique for detecting fraud claims. As a result, the logistic regression-based iterative imputer coupled with XGBoost classifier achieved the highest accuracy of 90% in this comparison research.

Keywords Fraud detection · Classification framework · Imputation technique · Machine learning · Logistic regression-based iterative imputer · XGBoost classifier · Fraud claims

1 Introduction

Artificial intelligence (AI) and efficient machine learning (ML) are two of the top ten strategic technological innovations that multinational companies are using to reimagine their operations for the digital era. The insurance industry is no exception, with technological advancements allowing for new means of service delivery as well as more data collection opportunities that can lead to better risk identification and mitigation techniques [1].

Effective fraud management [2] is now being adopted by the insurance industry. Technically and logistically, detecting insurance fraud is difficult. Insurance fraud detection has traditionally relied on specialist investigation and review [3]. Payment

M. Shanthini (✉) · B. Sanmugam
PSG Institute of Technology and Applied Research, Coimbatore, India
e-mail: 18cs147@psgitech.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_19

delays resulting from a protracted investigation have a negative influence on the services offered to insurance clients and their satisfaction [4]. Hence, there is a critical need to improve processes that can assist the insurance business in identifying potential suspected frauds, so that other claims may be processed quickly while the detected incidents can be thoroughly investigated [4], which can save dollars for insurance firms [3].

This research seeks to find the optimal imputation approach coupled with a machine learning classification framework to assist insurers in making choices. In this study, the missing values in the dataset were filled using several imputation strategies such as iterative imputer, categorical imputer, and KNN imputer, and the commonly used machine learning classification models such as logistic regression, random forest, decision tree, Gaussian Naïve Bayes, XGBoost, K-nearest neighbors, and AdaBoost were employed to make the final prediction if a claim is a fraud or non-fraud. In addition, the synthetic minority oversampling technique (SMOTE) was used to eliminate the class imbalance in the entire dataset.

The remainder of this paper is organized as follows: Sect. 1 includes the introduction. Related works have been discussed in Sect. 2, and the proposed methodology is discussed in Section 3. Implementation is described in Sect. 4. Section 5 discusses the result of the approaches implemented; Sect. 6 contains the conclusion followed by summary and future scope in Sect. 7. References are added at the end of the paper.

2 Literature Review

According to the survey, there are a variety of methods for predicting fraudulent claims. Each approach has its distinct feature. The goal of this study [5] is to construct a prediction model for identifying motor insurance fraud using a machine learning approach. To solve the problem of an imbalanced dataset, this work employs the Synthetic Minority Over-sampling Technique (SMOTE) and undersampling techniques. With Min–Max, the new dataset has been standardized so that all of the features have ranging between zero and one. The recommended classifiers such as multilayer perceptron (7P), decision tree C4.5, and random forest (RF) were applied to the dataset. To evaluate the model's performance, the confusion matrix, ROC curve, and features such as sensitivity are used. According to this study, Random Forest outperformed other classifiers with 98.5% accuracy. In terms of fraud cases and feature selection, the scope of this study is limited. To improve it, more fraud cases and features can be included, such as past historical claims, the policyholder's marital status, driver rating, and the base policy. By incorporating more ensemble learning classifiers like XGBoost, CatBoost, and AdaBoost, as well as applying optimization approaches, the model can be enhanced.

This research [6] proposes a machine learning technique for detecting fraudulent claims. The suggested solution uses the adaptive synthetic sampling (ADASYN) method and SMOTE to decrease dataset imbalances. support vector machines (SVM)

were then used to classify the claim cases. The variables in the dataset are a combination of integers and nominal variables. The dummy encoding strategy was suggested as a pre-processing step for nominal variables. The ADASYN algorithm dataset outperforms the SMOTE algorithm, according to the findings. The total accuracy of the SVM went from around 93% to over 98%. Instead of employing statistical processes, this model can be improved by implementing various balanced tactics based on a better understanding of the data patterns.

The gradient boosting method (GBM) was used to create a prediction model for auto insurance claims data in this study [7]. In data pre-processing, to deal with missing values, the company used several strategies such as removing them entirely, substituting them with the most seen value, and so on. The dataset was considerably skewed, so the SMOTE algorithm was utilized to fix it, and then it was divided into train and test sets in an 80–20 ratio. A gradient boosting technique with the Bernoulli loss function was the prediction model developed. The model included a total of 100 decision trees, and any decision tree chosen had a maximum depth of 5. Each model's forecast was given a weight of 0.03. With an F1-score of around 98% and an accuracy of 99%, the results were outstanding. Industry professionals used extreme value theory (EVT) to cross-validate this technique.

In the field of anomaly detection, this paper [8] uses nearest neighbor-based methods (distance-based and density-based) and statistics methods (interquartile range) to build a prediction framework to detect the existence of a fraud. The impact of applying feature selection was investigated using genetic algorithms and parameters from WEKA tools. CsfSubsetEval was the attribute evaluator in the feature selection process, and GeneticSearch was the search method. The accuracy value increased from 94.4 to 99.9% when the distance-based approach was combined with the genetic algorithm, the density-based method-enhanced to 82.0 from 35.2%, and the interquartile range method improved to 98.0 from 92.1%. The ideal sample for fraud detection, according to the conclusion of this paper's experiments had gone through a feature selection process utilizing a distance-based technique.

Unlike earlier approaches, the dataset was encoded using one-hot encoding and label encoding techniques. Then, SMOTE was used to balance the biased dataset, and the dataset was segmented into training and testing parts using the 70/30 rule. The most important aspect of this research is that it compares experiments using different modeling methods to detect fraud claims coupled with different imputation strategies to treat missing values. Finally, the imputation strategy that works best with the classification technique to forecast fraud claims in the dataset was discovered in this study.

3 Imputation and Modeling Methods Proposed

The major purpose of this study is to use multiple imputation procedures to impute missing values in the dataset and then apply various modeling approaches to the

new imputed dataset to determine the optimal one for spotting bogus claims. The implementation of the proposed approach is indicated in Fig. 1.

The insurance fraud dataset is loaded initially. Various data visualization methods were used to identify missing values, outliers, and class imbalances in the dataset. The numerical data is encoded before the imputation methods are applied. Table 1 shows the various imputation procedures used to clean the data.

After the missing values were filled in, the dataset was then balanced using SMOTE and split into training and testing samples. Different classification modeling approaches as shown in Table 2 were used on the training sample to adapt the algorithms to acquire insights, and then the prediction step was performed on the testing sample.

The metrics [2] used to assess each model's performance are as follows:

- Accuracy-a metric for determining how far a classifier is successful.
- Precision-defined as the percentage of relevant retrieved occurrences.
- Recall-defined as the fraction of relevant items retrieved.

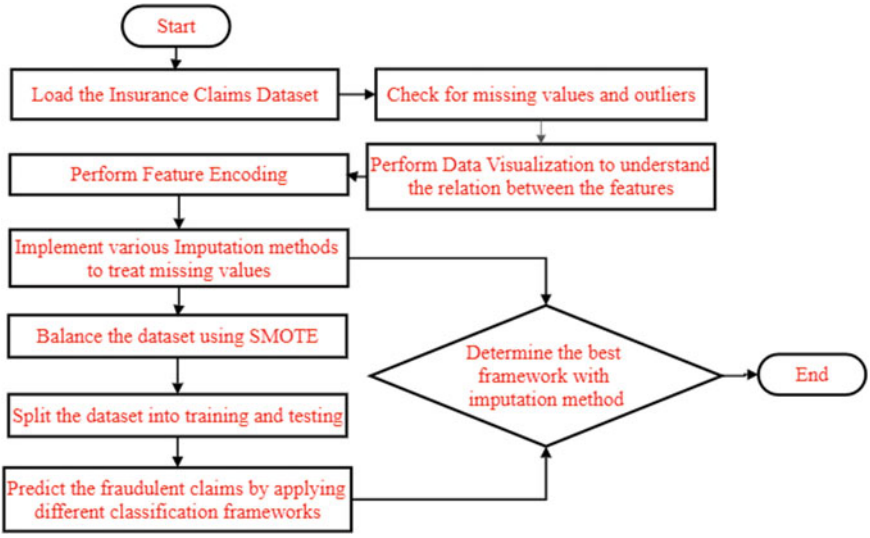


Fig. 1 Implementation flow diagram of the proposed approach

Table 1 Imputation strategies implemented

Imputer	Estimator used in imputer
KNN imputation	k-Nearest neighbors
Iterative imputation (MICE)	Logistic regression
	Random forest regressor
	Decision tree regressor
Categorical imputation	Frequently occurred

Table 2 Different classification models implemented

Classification models	Description
Random forest classifier	In order to increase forecast accuracy, this method uses the averaging technique [9]. In this study, the parameters are tuned using the Grid Search algorithm
Decision tree classifier	The outcome feature is determined using the model's decision rules acquired from the data attributes [10]. The maximum depth of the tree was taken as 10
XGBoost classifier	Different models are grouped to fulfill the same task in this technique [11]
Gaussian naive bayes classifier	It's a collection of supervised learning methods based on Bayes' theorem and the "naive" assumption of conditional independence among each set of features given the class variable's value [12]
AdaBoost classifier	It is a meta-estimator that keeps fitting classifier copies to the dataset by altering the poorly classified weights [13]. It is implemented with base estimators such as decision trees and random forests
KNN classifier	By calculating the distance between the points, KNN captures the concept of similarity and predicts where fresh data will appear [14]. The n neighbors were taken as 5
Logistic regression classifier	Its used to predict the likelihood of a specific class [15]. As the output variable has two classifications, 0 for non-fraud and 1 for fraud claims, a binary classification logistic regression classifier is utilized

- F1 score-the harmonic mean of precision and recall.

4 Implementation

The study's insurance claim fraud detection dataset taken from Kaggle was derived from a real-world auto insurance organization which is made up of 39 data characteristics and 1000 rows. As shown in Fig. 2, non-fraud cases outnumber fraud cases by more than three to one, i.e., there were 753 non-fraud and 247 fraud claims.

Insured age, policy state, insured education level, authorities contacted, incident severity, and other features are the input, and the output is fraud reported having classes 0 and 1 that represent the legitimate and the fraud cases, respectively. The variables in the dataset are a blend of 17 numerical types and 22 categorical types. The missing values were present in categorical variables such as police report available, collision type, and property damage.

As demonstrated in Figs. 3 and 4, respectively, data visualization using bar plots and pie charts of several parameters such as fraud reported by incident type and fraud reported by incident severity was done. These graphs show the relationship between the features and aid in outlier detection in the dataset. Figure 3 highlights

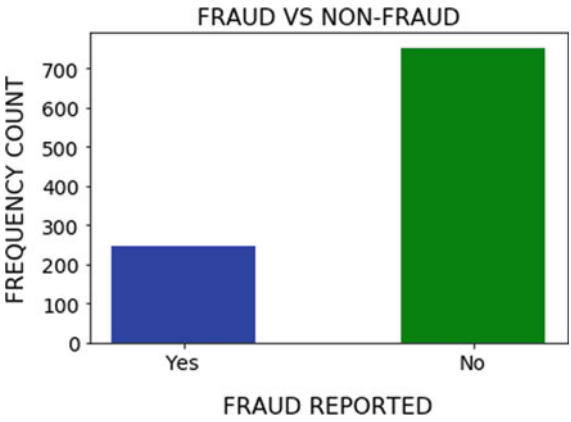


Fig. 2 Fraud versus non-fraud claims count

that single vehicle collisions and multi-vehicle collisions had more reported cases of fraud than the other kinds. Figure 4 depicts that the severity of the occurrence with major damage had more fraud recorded.

Then, label encoding and one-hot encoding techniques were used for data preprocessing. Using the various imputation methods indicated in Table 1, the missing values in the encoded dataset were filled. Then, the SMOTE algorithm which is a sort of data augmentation for the minority class was used to balance the new imputed dataset [16]. The balanced dataset was then divided into training and testing groups with a 70:30 split, respectively. The data was trained and tested using classifiers described in Table 2. The random forest classifier's hyperparameters were tuned using the grid search technique. The classification report which included measures such as the f1-score, accuracy, precision, and recall was used to assess each model's performance.

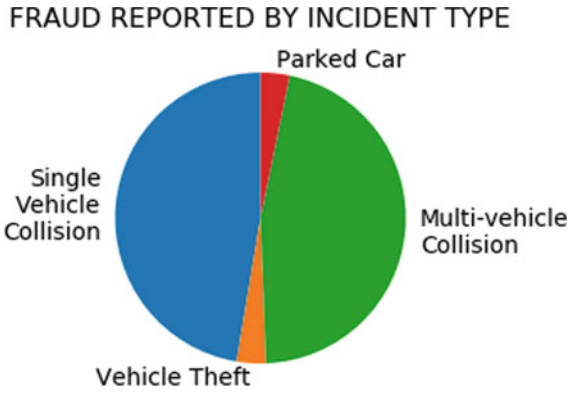


Fig. 3 Pie chart showing fraud reported by incident type

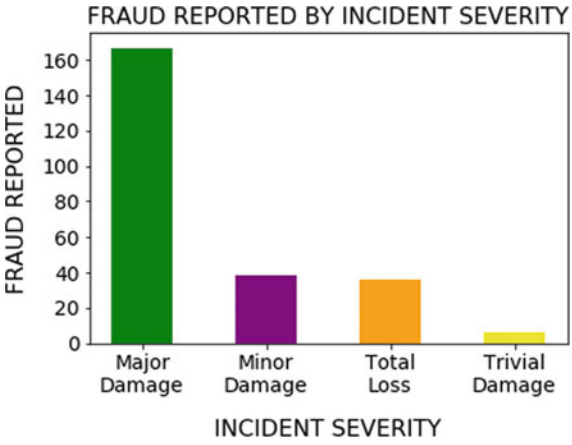


Fig. 4 Bar chart showing fraud reported by incident severity

5 Experimental Results

Table 3 shows a comparison among several imputation procedures coupled with classifier model prediction based on accuracy.

For random forest regressor-based iterative imputer and logistic regression-based iterative imputer, the XGBoost classifier has the maximum accuracy of 90%.

Table 4 and Fig. 5, respectively, demonstrate the performance metrics and the precision-recall curve for the XGBoost classifier with random forest regressor-based iterative imputer and the XGBoost classifier with logistic regression-based iterative imputer.

However, as seen in Fig. 6, the logistic regression-based iterative imputation takes less time to fill in the missing values than the random forest regressor-based imputation, making logistic regression-based iterative imputer coupled with XGBoost classifier, the best model for predicting insurance fraud claims.

6 Conclusion

Many factors must be considered when determining whether or not an automobile insurance claim is fraudulent. There are numerous fraud recognition indexes [3]. When there are biased train and test sets, machine learning classification algorithms perform poorly. To improve the performance of the algorithms, it is critical to balance the datasets [6].

The results reveal that datasets imputed with random forest regressor-based iterative imputer and logistic regression-based iterative imputer, integrated with XGBoost classifier modeling approach to detect bogus claims gave better results yielding the highest accuracy of 90% compared to other imputation-based modeling strategies coupled with classification methods. It could be discovered that the

Table 3 Imputation methods with classification models Based on Accuracy (in %)

Models	KNN imputer	Categorical imputer	Iterative imputer		
			Logistic regression	Decision tree regressor	Random forest regressor
AdaBoost with DT estimator	87	87	88	87	89
AdaBoost with RF estimator	87	86	89	89	89
Random forest classifier	85	87	87	86	86
Decision tree classifier	86	86	87	87	86
XGBoost classifier	89	88	90	89	90
GNB classifier	55	57	57	56	56
KNN classifier	66	65	66	68	67
Logistic regression classifier	60	58	60	58	54

Table 4 XGBoost classifier with random forest regressor-based iterative imputer and XGBoost classifier with logistic regression-based iterative imputer—metrics

	Random forest regressor-based iterative imputer			Logistic regression-based iterative imputer		
	Precision	Recall	F1-Score	Precision	Recall	F1-Score
0	0.89	0.91	0.90	0.89	0.90	0.90
1	0.91	0.89	0.90	0.90	0.89	0.90
Accuracy			0.90			0.90

logistic regression-based iterative imputer outperforms the random forest regressor-based iterative imputer in terms of imputation time taken. Therefore, the Logistic Regression-based Iterative Imputer integrated with the XGBoost classification algorithm produced the best outcome in detecting fraudulent claims, with overall accuracy, precision, recall, and F1 score of 90%.

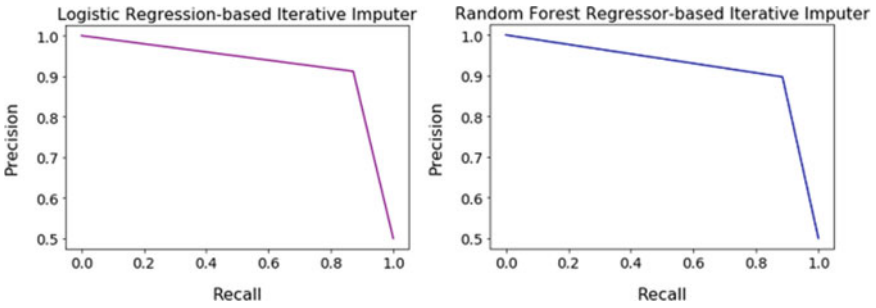


Fig. 5 XGBoost classifier with random forest regressor-based iterative imputer and XGBoost classifier with logistic regression-based iterative imputer-precision-recall curve

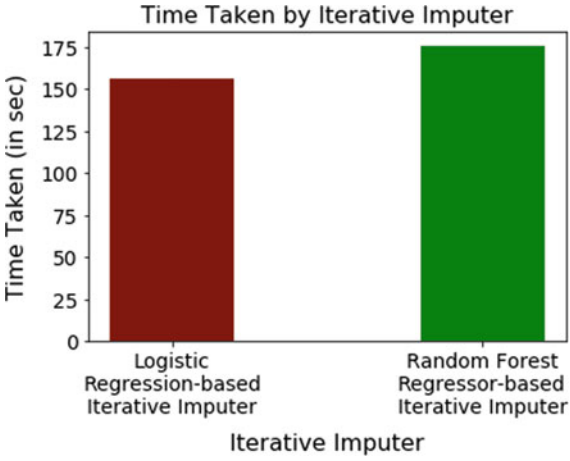


Fig. 6 Time taken by logistic regression-based and random forest regressor-based Iterative Imputer

7 Summary and Future Scope

Finding the appropriate Iterative Imputer combined with the classification model is the main goal of this research work. The dataset used included 1000 samples and 39 features comprising a mix of categorical and numerical data types. It also had a significant skew. The relationship between the features was explored using a variety of data visualization techniques, and the missing values were located. After data encoding, missing values were imputed using several imputers, including KNN, categorical, and iterative imputers. The SMOTE technique was then used to balance the imputed dataset. For the purpose of classifying the claims as fraudulent or not, various classification models, including random forest (RF), logistic regression, AdaBoost with decision tree-based estimator, AdaBoost with the random forest-based estimator, XGBoost, decision tree (DT), KNN, and Gaussian Naive Bayes, were used to an unbiased dataset. With an overall accuracy, precision, recall, and F1 score of 90%, the

logistic regression-based iterative imputer combined with the XGBoost classification algorithm achieved the best performance in identifying fraudulent claims.

In future work, to balance the dataset and test the performance, additional balancing approaches, such as undersampling and oversampling, can be applied. The performance of the classification strategy could be further enhanced by ensemble modeling techniques like stacking classifiers and voting classifiers. Future claim processing and documentation activities could be digitalized by integrating the top-performing classification model with an iterative imputer and a web application.

References

1. Machine Learning in Insurance. https://www.accenture.com/_acnmedia/pdf-84/accenture-machine-leaning-insurance.pdf
2. Roy, R., & Thomas George, K. (2017). Detecting insurance claims fraud using machine learning techniques. In *International Conference on circuits Power and Computing Technologies [ICCPCT]*.
3. Yan, C., Li, Y., Liu, W., Li, M., Chen, J., & Wang, L. (2017). An 5 colony-based kernel ridge regression for automobile insurance fraud identification. *Neurocomputing*. https://doi.org/10.1016/j.neucom.2017.12.072
4. Harjai, S., Kumar Khatri, S., & Singh, G. (2019). Detecting fraudulent insurance claims using random forests and synthetic minority oversampling technique. In *4th International Conference on Information Systems and Computer Networks (ISCON)*, pp. 123–128.
5. Nur Prasasti, M., Dhini, A., & Laoh, E. (2020). Automobile insurance fraud detection using supervised classifiers. In *International Workshop on Big Data and Information Security (IWBIS)*, pp. 47–52.
6. Muranda, C., Ali, A., & Shongwe, T. (2020). Detecting fraudulent motor insurance claims using support vector machines with adaptive synthetic sampling method. In *61st International Scientific Conference on Information Technology and Management Science of Riga Technical University (ITMS)*, pp. 1–5.
7. Gupta, R. Y., Sai Mudigonda, S., Kandala, P. K., & Baruah, P. K. (2019). Implementation of a predictive model for fraud detection in motor insurance using gradient boosting method and validation with actuarial models. In *IEEE International Conference on Clean Energy and Energy Efficient Electronics Circuit for Sustainable Development (INCCES)*, pp. 1–6.
8. Badriyah, T., Rahmaniah, L., & Syarif, I. (2018). Nearest neighbour and statistics method based for detecting fraud in auto insurance. In *International Conference on Applied Engineering (ICAE)*, pp. 1–5.
9. Random Forest Classifier Page. https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestClassifier.html
10. Decision Tree Classifier Page. https://scikit-learn.org/stable/modules/tree.html
11. XGBoost Classifier. https://www.section.io/engineering-education/machine-learning-with-xgboost-and-scikit-learn/
12. Naïve Bayes Classifier Page. https://scikit-learn.org/stable/modules/naive_bayes.html
13. AdaBoost Classifier Page. https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.AdaBoostClassifier.html#:~:text=An%20AdaBoost%20%5B1%5D%20classifier%20is,focus%20more%20on%20difficult%20cases
14. KNN Classifier. https://towardsdatascience.com/machine-learning-basics-with-the-k-nearest-neighbors-algorithm-6a6e71d01761

15. Logistic Regression. https://www.analyticsvidhya.com/blog/2021/07/an-introduction-to-logistic-regression/
16. Synthetic Minority Oversampling Technique. https://machinelearningmastery.com/smote-oversampling-for-imbalanced-classification/

Autonomous Health Care Robot

K. Umapathy, S. Omkumar, D. Muthukumaran, S. Chandramohan, and M. Sivakumar

Abstract The spread of corona virus has been intensive across the globe for the past two years. Medical services are one among the most vital things which can save the people with proper treatment and care. But, the doctors and hospital staff can also have a chance of getting affected with this virus during the treatment. So, robotic implementation can be a big boon in patient monitoring and healthcare services so that human interaction can be reduced with the virus affected patients to a large extent. This approach is not only useful in patient monitoring, but also in treating the patients and helping the staff over there in the hospitals with the robots started making their own mark. The proposed robot includes a Raspberry Pi controller along with appropriate sensors and motor drivers will assist the hospital staff and the patients for updating the patient details, dispatching the medicines in time, and informing the hospital authorities for any abnormal conditions of the patients.

Keywords Patient monitoring · Artificial intelligence · Mechatronics · Machine learning

1 Introduction

The robotic automation along with human intelligence and expertise in medical field can increase the efficiency and ability of the services to a large extent. In recent days, the robots were developed in large number for functioning in hospitals like helping the patients to take medication by remainders, updating the details of their

K. Umapathy (✉) · S. Omkumar · D. Muthukumaran · S. Chandramohan
SCSVMV Deemed University, Kanchipuram, India
e-mail: umapathykannan@gmail.com

S. Chandramohan
e-mail: chandramohan@kanchiuniv.ac.in

M. Sivakumar
Mohamed Sathak AJ College of Engineering, Chennai, India
e-mail: ece.sivakumar@msajce-edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_20

health parameters to the hospital authorities, and also the instructions of the doctors to the patients in the wards. Moreover with the help of advanced technology, many research and development organizations had built advanced robots to sense the tumors and other health issues just by scanning and helping the doctors in surgeries. This development of robotic involvement in health treatment leads to a great change which can improve the success rate because of their clear vision and perfect placement. In these type of robots, there are many things to be involved, constraints to be considered, and technologies to be implemented and integrated as a single system.

The embedded systems integrated with mechatronics will help the robot in its motion and artificial intelligence to learn things and make decisions on its own based on the situations, and internet of things to establish the wireless data transfer from the robot to detect objects and other things. Here, the robot was developed for assisting the hospital staff and the patients in making its own prominent role by updating the patient details, dispatching the medicines at prescribed time, and informing the hospital authorities of any abnormal conditions of the patients. Various health services provide medicines across the globe. But, increasing concentration of medicines will amount to risk. This has to be avoided in the care of primary. To create a correlation between risks and solutions, robots are employed to act in the hospital environment. By this robotic automation, dispensing of medicines is made simple and patient waiting period is reduced substantially.

2 Literature Survey

Wissam presented about intelligent medicine dispenser system to make it easier for elderly patients to take their medicines on time [1]. Automatic pill reminder provides an alerting mechanism using buzzer and display for the concerned person to take his medications on time without help of others [2]. Health complications like prolonged disease and late recovery can be resolved by intelligent medicine dispenser, which will remind patients to take their medicines at the right time [3]. A medication reminder device includes modules for continuous medical tablet reminders and pill module [4]. D. Ravi in his paper [5] enunciates the deep learning application in health industry. An embedded application is employed for the detection of intruder in a particular area using a similar arrangement [6]. Pang in his article explains the industry 4.0 application in health care industry [7]. A robot-based auto guided vehicle supplies medicines to the patients based upon the instructions given [8]. Rios in his article [9] highlights the importance of using an intelligent vehicle for home and industrial purposes including medical services. This system [10, 11] collects information about the environment using a robot and prevents the colliding of objects automatically. Muthukumaran points the formation of health cloud by which a lot of medical services can be provided to the patients on time [12]. A point alert system and an android-based health monitor also operate in the similar fashion [13, 14]. Ryan enunciates the survey of robots employed for various medical services [15].

3 Materials and Methods

The proposed system is to dispense the medicines in the patient wards automatically by using the data entered in the database. It checks the details regarding the time to deliver the medicine, type of medicines to be delivered, and also information regarding the wards to be visited. The data regarding bed vacancy is automatically updated in the database. Smart bed system is also implemented for patient monitoring purpose. Now robot is reset. With information available in database, it has to load medicines in the respective pill boxes and wait for the time to deliver the medicines. Once the times arrive to deliver the medicines, it will select a track towards the patient's place by the following method of line follower, where path is represented in black line to detect the obstacles on its way. Robot uses IR sensor which sends the signal and receive back the signal only if black line is detected. In this way robot moves in appropriate track to reach patient room. And also, robot uses ultrasonic sensor for obstacle detection, by sending and receiving the signal back only if obstacle is detected on this way.

If any obstacle is detected ultrasonic sensor send the signal to robot, which will stop its moment until obstacle is out of its way. It starts moving in the path and reaches the patient room. After reaching the patients room, it will look after the patient, and once patient is detected, it will capture the patient. Now, it will compare the patients face with the data present in the database. Earlier it is required to add the data regarding the patient in database which includes patient photo too. If data matches, the respective pill box opens. Once the patient received the pills, the pill box closes, and by following the method, it reaches every ward and dispenses the medicine as per requirement and following the same path system returns to its home position. Smart bed system is also implemented for patient monitoring purpose. The parameters like temperature and heartbeat of the patient will be continuously monitored and automatically updated in the database, so that the doctors have an idea about the variations in health conditions of the patient which will help to predict the abnormal conditions of the victims. Figures 1 and 2 illustrate the schematic and flowchart of the robot system.

Figure 3 shows the detection of track made by the robot. The robot system includes Raspberry Pi 3, real-time clock, two sensors—one for sensing ultrasonic and another for infrared and a driver for motor. The module of real time clock is employed to decide the time arrival of robot for providing medicines.

4 Results and Discussions

The following are the various steps involved in the system design-

Step 1: System to be enabled.

Step 2: Time needed if system needs to dispense the medicine.

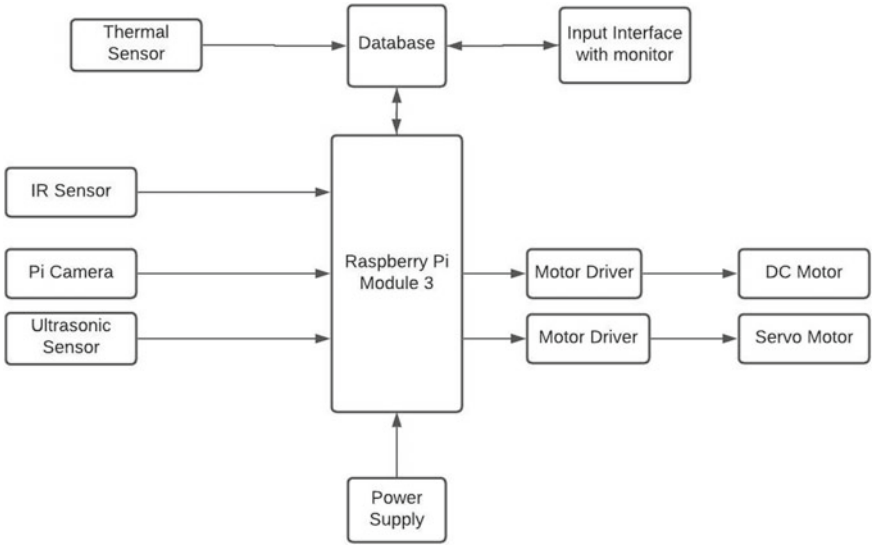


Fig. 1 Health care robot system

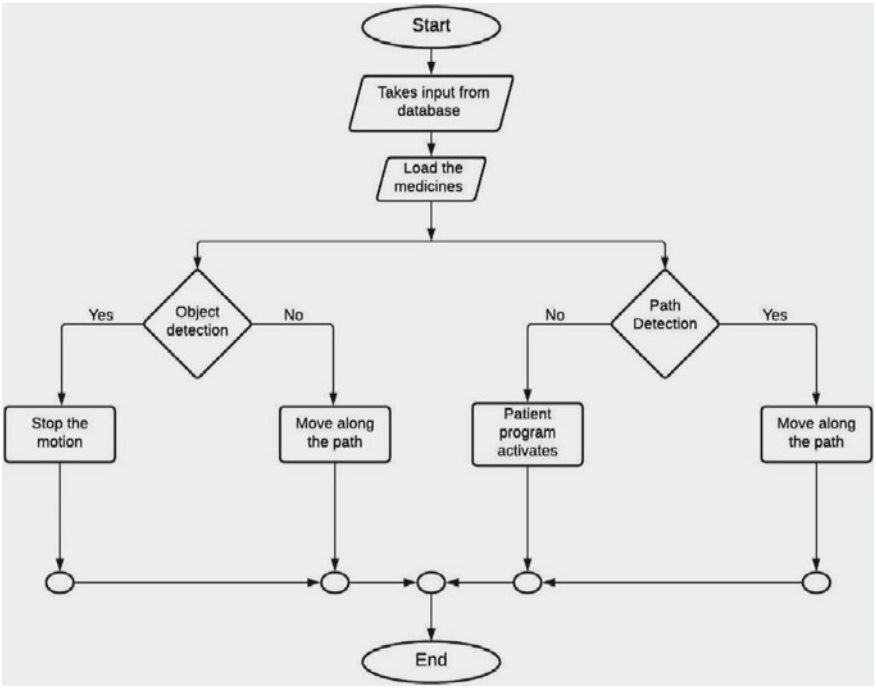


Fig. 2 Flowchart of system

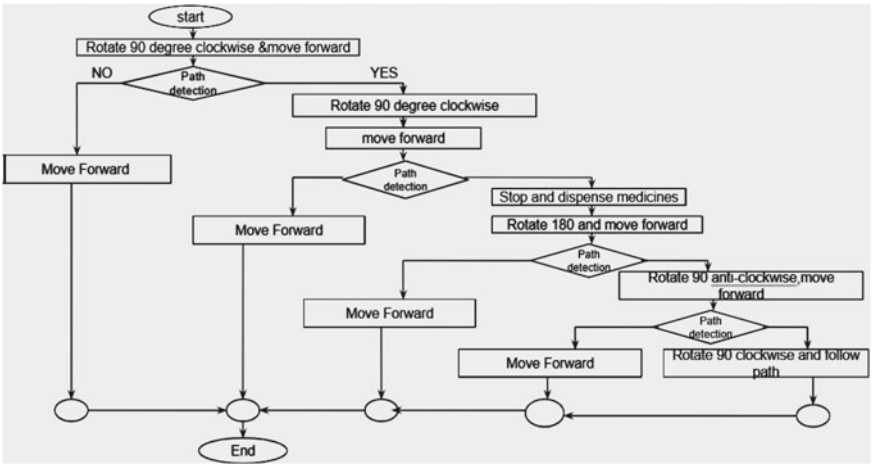


Fig. 3 Robot path detection

Step 3: Robot moves from reset position towards the place where patient is available after specified interval of time.

Step 4: The medicines are provided, after patient is recognized. Patient face is recognized with the help of tensor flow. Initially, all the patients have to be captured, and save the data along with patient name. So with the help of tensor flow it will recognize the patient and display along with the name as shown below. Now this data is compared with the data in database. When captured data matches with that of data in database it will dispense the medicine as per requirement. Once tablet is received by patient, pill box is closed and robot moves to its reset position (Figs. 4 and 5).

5 Conclusion

This paper proposed a real-time health care system by which on-time medicines can be issued to the patients without any time delay for fast recovery. Moreover, it is accurate in dispensing medicines to the patient compared to the human consultant, and it has a log system to keep track of all the medicine intake of the patient for future references. Furthermore, this robust system can send alerts to the in-charge doctor for any problem while intake of medicines by the patients. This way the system is more accurate toward the health care of the patient. Our robust model includes features such as economical, accurate sensing operation, reliable database, and a controller to update data in the cloud database. With the help of a cloud database any changes in the medicines or addition of new patient details can be easily be introduced which leads to a quick recovery. As a means of enhancement in the system, medicines can be given to elderly patients at homes periodically without the need to depend on other people.

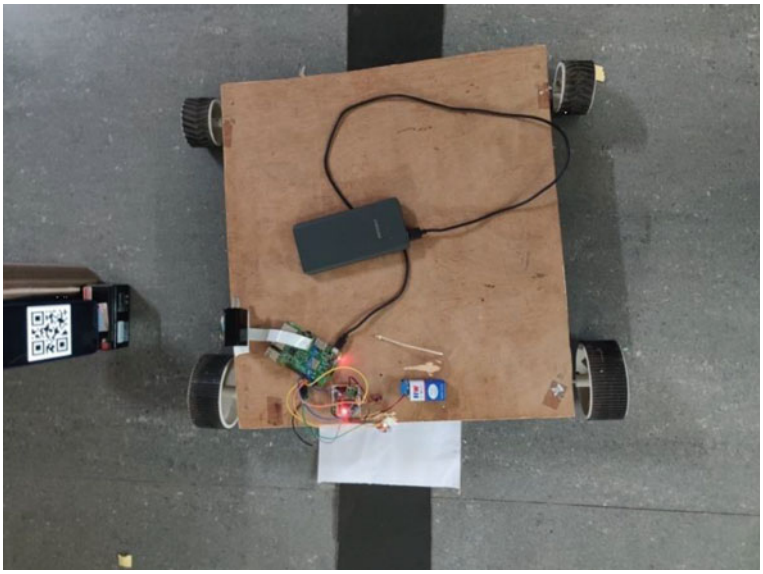


Fig. 4 Working prototype

Fig. 5 Processing and output display

```
Path detected, Moving Forward
Path detected, Moving Forward
Path detected, Moving Forward
Sign detected, Camera activated
Bed number 1 is detected
Patient name is S.Divya
21 years, suffering from Jaundice
Iron_xt medicine was dispensed
Path detected, Moving Forward
```

References

1. Antoun, W., Abdo, A., AlYaman, S., Kassem, A., Hamad, M., & El-Moucary, C. (2018). Smart medicine dispenser (SMD). In: *2018 IEEE 4th Middle East Conference on Biomedical Engineering (MECBME)*, March 2018, Electronic ISSN: 2165-4255. https://doi.org/10.1109/MECBME.2018.8402399
2. Jabeena, R. R., Sahu, A. K., & Sardar Basha, N. (2017). Automatic pill reminder for easy supervision. In *Proceedings of the International Conference on Intelligent Sustainable Systems (ICISS 2017)*, IEEE Xplore Compliant - Part Number: CFP17M19-ART, ISBN: 978-1-5386-1959-9.
3. Umapathy, K., Kishore, G., & Kethan Kumar, G. (2022). Health monitor using edge and android application. *International Journal of Research Publication and Reviews*, *3*(6), 4126–4128. ISSN: 2582-7421.
4. Bai, Y.-W., & Kuo, T.-H. (2016). Medication adherence by using a hybrid automatic reminder machine. In *2016 IEEE International Conference on Consumer Electronics (ICCE)*, March 2016, Electronic ISSN: 2158-4001. https://doi.org/10.1109/ICCE.2016.7430735

5. Chawla, S. (2016). The autonomous pill dispenser: Mechanizing the delivery of tablet medication. In: *2016 IEEE 7th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON).* https://doi.org/10.1109/UEMCON.2016.7777886
6. Ravi, D., et al. (2017). Deep learning for health informatics. *IEEE Journal of Biomedical and Health format, 21*(1), 4–21.
7. Umapathy, K., Sridevi, T., Navyasri, M., & Anuragh, R. (2020). Real time intruder surveillance system. *International Journal of Scientific & Technology Research (IJSTR)*, *9*(3), 5833–5837. ISSN: 2277-8616.
8. Pang, Z., Yang, G., Khedri, R., & Zhaang, Y-T. (2018). Introduction to the special section: Convergence of automation technology, biomedical engineering and health informatics toward the healthcare 4.0. *IEEE Reviews in Biomedical Engineering.*
9. Antony, M., Parameswaran, M., Mathew, N., Kumar, S., Jineeth Joseph, V. S., & Jacob, C. M. (2020). Design and Implementation of automatic guided vehicle for hospital application. In *IEEE 5th International Conference on Communication and Electronics Systems (ICCES)* (pp. 1031–1036). https://doi.org/10.1109/ICCES48766.2020.9137867
10. Rios, F., Flores, R. A., & Soloiu, V. (2018). Design of an intelligent vehicle for industrial office and home environments applications. *SoutheastCon, 2018*, 1–3.
11. Jiménez, F., & Naranjo, J. E. (2015). Autonomous collision avoidance system based on accurate knowledge of the vehicle surroundings. *IET Intelligent Transport Systems, 9*(1), 105–117.
12. Cheng, X., & Tao, R. (2011). Design of automatic guided vehicles and dunking robot system. In *2011 Third International Conference on Intelligent Human-Machine Systems and Cybernetics* (pp. 3–6).
13. Muthukumaran, D., Umapathy, K., & Omkumar, S. (2021). *Health cloud—Health care as a service. Lecture Notes in Networks and Systems*, ISSN: 2367-3370, Springer Nature, *Proceedings of 4th ICNGIOT 2021 on Next Generation of Internet of Things* (pp. 489–497), ISBN: 978-981-16-0666-3.
14. Mangayarkarasi, T, Umapathy, K., Sivagami, & A., Subitha, D. (1964). An IoT based safe assembly point alert system. *Journal of Physics: Conference Series*, *1964*(7). https://doi.org/10.1088/1742-6596/1964/7/072013
15. Beasley, R. A. (2012). Medical robots: Current systems and research directions. *Hindawi Publishing Corporation, Journal of Robotics, 2012*, 14 pages. Article ID 401613 doi:https://doi.org/10.1155/2012/401613

ThingSpeak-Based Garbage Monitoring and Collecting System

K. Umapathy, S. Omkumar, D. Muthukumaran, S. Chandramohan, and M. Sivakumar

Abstract Managing waste is one among the bothering factors in the present situation. It is our bound responsibility to look for an organized mechanism to sort out this problem. Hence, there is a need for smart systems with appropriate framework in tackling everyday garbage which includes major chunk of waste material of cities. This contributes to various environmental issues like global warming, environmental pollution, and health complications. This paper explains the prototype of a smart dust bin, where opening of dustbin occurs in the presence of human being. The occupancy of the dustbin is provided as an alert to mobile of the user. The smart dustbin is designed to give the exact percentage of occupancy of waste in the form of LCD display by employing a software application named as ThingSpeak.

Keywords Arduino · GSM · Dustbin · Ultrasonic Sensor · ThingSpeak

1 Introduction

IOT connects the objects relevant to a network. The technology is to transfer the flow of data within the network objects. IOT connect and activate the devices like ultrasonic sensor, rotating devices, controllers, etc. Generally, trash bin is employed for managing and storing of wastes. The tendency of human is to throw the waste in and around the dustbin if filled completely. To prevent this sort of situation, IOT technique is employed to keep the dustbin identify the level of occupancy with smart notification. This helps to keep the environment very clean. A regular dustbin is

K. Umapathy (✉) · S. Omkumar · D. Muthukumaran · S. Chandramohan
SCSVMV Deemed University, Kanchipuram, India
e-mail: umapathykannan@gmail.com

S. Chandramohan
e-mail: chandramohan@kanchiuniv.ac.in

M. Sivakumar
AJ College of Engineering, Chennai, India
e-mail: ece.sivakumar@msajce-edu.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_21

meant for putting the waste. A smart dustbin includes certain electronic components to indicate the waste level. It is very much productive in comparison with a normal dustbin. The distance and the occupancy of the dustbin can be measured using an ultrasonic sensor and ThingSpeak application. This smart dustbin provides a message whenever bin is filled. The important requirement is that there must be a strong carrier signal for sending the messages promptly.

2 Literature Survey

Wissam presented about intelligent medicine dispenser system to make it easier for elderly patients to take their medicines on time [1]. Automatic pill reminder provides an alerting mechanism using buzzer and display for the concerned person to take his medications on time without the help of others [2]. Health complications like prolonged disease and late recovery can be resolved by intelligent medicine dispenser, which will remind patients to take medicines at the right time [3]. A medication reminder device includes modules for continuous medical tablet reminders and pill module [4]. D. Ravi in his paper [5] enunciates the deep learning application in health industry. An embedded application is employed for the detection of intruder in a particular area using a similar arrangement [6]. Pang in his article explains the industry 4.0 application in health care industry [7]. A robot-based auto guided vehicle supplies medicines to the patients based upon the instructions given [8]. Rios in his article [9] highlights the importance of using an intelligent vehicle for home and industrial purposes including medical services. This system [10, 11] collects information about the environment using a robot and prevents the colliding of objects automatically. Muthukumaran points the formation of health cloud by which a lot of medical services can be provided to the patients on time [12]. A point alert system and an android-based health monitor also operate in the similar fashion [13, 14]. Ryan enunciates the survey of robots employed for various medical services [15].

3 Materials and Methods

This paper suggests a system for garbage monitoring based on the concept of IOT thereby creating a smart bin. There are certain demerits with the existing systems. The important one is unhygienic conditioning of air due to improper disposal of waste. The system proposed will eliminate all the above demerits and provide an optimum solution without affecting the surrounding. Moreover the smart bin employs a web page to indicate the completion of dustbin in an effective manner. The percentage of occupancy is indicated by sending a message to the user about the status of the dustbin. The status is not having any specific margin percentage of occupancy, which was an added advantage to the existing method. Figure 1 shows the block diagram of the smart garbage system, and Fig. 2 shows the flowchart of the system.

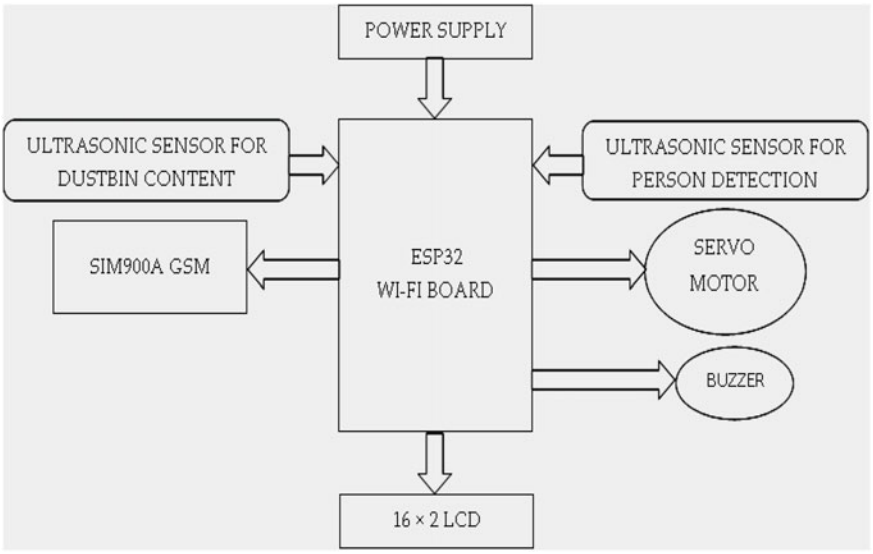


Fig. 1 Smart garbage system

Fig. 2 Flowchart of system

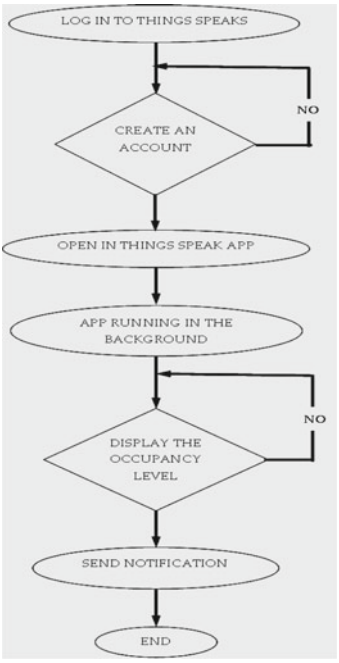


Fig. 3 Hardware components used

The components both hardware and software used in the system are as follows:

- ESP32 Development Board
- 16×2 LCD
- HCSR04 Ultrasonic sensor
- SIM900A GSM Modem
- Buzzer
- SG90 Servo motor
- 12 V Power supply
- Arduino DE Software
- THINGSPEAK IOT Platform

Figure 3 shows the various hardware components used in the system, and Fig. 4 illustrates the schematic layout of the garbage system.

These smart bins are equipped with appropriate sensors to monitor the weight and waste level thereby providing separate ID's for unique identification. The aim is reduction of human involvement with improvement in the vision of the smart city. The important advantage of this system is appropriate reduction in pollution of air. The completion of dustbin will often lead to an unacceptable scene leading to movement of animals. In addition, the status of the bin can be intimated to the office of contractor for immediate cleaning of the place. Since IOT is connected, live information about the bins can be provided then and there. Hence, a good management of waste system is vital for preventing the spread of contagious diseases in the society (Fig. 5).

4 Results and Discussions

The main objective of this system is to execute the garbage monitoring and collection operation smoothly in order to make the system more efficient. Figures 6 and 7 explain the actual performance level of the smart dustbin by using ThingSpeak where the level of the garbage dustbin with date is monitored on a regular basis and notification

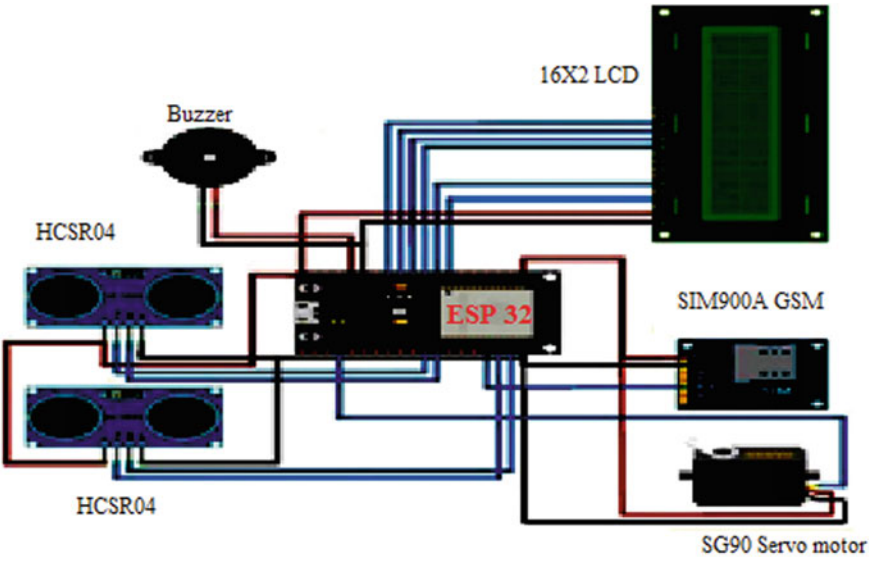


Fig. 4 Layout of the system

Fig. 5 Development of the system

is provided to the cleaning vehicle directly. Figure 8 shows the performance analysis with ThingSpeak coding.

5 Conclusion

The system proposed in this paper will guide the society for easy management of wastes thereby reducing the human efforts and make the surroundings neat and tide

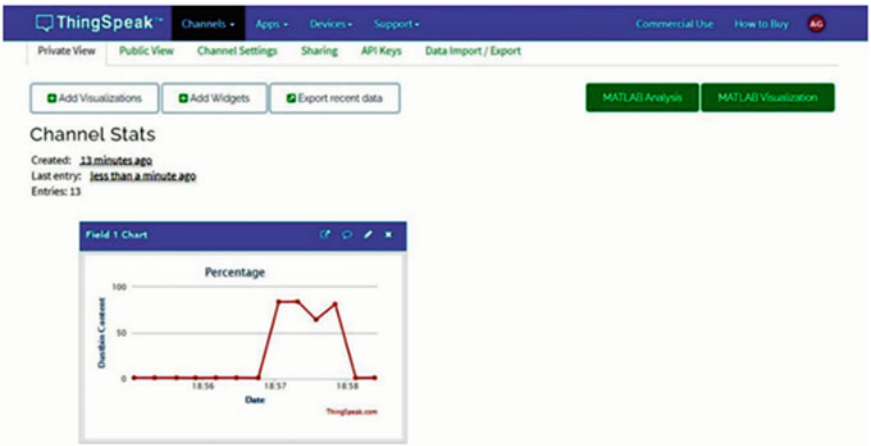
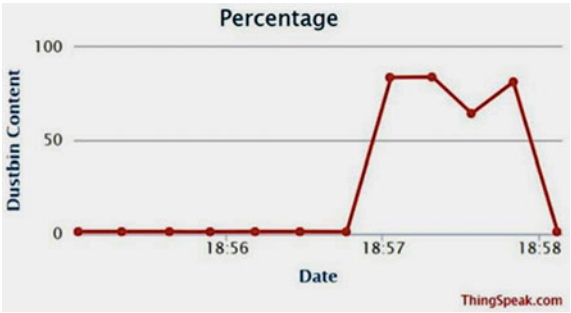


Fig. 6 ThingSpeak application

Fig. 7 Update of dustbin content with date



for a better living environment. The system makes the implementation of Swachh Bharat Mission easier. The system takes care of cleaning it properly at regular time intervals, when the level of occupancy becomes maximum inside the bin. If cleaning is not done in time, then appropriate messages will be given to concerned person for immediate action. Thus, the system guides the people to keep the environment clean and simplifies the management of waste. As an extension work, the bins can be equipped with a GPS where location, position and emptying of bins become very easier.

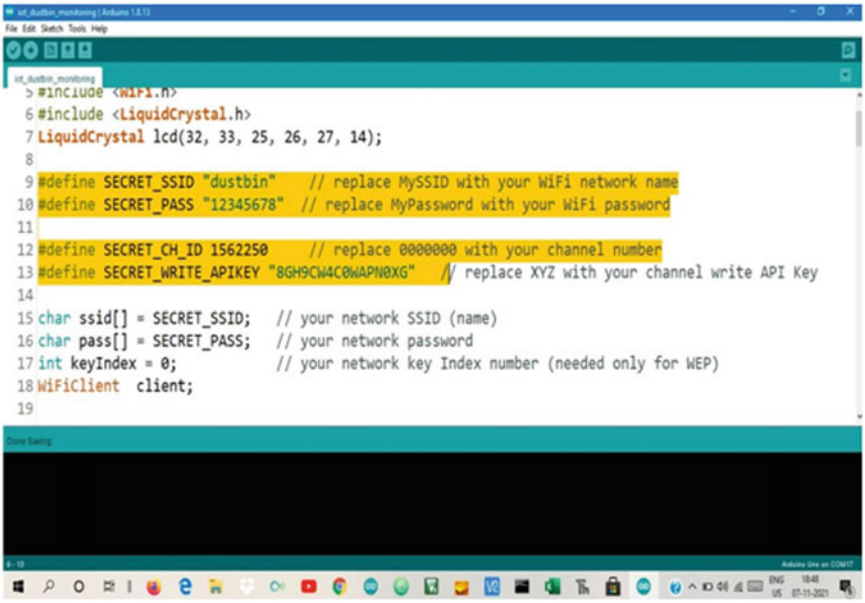


Fig. 8 Performance analysis with ThinkSpeak coding

References

1. Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste Management, 33*, 220–232.
2. Medvedev, A., Fedchenkov, P., Zaslavsky, A., Anagnostopoulos, T., & Khoruzhnikov, S. (2015). Waste management as an IoT-enabled service in smart cities. In *Conference on IOT and Smart Spaces, 2015. Lecture Notes in Computer Science. International Conference on Next Generation Wired/Wireless Networking* (pp. 104–115).
3. Dubey, S., et al. (2020). Household waste management system using IOT and machine learning. *Procedia Computer Science, 167*, 1950–1959.
4. Navghane, S., Killedar, M. S., & Rohokale, D. V. (2016). IoT based smart garbage and waste collection bin. *International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), 5*, 1576–1578.
5. Maheshwaran, K., et al. (2018). Smart garbage monitoring system using IOT. *International Journal of Engineering Research and Technology, 6*(3), 1–3.
6. Kasliwal Manasi, H., & Suryawanshi Smithkumar, B. A. (2016). A novel approach to garbage management using internet of things for smart cities. *International Journal of Current Trends in Engineering & Research, 2*, 348–353.
7. Umapathy, K., Sridevi, T., Navyasri, M., & Anuragh, R. (2020). Real time intruder surveillance system. *International Journal of Scientific & Technology Research (IJSTR), 9*(3), 5833–5837. ISSN: 2277-8616.
8. Sinha, T., Kumar, M. & Saisharan, P. (2015). Smart dustbin. *International Journal of Industrial Electronics and Electrical Engineering, 3*(5), 101–104.
9. Premkumar, R., et al. (2018). Smart dumpster monitoring system. *International Journal of Engineering & Technology, 3*(3), 172–174.

10. Mangayarkarasi, T., Umapathy, K., Sivagami, A., & Subitha, D. (2021). An IoT based safe assembly point alert system. *Journal of Physics: Conference Series, 1964*(7). https://doi.org/10.1088/1742-6596/1964/7/072013
11. Vinoth Kumar, S. (2017). Smart garbage monitoring and clearance system using internet of things. In *2017 IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM).*
12. Abba, S., et al. (2020). IoT-based framework for smart waste monitoring and control system: a case study for smart cities. *MDPI Engineering Proceedings.* https://doi.org/10.3390/ecsa-7-08224,pp.1-10
13. Arul Anitha, A., & Arockiam, L. (2020). Promoting a clean and hygienic environment using IOT. Smart garbage management system. *International Journal of Recent Technology and Engineering, 8*(5), 4722–4726.
14. Umapathy, K., Mangayarkarasi, T., Subitha, D., & Sivagami, A. (2020). Android application and SMS alert based garbage monitoring and navigation system. *Journal of Physics: Conference Series, 1964*(6). https://doi.org/10.1088/1742-6596/1964/6/062064
15. Umapathy, K., Sai Swaroop, V., Viswam, P., & Balaswami Sairaja, T. (2020). Counterfeit bank note detecting system. *International Journal of Scientific & Technology Research (IJSTR), 9*(3), 1033–103. ISSN: 2277-8616.

Technology-Assisted Teaching during the COVID-19 Pandemic: L2 Teachers' Strategies and Encountered Challenges

Mai Khanh Chau and Hung Phu Bui

Abstract Technological advancement has changed the landscape of education by providing technological tools and opportunities for distance learning. Recent research has explored different aspects of online teaching, but few studies have examined the strategies employed by Asian second language (L2) teachers in the online classroom and challenges they encountered. This study extends this research line by investigating the pedagogical strategies which Vietnamese L2 English secondary school teachers employed in online teaching and challenges they encountered from applying these strategies. Individual semi-structured interviews were conducted with eighteen randomly selected EFL teachers from ten secondary schools in Tra Vinh Province, Vietnam. The study adopted a content-based approach to data analysis. Results showed that the teachers used a diversity of pedagogical strategies regarding classroom management, instruction delivery, students' engagement, and interaction. During the teaching process, they dealt with four main types of challenges: technological, pedagogical, organizational, and psychological. The findings suggest implications for online teaching and teacher education for online language teaching.

Keywords Asynchronous · Challenges · EFL teachers · Pedagogical strategies · Remote teaching · Synchronous

1 Introduction

Recent studies show that online education has become a popular option and a global trend. Assisted by technology, online education has demonstrated some benefits and challenges. Teachers now can access advanced digital technology and have chances to apply software to improve their information technology skills. To date, students can

M. K. Chau
Tra Vinh University, Tra Vinh, Viet Nam
e-mail: ckmai@sdh.tvu.edu.vn

H. P. Bui (✉)
University of Economics Ho Chi Minh City (UEH), Ho Chi Minh City, Viet Nam
e-mail: hungbp@ueh.edu.vn

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_22

contact experts online, have time flexibility, choose a diverse range of course types, participate in large communities, and practice self-regulation. However, the online teaching and learning modality has several drawbacks, including challenges from internet browsing, computer compatibility, technical training, socioeconomic factors, assessment methods, and heavy workload. It requires teachers and students to have relevant skills to achieve expected outcomes and necessary facilities and learning environments [1].

The emergency shift from traditional (face-to-face) to remote learning in response to the COVID-19 pandemic is called emergency remote teaching (ERT), defined as a temporary transition of instructional delivery to an alternative delivery model due to crisis circumstances [2]. This unprecedented shift exhibits potential challenges for teachers and students due to insufficient training and preparation. Hughes [3] suggested teacher training courses in necessary technological and pedagogical skills for remote teaching. Also, students may face challenges from a lack of necessities for remote learning (personal space, Internet access, and devices). Social isolation and lack of social interaction between teachers and students are also a source of challenges, which require students to familiarize themselves with self-regulated learning and acquire necessary skills.

2 Literature Review

Effective online teaching and learning is an overly specific procedure that can be seen in roles, competencies, and approaches to career development as well as in curricula, pedagogy, assessment, and the nature of the interactions between the participants. Garrison and Anderson [4] stated three interdependent aspects that frame the educational experience, including social, cognitive, and teaching presence. Teaching presence is essential to a quality learning experience, providing the foundation for social and cognitive presences through curriculum, course design, direction, guidance, and facilitation. Carrillo and Flores [5] reviewed the literature in a total of 134 empirical studies and found that teaching presence supports social and cognitive presence to achieve specific learning outcomes. Ahmed and Opoku [6] explored L2 teachers' teaching strategies regarding interacting with students, learning new tools, constantly seeking feedback, investing time in preparation, sharing cameras, empathizing with students, sharing experiences, repeating concepts, and recording lectures. In general, these studies gave implications for new digitally supported pedagogical practices in the post-pandemic era.

Recent studies have highlighted the challenges of digital transition in applying remote strategies during the COVID-19 pandemic. Giving students access to the necessary technology and the internet is a major challenge for educational institutions, teachers, and students. Also, in some studies, racial, economic, and resource disparities and teachers' insufficient preparation significantly impact student learning outcomes. Other factors include students' and teachers' low digital literacy to use digital libraries, teachers' heavy workload in converting learning content, the sudden

arrival or interruption of family members, friends, or pets, and the compatibility with hands-on experiments. Kopp et al. [7] made five common assumptions as barriers to the digital transformation of higher education institutions related to change, pace, technology, competencies, and financing. Shamir-Inbal and Blau [8] explored the pedagogical, technological, and organizational challenges encountered by teachers in the digital learning environment. These researchers suggested training courses for teachers to overcome these challenges. Similarly, Ahmed and Opoku [6] added psychological factors faced by students and teachers are significant challenges in decreasing teaching and learning quality. The results showed that teachers' efficient communication and teaching styles, proficient use of technology, and adaptable, amiable, and supportive attitudes were unprepared for sudden transformation.

Although educational issues emerging in remote teaching during the pandemic have been explored, strategies employed by Asian EFL secondary school teachers and the challenges they encountered are relatively neglected. Given the possibility of similar unexpected situations and school closure in the future, the education system might need to get back to previous experiences found in this study to prepare for better remote language teaching. EFL teachers may need professional and technological training in digital technologies. Explorations into EFL teachers' strategies and their challenges can provide implications for classroom practice development and teacher training. This study seeks to address the following research questions:

RQ1. What pedagogical strategies did Vietnamese secondary school EFL teachers employ in remote teaching during the COVID-19 pandemic?
RQ2. What challenges did Vietnamese secondary school EFL teachers encounter from applying their pedagogical strategies during the COVID-19 pandemic?

3 Methodology

This study included 18 teachers from ten secondary schools in Tra Vinh Province. At these schools, English was a required foreign language in the national curriculum, with 5 periods (45 min each) per week; however, it was reduced to 2 or 3 periods per week. The decrease in teaching and learning hours was supposed to reduce teachers' and students' sufferings due to the pandemic in the place.

The first researcher sent an email to all secondary school EFL teachers in the place. Twenty-eight teachers replied, and twenty of them volunteered to participate in the study. Two teachers later withdrew, resulting in 18 remaining participants (7 males and 11 females, aged 38–59) in the study. After receiving their email consent, the researcher contacted the participants to arrange interviews. The researchers informed them of ethical considerations and their rights as participants. For identity confidentiality, they were anonymized as T1-18 in the data report.

Data were collected at around the end of May and the beginning of June 2022, after the government's announcement of the New Normal Era in Vietnam. This study employed a prompt semi-structured interview strategy. The interviews, conducted in person and on Google Meet video calls, lasted about 25 mins each, all of which

were recorded for data analysis. During the interviews, the researcher interviewer and participants used Vietnamese, and the participants' responses were confirmed and clarified to increase trustworthiness. The interview protocol was composed of two main sections: (1) pedagogical strategies teachers employed in remote teaching and (2) the challenges that teachers encountered from applying these strategies. The interview scheme, piloted with three teachers in the first phase to increase research reliability and validity, was based on Ahmed and Opoku [6] and Shamir-Inbal and Blau [8]. After the pilot study, no further change was made to the interview scheme. The participants involved in the pilot study were not involved in the main study.

Data collected from the interviews with the teachers were analyzed by using the theme-based approach. The process was inductive to find out emerging themes and sub-themes. They were first transcribed by the first researcher. Then, she read and reread transcribed contents to code data. This step was mainly based on content, not affected by the participants' language. The codes were modified and refined to eliminate redundancy and overlap, as well as to develop themes [9].

4 Results

4.1 Pedagogical Strategies Employed by Vietnamese Secondary School EFL Teachers in Remote Teaching

The teachers used various applications to connect with students' parents and students outside the classroom to respond to information quickly. For the management inside the classroom, the teachers collaborated with the Information Technology staff to check students' attendance. In addition, they imposed strict classroom rules which required students to attend class fully, log in time, turn off or turn on the microphone, open the camera, and randomly call students to answer questions or give comments on the lesson to regain their concentration. For schoolwork, all teachers ($n = 18$) assigned tasks to students by using different support tools such as email, Google Drive, Zalo, online books, or websites to implement assignments. Most teachers ($n = 16$) thought that assignments should be divided into different levels of students' competence. As T6 responded:

> In my opinion, for students in rural areas, I was concerned about how to assign tasks to each group so that they could promote their capacity. For example, group A would be assigned the tasks differently from group B, which had slightly more limited capacity. In addition, with the same knowledge goal, I adjusted the content of lessons to match their abilities.

The teachers devised appropriate teaching strategies, depending on their technological and pedagogical competence and the class size. Most teachers used online resources and multimedia applications such as Google, Azota, Kahoot, Quizizz, Youtube, and websites to add pictures, quizzes, or short videos to illustrate their instructions. They shared useful materials with students and guided them in self-study at home. All teachers received and gave feedback from their students with

synchronous and asynchronous modes through videoconference, email, phone, Zalo, or Facebook. They gave feedback in the form they received from students. Regarding comprehensive instructions to their students, they only focused on the core content and common daily vocabulary, provided illustrations for complicated structures or questions, and translated them into Vietnamese if necessary. Most teachers (n = 16) used verbal praise when students performed tasks well, encouraged students to speak, engaged students to interact by giving peer feedback, and organized group work discussions. T1 said:

> In K-12 online, I divided the students into small groups of 4-5 students to practice. Most students did well; only a few were shy and rarely attended. I used Google Drive for writing so they could look at their friends' work and help each other correct it.

Overall, EFL secondary teachers adopted various pedagogical strategies in remote teaching, including classroom management, instruction delivery, students' engagement, and interaction. However, their strategies mainly stemmed from their personal opinions. Their responses showed that insufficient training hindered their teaching, and they did not know why they applied such strategies.

4.2 Challenges Encountered by Vietnamese Secondary School EFL Teachers From Applying the Pedagogical Strategies

All teachers (n = 18) said that the primary technological challenge occurred from unstable and intermittent internet connections. They reasoned that the teaching system at that time was overloaded to guarantee all students' participation. The students' lack of learning devices challenged remote teaching and learning tremendously. T5 noted:

> Only 50% of students have enough devices to participate in remote learning. Most students in the area where I teach are from the Khmer ethnic group with difficult economic conditions. Most parents work far away to earn a living and cannot equip learning devices. Some students in better condition families use their parents' phones; however, when their parents go to work, they cannot attend class. In another case, some students have phones but don't have wifi; they have to go to the next house connected to study.

Regarding technical capability, some students did not know how to log in to class and therefore needed teachers' support. The teachers, especially those who were inexperienced, suffered a lack of technical skills when they began to teach online. The technological challenges they countered also depended on their students' regions, financial capacity, and technical skills.

All teachers (n = 18) also encountered pedagogical challenges from contacting students on the first days because their students came from different places in the province. Regarding the delivery of tasks to students, the teachers could not deliver lessons, especially listening and speaking skills, as scheduled due to the limits of technological tools. It was challenging for the teachers to ensure all students' assignment

completion and know the individual student's difficulties to support them promptly. For instance, T10 responded:

> When giving the assignment, I see that they also do and send it via Zalo or Google Drive, but only a few submit it. Other students did not complete the task and reported having problems with the internet connection or did not know how to do it. Some even copy others' work, and their ability is not the same as when they return to face-to-face learning.

Regarding the interaction, the teachers stated they had difficulties interacting effectively with students. They reasoned that they called several times but received no response. Some students explained they suffered Internet failure, which was challenging to verify. Most teachers ($n = 14$) encountered problems assigning students' group work as the applications they used did not allow them to observe students' discussions. Some teachers also encountered some students' disruptive behaviors, such as turning on music and speaking. The teachers faced numerous pedagogical challenges, which required additional support for these problems.

Most teachers ($n = 17$) revealed that their school managers and staffs were generally responsive. However, the initial teaching conditions did not occur in all schools; only a few schools were eligible to be selected as the main place. Regarding the support of colleagues, all teachers ($n = 18$) stated they received support from their colleagues. However, six teachers said remote teaching was relatively difficult for all teachers, so there was little support, and they asked for the community's sympathy. Most teachers ($n = 14$) reported that they participated in the training program organized by the Ministry of Education, but the training mainly focused technical skills for online teaching. They were in more need for online language pedagogy. Some teachers ($n = 4$) faced many difficulties, such as finding the resources, images, and video clips that matched their lesson contents, as illustrated in T3's response:

> The IT teacher trained me to use K-12 online, divide breakout rooms, and do other functions. But I could not remember them because many features were trained in such a short time (…). I was not directly participating in the training program from the Ministry of Education and only receiving support from my colleagues who had participated in the training.

When asked about health issues, the teachers ($n = 15$) that responded most students and teachers faced eye strain and were exhausted from spending so much time in front of the screen of an electric device. Some older teachers experienced additional health problems, such as dizziness and headaches. Regarding students' emotions, 14 teachers reported students felt stressed, bored, and lonely, and expected to learn in the face-to-face classroom. Some teachers commented:

> I think (…). Of the four grades, grade 6th may be the most disadvantageous because they could not meet and get acquainted with their classmates in the transition from primary to secondary school. They don't know who to ask when they have questions and are partly afraid to ask the teachers (T1).
>
> Students did not turn on their cameras, so I did not know how much they followed the lesson. I called some students several times, but they did not answer. I felt like I was talking to myself, which made me so lonely. (T15)

5 Discussion

The present study provided insights into teachers' pedagogical strategies and the challenges they encountered from online teaching. Results showed that the teachers adopted various pedagogical strategies to manage class, deliver tasks, and facilitate students' engagement and interaction. The findings showed when adopting the strategies, teachers encountered challenges with technology, pedagogy, organization, and psychology.

This study extended the literature on teachers' pedagogical strategies in remote teaching during the COVID-19 pandemic. Results showed that the teachers generally received support from the managements and staffs. Ahmed and Opuku [6] recommend mutual support in educational settings to restrict the effects of the pandemic. Results also showed that the teachers kept contacting students and supporting their learning by utilizing digital resources. Although the teachers revealed they were embarrassed and confused on the first days of online teaching, they gained experience which could be used for online teaching. They learned how to interact with students, use technological tools to mediate students' learning, and integrate resources into their online lessons [10]. They also expressed that they understood problems students potentially encountered from online learning and teaching. Also, students may have learned to be independent by acquiring self-regulated learning [8]. It might be necessary for novice teachers to collect student feedback to improve their online teaching [6].

Also, results indicated that teachers dealt with several significant challenges when applying pedagogical strategies in remote teaching. Regarding technology, they faced problems from the Internet connection, lack of learning equipment, and inadequate training, which hindered teaching and learning activities. The challenges also occurred from students' problems, such as lack of online learning skills and electronic devices. It might be important for school administrators and parents to invest in learning to improve the quality of teaching and learning. Teaching and learning are the two sides of the same coin which influence each other. For effective online education, both teachers and students need sufficient training [8]. The study also indicated that teachers' and students' psychology was significantly affected during the pandemic. This result confirmed the research by Ahmed and Opuku [6], which emphasized the emotions of anxiety, stress, and feelings of isolation from peers in crisis. It might be necessary for the government to provide psychological consultancy on resilience strategies in social media. Several researchers have recommended the use of both synchronous and asynchronous modes in online language education [11].

This study contributes to the literature in remote teaching environments in Vietnam. The results can be considered a reference for Vietnam and other similar contexts. The data analysis sheds light on how teachers expect to build pedagogical approaches to advance their proficiency through the effective integration of digital tools to enhance students' interaction, motivation, and competency. This study recommends researchers to conduct further research into potentially similar

scenarios to create more effective pedagogical strategies based on teachers' prior remote teaching experiences.

6 Conclusion

This current study provides a descriptive analysis of the pedagogical strategies of L2 English secondary school teachers, along with the challenges they encountered when applying strategies during the COVID-19 pandemic. It is important to train more digital skills and effective online teaching for teachers who teach remotely, as well as equip schools with infrastructure and minimal digital learning devices for students to meet the needs of language education. Psychological factors of teachers and students also need to be more concerned.

References

1. Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to Coronavirus pandemic. *Asian Journal of Distance Education, 15*(1), i–vi.
2. Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review, 27*, 1–12.
3. Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education, 13*(2), 277–302.
4. Garrison, D. R., & Andersen, T. (2003). *E-learning in the 21st century: A framework for research and practice* (2nd ed.). Routledge/Falmer.
5. Carrillo, C., & Flores, M. A. (2020). Covid-19 and teacher education: A literature review of online teaching and learning practices. *European Journal of Teacher Education, 43*(4), 466–487.
6. Ahmed, V., & Opoku, A. (2021). Technology supported learning and pedagogy in times of crisis: The case of Covid 19 pandemic. *Education and Information Technologies, 27*(1), 365–405.
7. Kopp, M., Gröblinger, O., & Adams, S. (2019). Five common assumptions that prevent digital transformation at higher education institutions. In *INTED 2019 Proceedings,* Valencia, Spain (pp. 1448–1457).
8. Shamir-Inbal, T., & Blau, I. (2021). Facilitating emergency remote K-12 teaching in computing-enhanced virtual learning environments during Covid-19 pandemic—Blessing or curse? *Journal of Educational Computing Research, 59*(7), 1243–1271.
9. Hung, B. P., Khoa, B. T., & Hejsalembrahmi, M. (2022). Qualitative research in social sciences: Data collection, data analysis, and report writing. *International Journal of Public Sector Performance Management*, *9*(4) (2022) (in press).
10. Huong, L. P. H., & Hung, B. P. (2021). Mediation of digital tools in language learning. *LEARN Journal of Language Education and Acquisition Research Network*, *14*(2). https://so04.tci-thaijo.org/index.php/LEARN/article/view/253278
11. Hung, B. P., Anh, D. P. T., & Purohit, P. (2022). Computer-mediated communication and second language education. In R. Sharma, & D. Sharma (Eds.), *New trends and applications in Internet of things (IoT) and big data analytics* (pp. 109–122). Springer.

The Application of Artificial Intelligence Technologies in Social Media to Detect Fake News: A Systematic Review

Pham Chien Thang and Ta Thi Nguyet Trang

Abstract News is considered a part of communication that keeps people up-to-date regarding ongoing events, worldwide issues, and significant emerging characters. This highlights the significance of spreading accurate yet timely news around the world. However, with time, fake news is getting associated with the internet, especially social media, making it difficult for the audience to differentiate fact from fiction. Based on this perspective, fact-checking a story, news, or comment is becoming a crucial task in detecting fake news. Amid several technological developments, artificial intelligence (AI) is acknowledged as a major melioration for detecting fake news circulating the Internet. Intelligent algorithms are used to target websites, scan fake news sources, and help predict the most accurate versions of news, stories, or comments. The following systematic review provides an evaluation of different AI algorithm-based research studies to highlight some specific algorithms that result in the detection of fake news on social media. For this purpose, analytic and experimental research studies are targeted and subjected to data synthesis and analysis to evaluate the effectiveness of AI algorithms.

Keywords Artificial intelligence · Face news · Social media

1 Introduction

The last two decades have significantly marked the pivotal role played by "technology" in the evolution of the media industry and communication. According to the study by Rein and Venturini [1], due to the perpetual stream of online news platforms and subsequent growth in social media, users have been provided with a digital

P. C. Thang (✉)
Thai Nguyen University of Sciences, Thai Nguyen 24000, Vietnam
e-mail: thangpc@tnus.edu.vn

T. T. N. Trang
International School, Thai Nguyen University, Thai Nguyen 24000, Vietnam
e-mail: trangttn@tnu.edu.vn

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_23

landscape with more convenient ways to access news than ever before. Nevertheless, along with the convenience, social media is also being suspected to be a rather suitable medium for the spread of fake news around the globe [2].

Fake news is referred to as misleading information which is intentionally spread across social media to manipulate the users into a certain party's favor, damage the reputation of an entity, person, or organization, or use advertising revenue as a source of money [3]. Considering the extent to which fake news could be escalated throughout social media, authorities have been concerned about developing reliable, skilled, and effective ways to terminate the loops across a particular site, while artificial intelligence (AI) has been identified as a prominent one.

Where filtering the news is concerned, AI could play a pivotal role. For instance, a search algorithm update was proposed by Google in 2017 to stop the spread of hate speech and fake news on the Internet. Intelligent algorithms feed targeted websites, scan for fake news sources, and help predict the most accurate versions of news, stories, or comments [4]. As the algorithms targeted for 'fake news' detection purposes are based on artificial intelligence, these tend to learn over time from each website being fed into them and incorporate that knowledge in the upcoming detection process. Therefore, AI algorithms tend to self-increase their efficacy. However, this technology is not yet considered 100% accurate, and there is a limit to the maximum efficacy of AI algorithms. Although several studies have focused on the application of artificial intelligence in the media field, there is a lack of research investigating the application of artificial intelligence in media to counter the spreading of fake news specifically. A further lack of literature regarding the most effective AI algorithms in fake news detection has also triggered this systematic review. Therefore, the following study is a systematic review that targets the AI methods to detect fake news that may spread worldwide through social or traditional media.

In the following study, relevant literature would be used to identify key themes and analyze different perspectives regarding the spread of fake news on social media. Data regarding the AI algorithms used to detect fake news across social media and key themes regarding the application of these AI algorithms would be collected and synthesized. The data synthesis will be followed by a thematic analysis of AI algorithms, their efficiency in detecting fake news, and how much the spread of fake news is reduced in the aftermath. This will be finally followed by a discussion of the theoretical and practical contributions of this paper and its future implications. Based on the study's rationale, the research questions could be formulated as follows:

RQ1. How is fake news spread across social media?
RQ2. How fake news is detected through using AI algorithms across social media?
RQ3. To what extent does the application of AI algorithms have reduced the spread of fake news across social media?

2 Methodology

The methodology used in the following systematic review comprises a sequential component to be elaborated including question formulation, search strategy, selection criteria, data synthesis, and reporting results through discussion [5]. The underlying rationale for following this methodology pattern is that it promotes transparency and reproducibility in the review process.

2.1 Search Strategy

We considered all currently available research from peer-reviewed and some unreviewed sources published between 2018 and more expected 2022. Analytic and experimental studies will be an integral part of the study designs. Regardless, only English language publications would be targeted to ease the method of data extraction, synthesis, and evaluation. Any type of gray literature such as conference reports, newspapers, opinions, magazines, commentary, editorial, dissertation, blogs, and brief policy submissions was not accepted in this study. PubMed, Science Direct, and Google Scholar were the main databases for searching relevant literature articles that match the qualifying requirements.

The PICOS tool, which is accessible through PubMed, was used to enter the primary keywords, with the population being "social media users"; artificial intelligence, machine learning, or natural language processing (NLP) are all used as interventions to detect fake news. Specific key terms such as, "Artificial Intelligence (AI)", and "fake news" were frequently used in the search strategy. To search for relevant literature, certain phrases were used such as "spread of fake news across social media", "impact of fake news on social media users", "application of AI to detect fake news", and "AI algorithms to detect fake news across social media", etc. In addition to this, boolean logic such as "AND" was used between phrases to acquire extensive research, for example, "AI algorithms AND fake news detection", "AI algorithms AND fake news detection AND social media users", etc.

All identified records from our databases will be exported to the research information management system after applying search phrases and keywords. An approximate 214 research articles were identified through a database search. After extracting the duplicate articles from the overall number of records before being noted, only 194 research were left for analysis. First, titles and abstracts were skimmed to identify suitable studies; records that were pertinent were removed leaving behind 72 articles. These then were subjected to full-text analysis, excluding around 59 more articles that did not pass the selection criteria. Only seven studies were assumed suitable for answering the research objectives.

2.2 Data Synthesis

In order to report the main characteristics of the targeted paper such as methodologies, outcomes, and publication details, a data extraction process was manually developed for this study while taking into account previous systematic reviews [6–8]. Table 1 indicates the synthesis of data. These identified articles were then inductively coded into themes, independently while taking the research objectives into account such as "AI-algorithms used to detect fake news across social media" and "Circulation of fake news across social media". This method eventually provided a broader scope to understand and conceptualize themes.

3 Thematic Analysis and Discussion

3.1 RQ1: How is Fake News Spread Across Social Media?

Three studies were significantly targeted to evaluate fake news and its spread across media. The study by Meel and Vishwakarma [13] focused on the evaluation of to what extent social media content is manipulating the perceptions and mindsets of the users. This extended literature review provides a holistic view of how people are using the information as a weapon to accomplish their pernicious motives while turning people's perceptions regarding a person or event into biased ones. On the other hand, Zimmer et al. [14] focused on the behavioral bias demonstrated by users playing as a major factor in the circulation of fake news. Waszak et al. [15] rather conducted an experimental analysis to evaluate the circulation of fake news across media. The results completed inclined in the negative direction, indicating a high score of shares of false news. There are two types of fake news, including deliberate fake news and non-deliberate fake news. While the former is intentionally created and posted on social media to achieve financial gain, political benefit, or to generate controversies through spreading it, the latter is rather a misinformation that is mistakenly released by an individual [16, 17]. Nevertheless, the damage caused by both is rapid and adverse. Several factors are potentially responsible for the circulation of fake news as discussed in the following:

Cognitive biases assist people in making quick judgments during navigation in daily activities which may often result in irrational interpretation [18]. Therefore, it greatly impacts the way humans perceive information. For instance, the Bandwagon effect is generated when the majority of the people tend to support news just because the majority of them find it interesting, which may eventually result in people sharing it over and over again regardless of whether the news is fake or real [19]. On the other hand, the pernicious impact of partisanship also results in the spread of fake news, where the preexisting political alignment of people encourages them to share information or news regardless of its truthfulness [20]. These cognitive biases eventually

Table 1 Data synthesis

Themes	Study	Type of research	Approach (Setting)	Outcomes or findings
AI algorithms are used to detect fake news across social media	Ozbay and Alatas [9]	Analytic study	A two-step method is used Step 1: Pre-processing to convert unstructured data sets into structured ones. TF weighting method and Document-Term Matrix are used to obtain vectors for text representation in data Step 2: 23 artificial intelligence algorithms are implemented in the structured data set through text mining methods	The decision tree algorithm provided the best mean values in terms of accuracy, precision, and f-measures. ZeroR, CVPS, and WIHW algorithms were considered the best algorithms in terms of recall metric
	Jain et al. [10]	Experimental study	Three modules: 1. Aggregator 2. News authenticator 3. News suggestion and recommendation system	The proposed model provided correctness of up to 93.6%
	Sharma et al. [11]	Experimental study	1. Python and its Sci-kit libraries to collect articles for analysis 2. Django is used for web-based deployment of the model 3. Datasets for fake news classification of data are used, such as Buzzfeed News, LIAR, and BS Detector	Logistic regression and grid search parameter optimization provided 75% accuracy in results

(continued)

Table 1 (continued)

Themes	Study	Type of research	Approach (Setting)	Outcomes or findings
	Gupta et al. [12]	Experimental study	AI library is used in Python. Python computational tool is used as PNL (natural language processing). Data were split into testing and training sets	The precision of 94.85% is achieved
Circulation of fake news across social media	Meel and Vishwakarma et al. [13]	Literature survey study	Qualitative thematic analysis	Approximately 40% of the targeted research literature, focused on the utilization of machine learning and deep learning in order to detect false news across social media
	Zimmer et al. [14]	Case study	Quantitative survey and qualitative content analysis	Reading fake news and finally composing a remark or response may be the outcome of users' selective exposure to information resulting in confirmation bias
	Waszak et al. [15]	The pilot quantitative study	Quantitative analysis	Fake, misleading, and over-interpreted health news in social media

give rise to influential operations where certain political characters take advantage of this cognitive bias of people to spread deliberate fake news across social media.

Modern technologies are observed to amplify cognitive biases in a harmful direction. For instance, bots are also considered to play a critical role in the spread of fake news across social media. The study by Himelein-Wachowiak et al. [21] elaborated on the functionality of social bots while defining them as computer algorithms that can automatically generate contact and have the potential to interact with humans on social media, with the aim to imitate and manipulate human behavior. Therefore,

these bots eventually allow malevolent actors to take advantage of the vulnerabilities and give false impressions regarding a specific aspect, regardless of its truthfulness. Nevertheless, the overall issue is associated with the factors that allow the proliferation of fake news.

3.2 RQ2: How Fake News is Detected Through Using AL-Algorithms Across Social Media?

Although a number of computational techniques are available that are being utilized to indicate certain articles as fake while considering their textual content. This phenomenon is associated with "Fact-checking", whereas certain websites such as "PolitiFact" and "Snopes" are used as fact-checking websites. The most commonly used framework which induces AI algorithms to detect fake news is shown in Fig. 1. The procedure starts with data collection of suspected fake news from social media, which is subjected to the pre-processing stage to refine the data. This refined data is then passed through evaluating model, where a specific type of AI algorithm must be used. The acquired effectiveness of the used algorithm is then measured through comparison.

Considering the research methods and approaches, two studies Ozbay and Alatas [9] and Sharma et al. [11] initiated their research through data cleaning or text mining. Both the studies underwent a sequenced procedure to achieve structured data from the targeted news articles that are unstructured. The pre-processing of text mining procedure includes tokenization, stop-word removal and steaming, and extraction and selection of features. On the other hand, Gupta et al. [12] used the test split capacity of the sklearn library to organize and split data while incorporating it into the Data frame design to get the shape of the information. Nevertheless, three of the studies, including Ozbay and Alatas [9], Sharma et al. [18], and Gupta et al. [12] performed data vectorization, where text is encoded as integers. For this purpose, both studies used a vector space model (VSM), where each word is represented by a specific value such that it indicates the weight of a word in a document. Although

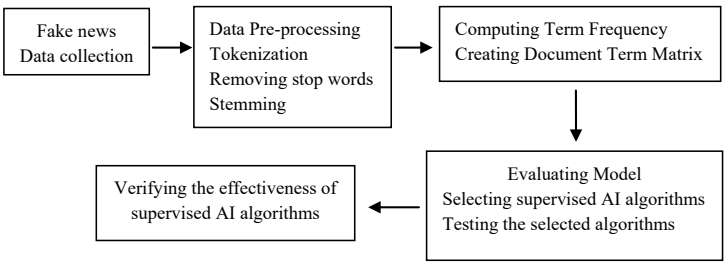


Fig. 1 AI algorithm for detection of fake news [9]

different VSM methods are used, term frequency-inverse document frequency (TF–IDF) is common among the three studies. The formula used to measure TF–IDF is as follows:

$$\text{idf}(t) = \log(N/(\text{df} + 1)).$$

TF–IDF vectorization functions as the right measure to assess the importance of a word in a document in a collection or corpus. Data vectorization is then significantly followed by the integration and implementation of an algorithm. Starting with the analytical study by Ozbay and Alatas [9], the researcher technically investigated 23 of the above algorithms to extract mean accuracy, precision, recall, and F-measure. The results showed that the decision tree algorithm has the highest mean accuracy, mean-f, and precision values of 0745, 0741, and 0759, whereas mean recall values were highest for ZeroR, CVPS, and WIHW. These results proved decision trees as an effective artificial intelligence algorithm to detect fake news worldwide. Research by Sharma et al. [11] also incorporated a decision tree algorithm under the Random Forest and bagging method. According to the study by Niculaescu [21], the decision trees algorithm tend to use multiple algorithms which assist it in deciding regarding splitting a node into sub-nodes. This method increases the homogeneity of sub-nodes. However, Gupta et al. [12] used only one algorithm, a passive-aggressive classifier. Meanwhile, Jain et al. [10] focused on mixing different algorithms, including the Naïve Bayes algorithm with SVM and NLP.

From the synthesis results, a significant algorithm was found to be common in two of the studies by Jain et al. [10], and Sharma et al. [11] is the Naïve Bayes algorithm. According to Jain et al. [10], a Naïve Bayes classifier is a supervised machine learning algorithm in which the Bayes theorem is mainly used. Accordingly, variables independent of each other are used to generate the Naïve Bayes model. As targeted by two studies, this model is supposed to be a popular algorithm that could be used to find the accuracy of the news, determining whether it is real or fake. Aside from this, a study by Sharma et al. [11] explained Naive Bayes as algorithm used in various tasks such as spam filtering, sentiment analysis, recommendation systems, etc. The underlying rationale for their usage is that the Naïve Bayes algorithm is expeditious and intuitive as well. However, a major disadvantage to their functionality is that the predictor must be independent.

Another significant algorithm was found common in two studies by Sharma et al. [11] and Gupta et al. [12] was a passive aggressive classifier. According to the study by Shama et al. the passive aggressive algorithm is explained as an online algorithm that is considered an ideal algorithm for classifying massive data streams such as Facebook and Twitter. Compared to the Naïve Bayes algorithm that is observed to be used specifically for news articles, detecting whether it's fake or real, the passive aggressive algorithm is more social media oriented that could be used to classify fake comments, etc. Sharm et al. [11] illustrate the passive aggressive algorithm as an easy and fast classifier that tends to function by learning from examples and disposing of them after completing the task. Therefore, this algorithm tends to remain passive for

a correct classification outcome, whereas it tends to turn aggressive during updating, adjusting, or detecting miscalculations.

3.3 RQ3: To What Extent Does the Application of AI Algorithms Have Reduced the Spread of Fake News Across Social Media?

The study by Gupta et al. was briefly concluded after using the passive aggressive algorithm, while the results obtained showed an accuracy of 94.85%. A study by Sharma et al. [11] implemented four significant algorithms and vectorizers, including count vectors and Tf–Idf vectors at Ngram and word levels. As four different models, and algorithms, were used, the accuracy was determined for each. To improve the effectiveness of the proposed and implemented models, the K-fold cross-validation technique was used. Results demonstrated that Naïve Bayes attained an accuracy of 60%, random forest (decision tree) attained an accuracy of 59%, and logistic regression attained 65%, whereas a passive aggressive classifier attained an accuracy of 92%. Furthermore, it was noted that integrating a grid search parameter optimization, also known as a confusion matrix, tends to increase each algorithm's performance, thereby increasing its accuracy in detecting fake and real news.

As Sharma et al. [11] used a confusion matrix in association with the algorithms, a study by Jain et al. [10] also used SVM and NLP along with the Naïve Bayes algorithm to increase its accuracy in detecting fake and real news. The results from this study demonstrated that Naïve Bayes alone attained an accuracy of 74%, whereas with the SVM and NLP, the accuracy increased to 93%. Furthermore, while concluding the overall studies, the passive aggressive classifier (PAC) showed the highest accuracy in detecting fake and real news even when used solely. On the other hand, other the efficiency of other algorithms, such as Naïve Bayes and decision tree, could be increased through the integration of several interventions.

4 Conclusion and Limitations

This research aims to evaluate the application of the artificially intelligent algorithm to detect fake news circulating on social media. In this study, seven studies were targeted, extracted, observed, analyzed, and assessed to identify the most commonly used AI algorithms and their efficacy and accuracy in detecting misinformation and disinformation. Research results show that using a combination of different algorithms can increase its accuracy in detecting fake and real news (e.g., SVM, NLP, and Naïve Bayes). Future iterations of the algorithm could deliver superior outcomes using hybrid ways to achieve the same goals. Additionally, the current work may be

enhanced by investigating new algorithms, combining existing algorithms, and incorporating intelligent optimization algorithms for better outcomes. Finally, combining ensemble approaches with other feature extraction techniques to enhance model performance is possible. For instance, decision tree algorithms could be paired with a confusion matrix to increase its efficacy for detection of fake news speedily and with higher accuracy so that quick action could be taken. However, this study's limitations are as follows:

One prominent limitation that could be observed in this systematic review is the analysis of insufficient literature for statistical measurements. Considering the data synthesis table, only four studies were evaluated for AI algorithms and their accuracy in detecting misinformation. Although plenty of literature is available regarding the topic, this study's time constraints were another limitation. An extensive analysis of each targeted article is a time-consuming task.

Another limitation is that although it highlights the accuracy of some popular AI algorithms, the study does not exponentially explain the methods, approaches, models, and systems used in coordination with these algorithms to expand their accuracy spectrum. Therefore, the focus is shallow. Moreover, three of the four studies taken into account are published in the same year, which is 2020, whereas one is from 2019. This eventually provided constricted results, where the similarity is higher among conclusions provided by each study. Based on this perspective, this systematic review may not target AI algorithms' development and evolution over the past few years.

References

1. Rein, K., & Venturini, T. (2018). Ploughing digital landscapes: How Facebook influences the evolution of live video streaming. *New Media and Society, 20*(9), 3359–3380.
2. Bali, A., & Desai, P. (2019). Fake news and social media: Indian perspective. *Media Watch, 10*(3), 737–750.
3. Bakir, V., & McStay, A. (2018). Fake news and the economy of emotions: Problems, causes, solutions. *Digital Journalism, 6*(2), 154–175.
4. Sachdeva, J., Chaudhary, K. K., Madaan, H., & Meel, P. (2021). Text based hate-speech analysis. In *2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS)* (pp. 661–668). IEEE (2021).
5. Prieto, M. S., & Rumbo-Prieto, J. M. (2018). The systematic review: Plurality of approaches and methodologies. *Enfermería Clínica (English Edition), 28*(6), 387–393.
6. Cinar, E., Trott, P., & Simms, C. (2019). A systematic review of barriers to public sector innovation process. *Public Management Review, 21*(2), 264–290.
7. Vicente-Sáez, R., & Martínez-Fuentes, C. (2018). Open Science now: A systematic literature review for an integrated definition. *Journal of business research, 88*, 428–436.
8. Vrontis, D., & Christofi, M. (2019). R&D internationalization and innovation: A systematic review, integrative framework and future research directions. *Journal of Business Research.* Advance 38 online publication.
9. Ozbay, F. A., & Alatas, B. (2020). Fake news detection within online social media using supervised artificial intelligence algorithms. *Physica A: Statistical Mechanics and its Applications, 540*, 123174.

10. Jain, A., Shakya, A., Khatter, H., & Gupta, A. K. (2019). A smart system for fake news detection using machine learning. In *2019 International Conference on Issues and Challenges in Intelligent Computing Techniques (ICICT)* (Vol. 1, pp. 1–4). IEEE.
11. Sharma, U., Saran, S., & Patil, S. M. (2020). Fake news detection using machine learning algorithms. *International Journal of Creative Research Thoughts (IJCRT), 8*(6), 509–518.
12. Gupta, S. K., Alareeni, B., Karpa, M. I., Umrao, L. S., & Gupta, M. (2020). Detection of fake news problems and their evaluation through artificial intelligence. In *International Conference on Business and Technology* (pp. 94–101). Springer, Cham.
13. Meel, P., & Vishwakarma, D. K. (2020). Fake news, rumor, information pollution in social media and web: A contemporary survey of state-of-the-arts, challenges and opportunities. *Expert Systems with Applications, 153*, 112986.
14. Zimmer, F., Scheibe, K., Stock, M., & Stock, W. G. (2019). Fake news in social media: Bad algorithms or biased users? *Journal of Information Science Theory and Practice, 7*(2), 40–53.
15. Waszak, P. M., Kasprzycka-Waszak, W., & Kubanek, A. (2018). The spread of medical fake news in social media—The pilot quantitative study. *Health Policy and Technology, 7*(2), 115–118.
16. Ghiţoi, A. (2018). False News and the Public Agenda. *Revista de Studii Media, 7*, 63–76.
17. Engler, J. O., Abson, D. J., & von Wehrden, H. (2019). Navigating cognition biases in the search of sustainability. *Ambio, 48*(6), 605–618.
18. Lim, H. S., Bouchacourt, L., & Brown-Devlin, N. (2021). Nonprofit organization advertising on social media: The role of personality, advertising appeals, and bandwagon effects. *Journal of Consumer Behaviour, 20*(4), 849–861.
19. Almenar, E., Aran-Ramspott, S., Suau, J., & Masip, P. (2021). Gender differences in tackling fake news: Different degrees of concern, but same problems. *Media and Communication, 9*(1), 229–238.
20. Himelein-Wachowiak, M., Giorgi, S., Devoto, A., Rahman, M., Ungar, L., Schwartz, H. A., Epstein, D. H., Leggio, L., & Curtis, B. (2021). Bots and misinformation spread on social media: Implications for COVID-19. *Journal of Medical Internet Research, 23*(5), e26933.
21. Niculaescu, O. (2018). Classifying data with decision trees. *XRDS: Crossroads, The ACM Magazine for Students*, *24*(4), pp.55–57 (2018).

Design and Optimization of Compact RFID Antenna Tag for Biomedical Applications

M. Sivakumar, I. Manju, K. Umapathy, K. S. Srinivasan, and D. Muthukumaran

Abstract A compact RFID antenna tag is designed and optimized for biomedical applications. The sensors provide a good rate of transfer of data along with a lengthy reading of range. However, tags of antenna will face distortion in frequency if come across metals and surfaces of liquids. We focused on those factors to enhance the range of observation in antenna and increase in number for smaller applications. The RFID antenna is meant for designs smaller in size and better efficiency connected with surfaces of metal applications. The simulations are carried out by Matlab antenna tool box and optimization toolbox. The results show the values of observation as 6-m and 4.4-m for 902 to 928 MHz and 840 to 845 MHz typical frequency bands, respectively. The proposed design has low profile, low cost, and long readable range with good conjugate matching and unidirectional radiation.

Keywords RFID · IoT · Antenna tag · Optimizer

1 Introduction

This work presents modeling and analysis of a smart design of compact antenna appropriate for radio frequency identification (RFID) tag design using Matlab. The technique of RFID shall be employed for Medicare in conjunction of IOT and sensors economical in type. This approach also enhances the collection of data in real-time mode. The RFID antenna tag and H-Type microstrip patch antenna are designed for IoT-based RFID applications. Initially, the antenna tag is designed which has

M. Sivakumar · I. Manju · K. S. Srinivasan
Mohamed Sathak AJ College of Engineering, Chennai, India
e-mail: ece.sivakumar@msajce-edu.in

I. Manju
e-mail: ece.manju@msajce-edu.in

K. Umapathy (✉) · D. Muthukumaran
SCSVMV Deemed University, Kanchipuram, India
e-mail: umapathykannan@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_24

general dimension of 22 mm × 22 mm operated at 920 MHz. The antenna tag is designed, and impedance values are analyzed using Matlab functions with antenna toolbox. From the impedance analysis, the result indicates inductive characteristic of the antenna with low value of resistance. For successful operation of the tag and improved performance, there is a need of smart matching network design at 920 MHz. The smart matching network ensures maximum power transfer at 920 MHz which is achieved by using L-section double tuning network. Next, H-Type microstrip patch antenna is modeled and simulated using Matlab PCB antenna designer application. From the simulations, the directivity of the RFID antenna is having better coverage with a value of 1.55 dBi. This demonstration indicates operation of antenna in a small from the origin, which is a constraint for the tag. The scalar and vector frequency result analysis in the form of impedance, S Parameter, AZ and EL pattern, and current distribution of H-Type microstrip patch antenna are described. The antenna gain is optimized by SADEA and surrogate optimizer using Matlab optimization tool box. The results show that the antenna gain is to be 7.38 dB and the return loss S_{11} equals –11.8 dB at 920 MHz with a loss of −34.66 dB. The design is found to be simple and economical. Moreover, outcomes show these antennas at 920 MHz are a smart key for applications of RFID in the required band.

2 Literature Survey

Mansour et al. [1] proposed a compact waveguide antenna operating at 845 MHz ISM/RFID Band. This antenna has a simple, non-uniform structure, and corresponding observations were employed to authenticate applied outcomes. Omar, et al. [2] developed a smart patient management system which includes a clear method of follow-up. This is employed in large hospitals to computerize and organize their information management using RFID technology. Chen et al. [3] proposed Hospital emergency medical care system with RFID technologies such as RFID identity recognition, RFID Positioning to detect the locations of Medical care personnel and patient having wearable sensors. Lin et al. [4] developed a multiple-biosignal system that incorporates EEG, ECG, and SpO_2 modules for bio medical applications. Abuelkhail et al. [5] offered an approach using IOT and clustering concept for applications of medicare to collect information proficiently. Tsao et al. [6] developed a system with IOT for measurement of various parameters such as level of oxygen, BP, temperature etc. Pai et al. [7] proposed Health Monitoring using RFID technology for storing and recollecting data after logging into physician's account. Shanin et al. [8] developed a system having recording facility, economical, low in weight and energy effectively tested with real time data. Naresh et al. [9] recommended a system of medicare developed by employing IoT and RFID tags. K. V. Sahukara et al. offered a system of medicare to trace various parameters of interest to unify and automate database [10, 11].

3 Proposed Work

The scope of this work is to design, analyze, and optimize prototype RFID reader antenna tag and H-Type microstrip patch antenna using Matlab antenna designer toolbox.

3.1 Design 1: Prototype RFID Reader Antenna Tag

A. *The Prototype RFID reader Antenna Tag*

Figure 1 shows proposed prototype RFID reader antenna tag and mesh design and analysis using Matlab. The tag is found to be of 22 mm × 22 mm. The impedance of the RFID antenna tag is operated at 845 and 920 MHz. By using Matlab PDE toolbox, the custom antenna mesh element can be designed. The code below executes the antenna impedance measurement for both 845 and 920 MHz. This result specifies that inductive characteristics of antenna with a low value of resistance.

```
>> z = (ant, 845e6)
z = 4.1899e−01 + 2.4873e+02i
>> z = (ant, 920e6)
z =7.3266e−01 + 2.9506e+02i
```

B. *Technique Applied to Structures*

A circuit of matching at 845/920 MHz needs to be considered for effective functioning of tag. The matching network must ensure maximum power transfer at 845/920 MHz. This is achieved by using a tuning circuit of L-section as shown in Fig. 2. By this

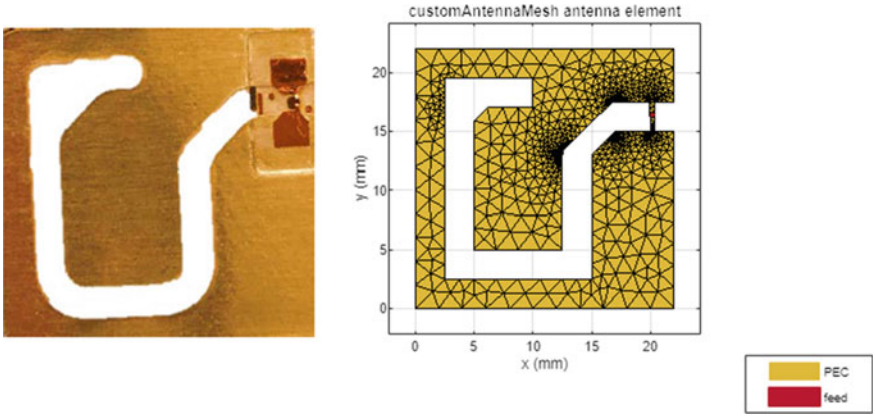


Fig. 1 Layout of RFID reader antenna tag

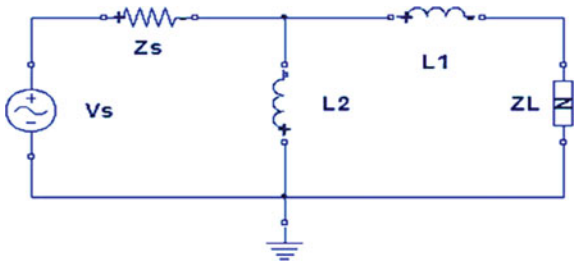


Fig. 2 Proposed L-section double tuning network design of matching network

network topology, the capacitance of larger value is nullified at 845/920 MHz, and matching between input and output resistance are enhanced.

C. *Simulation and Analysis of RFID Tag*

The proposed L-section double tuning network with proposed RFID reader tag simulation as shown in Fig. 3 was implemented using Matlab Antenna Toolbox. The characteristics of antenna from simulations are obtained and verified with following parameters.

The simulation results of proposed RFID Tag Antenna Radiation pattern is shown in Fig 5. Also, 3D radiation pattern at the frequency of 845 MHz and 920 MHz are illustrated in Figs. 5 and 6 respectively. The code below executes the 3D antenna Radiation Pattern measurement for both 845 MHz and 920 MHz.

```
>> Pattern(ant, 845e6);

>> Pattern(ant, 920e6);
```

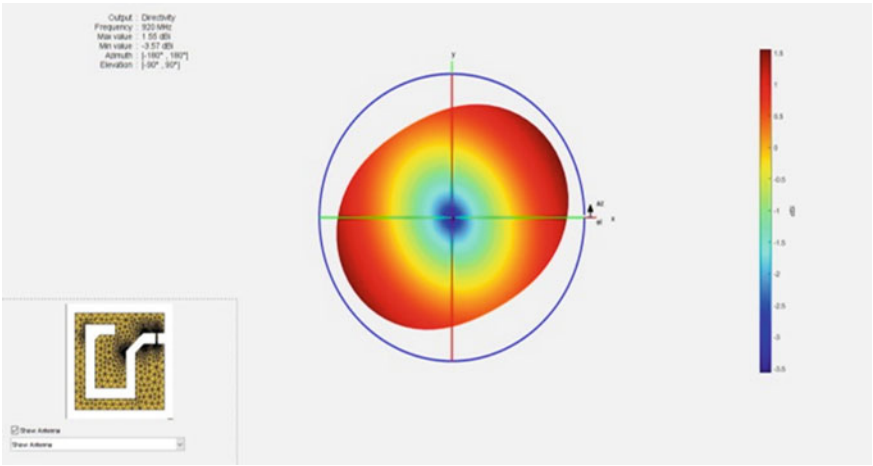


Fig. 3 Proposed RFID reader antenna tag and mesh design

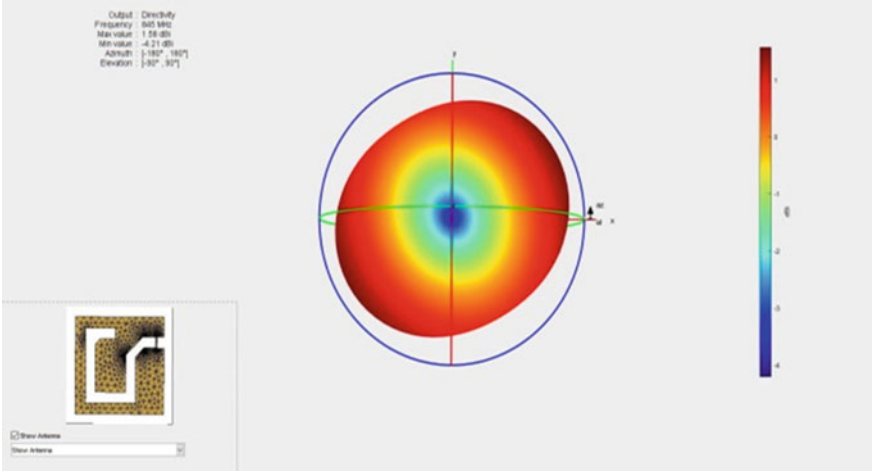


Fig. 4 Proposed RFID rag antenna radiation pattern

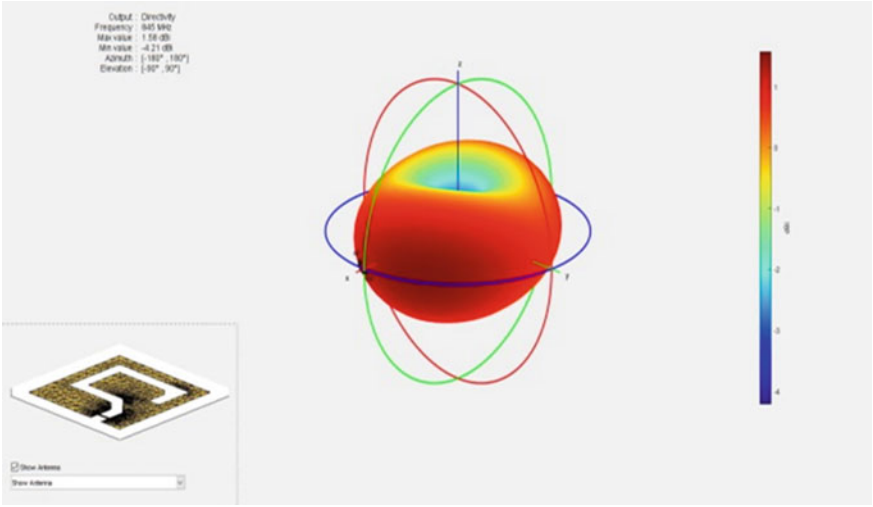


Fig. 5 3D pattern of radiation @ 845 MHz

The tag holds value of null with respect to zenith but provides an optimum coverage value of about 1.55 dBi. These illustrations show function of antenna in a small distance from point of observation which is essential for the tag.

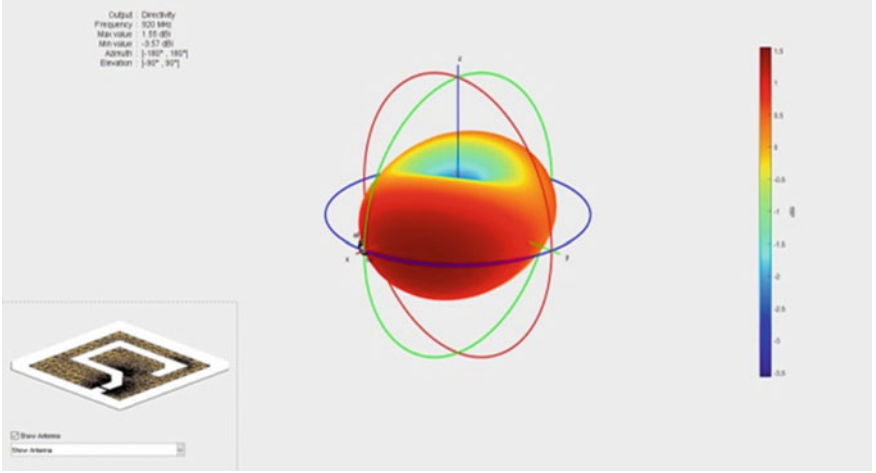


Fig. 6 3D pattern of radiation @ 920 MHz

3.2 Design 2: Design of H-Type Microstrip Patch Antenna

The next work is proposed for the design of H-Type microstrip patch antenna operated at 845/920 MHz ISM/RFID band. By using Matlab antenna designer and optimizer app, H-Type microstrip patch antenna is designed and optimized. Figure 7 shows the design of H-Type microstrip patch antenna, scalar, and vector analysis of proposed antenna includes impedance, S-parameter, current distribution, azimuth (AZ), and elevation (EL) directivity pattern operated at 920 MHz frequency.

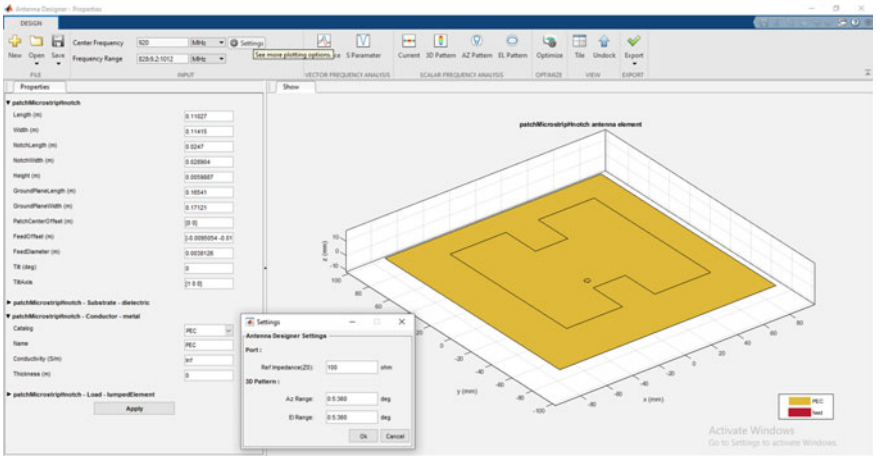


Fig. 7 Modeling and analysis of H-type microstrip patch antenna using Matlab antenna designer app

3.3 *Design 3: Optimization of H-Type Microstrip Patch Antenna*

This section shows the proposed antenna structure further optimized using Matlab SADEA and surrogate optimizers for the objective function in order to minimize the area of the structure and maximize antenna gain. The objective of array optimization is to maximize the gain and ratio between the front lobe and the first side lobes of the antenna. It is also meant to increase the front-lobe-to-back-lobe ratio. The main objective is to minimize the maximum area occupied by the antenna. Figures 8 and 9 show the simulation results of optimization of proposed H-Type microstrip patch antenna using Matlab in-built Sadea and Surrogate optimizer. The following parameters are considered below for the optimization process. The objective function minimizes the array aperture if the dimension of the array element is smaller than the aperture.

- Objective Function: Minimize Area
- Frequency Range: 828:9.2:1012 MHz
- Center Frequency: 920 MHz
- Main Lobe (AZ,EL): [0 90]
- Iteration: 100

SADEA Optimization Algorithm:

This algorithm includes two stages of process. The first one is building the model, and second process is optimization. During the first stage, a SADEA model is construed from the work space. The stated objectives and functions of limitations are derived.

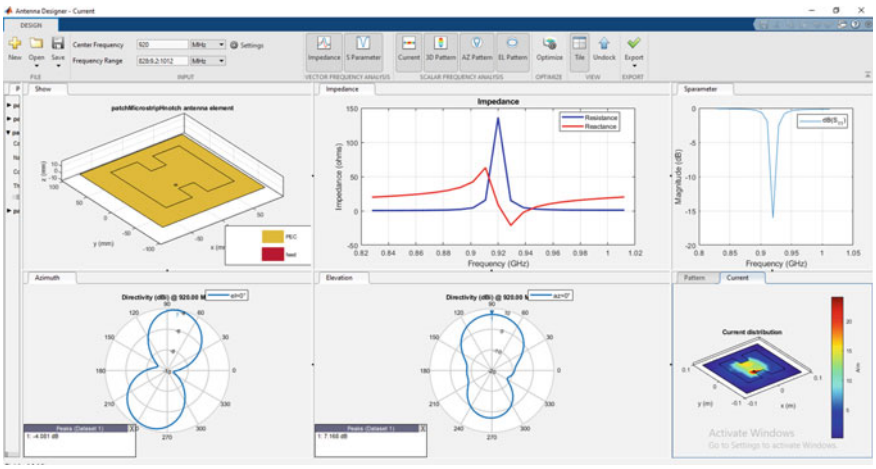


Fig. 8 Simulation results of H-Type microstrip patch antenna using Matlab antenna designer app

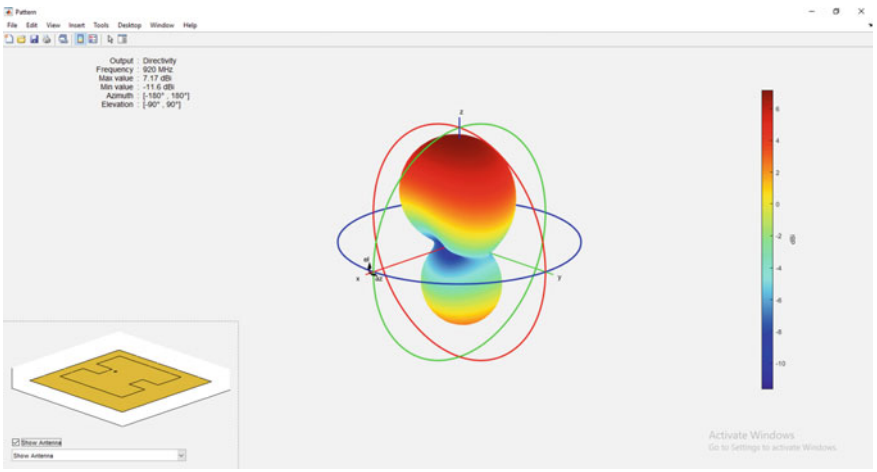


Fig. 9 Radiation pattern analysis of H-type microstrip patch antenna using Matlab

The process is accomplished on the points of sample. Once the antenna model is constructed, the optimizer is executed as per specified iterations.

Similarly, another optimizer can be selected from the app called surrogate model is employed. Figures 10 and 11 show the optimization of antenna using SADEA and surrogate optimizers, respectively. Table 1 illustrates the comparison with literature.

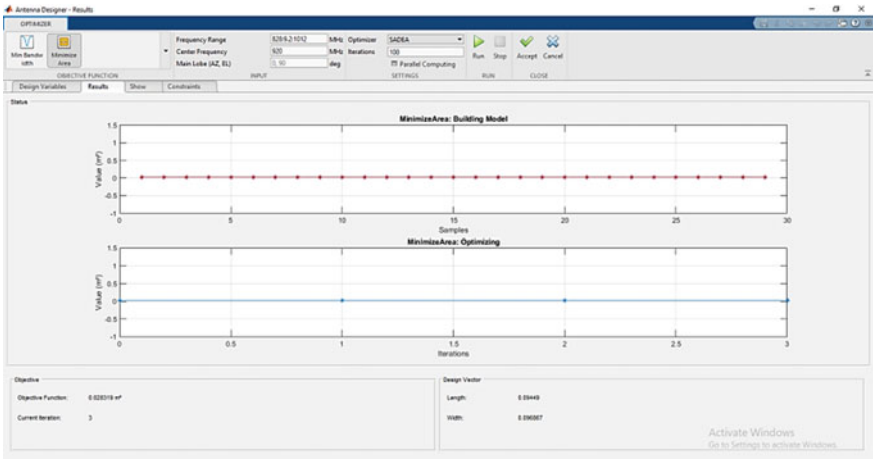


Fig. 10 Antenna optimization using SADEA optimizer

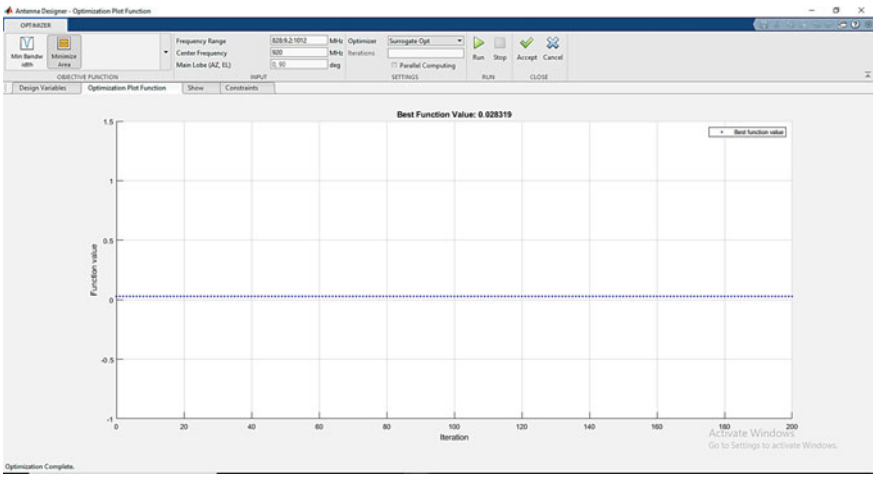


Fig. 11 Antenna optimization using surrogate optimizer

Table 1 Comparison with literature

Ref. No	Antenna structure	Size (mm^2)	Gain (dB)
[12]	C-slot Rectangular MSA	0.5 × 6	2.45
[13]	Ring antenna	35 × 20	5.2
[14]	Patch antenna	30 × 35	4.1
[15]	Hexagonal MSA	30.4 × 35.4	3.6
Optimized H –Type microstrip patch antenna	Optimized H –Type microstrip patch antenna	22 × 22	5.32

4 Conclusion

An 845/920 MHz RFID antenna tag and H-type microstrip patch antenna are demonstrated, operated, and simulated using Matlab. After optimization, gain of antenna is 7.38 dB, loss of returns is −11.8 dB and dimension is 166 mm × 166 mm. The antenna frequency is resonant at 845/920 MHz with loss of −34.66 dB. The design is simple in structure and can be fabricated easily. The observations indicate that patch antenna at specified frequencies can be an optimum solution in the field of IoT-based biomedical applications. The future scope of this work is to apply this structure for patch antennas of smaller size in the band of microwave frequencies with low profile, low cost and easy fabrication.

References

1. Mansour, M., & Kanaya, H. (2020). Design of a compact CPW antenna operating at the 920 MHz ISM/RFID band. *IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting, 2020*, 1315–1316. https://doi.org/10.1109/IEEECONF35879.2020.9329844
2. Omar, H. Q., Khoshnaw, A., & Monnet, W. (2016). Smart patient management, monitoring and tracking system using radio-frequency identification (RFID) technology. In *2016 IEEE EMBS Conference on Biomedical Engineering and Sciences (IECBES).* https://doi.org/10.1109/iecbes.2016.7843411
3. Chen, R.-S., et al. (2018). RFID-based system on emergency medical care. In *2018 9th International Symposium on Parallel Architectures, Algorithms and Programming (PAAP)* (pp. 6–11). https://doi.org/10.1109/PAAP.2018.00009
4. Lin, C. T., Wang, C. Y., Huang, K. C., Horng, S. J., & Liao, L. D. (2021). Wearable, multimodal, biosignal acquisition system for potential critical and emergency applications. *Emergency Medicine International, 10*(2021), 9954669. https://doi.org/10.1155/2021/9954669.PMID:34221510;PMCID:PMC8213464
5. Abuelkhail, A., Baroudi, U., Raad, M., et al. (2021). Internet of things for healthcare monitoring applications based on RFID clustering scheme. *Wireless Networks, 27*, 747–763. https://doi.org/10.1007/s11276-020-02482-1
6. Tsao, Y.-C., Cheng, F.-J., Li, Y.-H., & Liao, L.-D. (2022). An IoT-based smart system with an MQTT broker for individual patient vital sign monitoring in potential emergency or prehospital applications. *Emergency Medicine International., 2022*, 1–13. https://doi.org/10.1155/2022/7245650
7. Pai, G., D'souza, J. M., D'souza, J. T., Acharya, S. R., & Chaitra. (2017) Health monitoring using RFID. *American Journal of Intelligent Systems, 7*(3), 100–103. https://doi.org/10.5923/j.ajis.20170703.13
8. Shanin, F., et al. (2018). Portable and centralised E-health record system for patient monitoring using Internet of Things(IoT). In *2018 International CET Conference on Control, Communication, and Computing (IC4)* (pp. 165–170). https://doi.org/10.1109/CETIC4.2018.8530891
9. Naresh, V. S., Reddi, S., & Murthy, N. V. E. S. (2020). Secure lightweight IoT integrated RFID mobile healthcare system. *Wireless Communications and Mobile Computing, 2020*, 1–13. https://doi.org/10.1155/2020/1468281
10. Sahukara, K. V., Ammisetty, M. B., Devi, G. S. K. G., Prathyusha, S., & Nikhita, T. S. (2021). COVID-SAFE: IoT based health monitoring system using RFID in pandemic life. In *2021 IEEE International Conference on RFID Technology and Applications (RFID-TA)* (pp. 203–206). https://doi.org/10.1109/RFID-TA53372.2021.9617312
11. Rajagopal, S., & Mehta, S. (2021). An IoT based health monitoring system. *SPAST Abstracts 1*(01). Retrieved from https://spast.org/techrep/article/view/1785
12. Padmavathy, T. V., Venkatesh, P., Bhargava, D., & Sivakumar, N. (2018). *Design of I-Shaped Dual C-Slotted Rectangular Microstrip Patch Antenna (I-DCSRMPA) for Breast Cancer Tumor Detection.* Springer.
13. Amdaouch, I., Aghzout, O., Naghar, A., Alejos, A. V., & Falcone, F. (2018). Breast tumor detection system based on a compact UWB antenna design. *Electromagnetics, 64*, 123–133.
14. Zhu, X. F., & Su, D. L. (2010). A study of a compact microstrip-fed UWB antenna with an open T-slot. *Electromagnetics, 13*, 181–189.
15. Ali, A. S., & Mathur, D. (2015). A novel UWB modified hexagonal microstrip antenna with improved gain. *IJCE, 3.*

Low-power High-speed Approximate Multiplier Design Using Compression Techniques

Shayanki and C. Paramasivam

Abstract Approximate computing is a promising approach in digital circuit and digital signal processing applications which are implicit error tolerant circuits. In this project, four approximate multipliers are proposed with three approximate 4–2 compressors designs. To extend the applicability of the proposed approximate multiplier design highly configurable signed/unsigned multiplication is introduced using a high-level configuration parameter. Inner stage pipelining technique is used to maximize the operating speed with least path delay overhead which bring further improvements in performance efficiency, and optimal clock gating technique is used to reduce the power consumption rate, which bring improvement in energy efficiency. The proposed method was implemented in Xilinx ISE 14.7 version tool and synthesize in cadence genus tool with 45 nm technology. The four proposed multipliers are used in the application of image multiplication by discretizing image in MATLAB and Modelsim. As a result, the area, power, and delay were reduced from the exact multiplier, and the energy efficiency and performance efficiency is more when compared with the existing method.

Keywords Low power · High performance · Approximate 4:2 compressor · Approximated signed/unsigned multiplier · Energy-efficient

1 Introduction

Approximate computing is a promising approach in the field of digital design, allowing for significant performance improvements in terms of area, power, and speed by removing the need for exact computation. It is becoming more relevant for mobile and embedded systems, which have very tight energy and speed restrictions

Shayanki (✉) · C. Paramasivam
Department of Electronics and Communication Engineering, Amrita Vishwa Vidyapeetham, Bengaluru, India
e-mail: bl.en.p2vld20013@bl.students.amrita

C. Paramasivam
e-mail: c_paramasivam@blr.amrita.edu

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_25

[1]. A few examples of these are data mining and recognition, as well as machine learning and multimedia processing. Many different types of embedded and DSP systems rely on multipliers, from simple filtering to CNN. Partial product creation, reduction, and carry-propagate addition [2] are some of the buildings of a multiplier.

Faster systems with lower complexity and power consumption may be achieved via the use of arithmetic approximation. However, the performance of multimedia and machine learning applications will not be harmed as a result of the trade-off [3]. Accordingly, in 4:2 compressors, numerous approximation designs are introduced [5–12]. In [5], two different inventive approximate 4:2 compressors are projected and embedded with the multipliers.

In [11] Mux-based architecture for hardware security is used in approximate multiplier, and in [12] high-performance LUT-based FET architecture is also used in approximate multiplier fast multiplier concept based on approximate 4:2 compressors and modified booth encoding is represented in [13]. In [14], a new derivation approach is suggested; and circuit optimization for lower supply voltage applications at transistor level is presented. At the same time, as computer systems become more integrated and mobile, a wider range of computational activities now include data mining, media processing (graphics, video, audio, and images), and recognition. Imprecision tolerance may stem from a variety of places. The order of the present work is as discussed below; Sect. 2 deliberates the related works. Section 3 details about the projected work by discussing the proposed approximated multiplier design highly configurable signed/unsigned multiplication is introduced using high-level configuration parameter. Inner stage pipelining technique is used to maximize the operating speed with least path delay overhead to enhance the performance efficiency and to lower the power consumption optimal clock gating technique is used. In Sect. 4, the implementation on a multiplier is discussed. And in Sect. 5, the synthesis results are analyzed and compared with the application of proposed four multipliers are discussed, and in Sect. 6, conclusion and future scope are presented.

2 Relatedwork

2.1 Exact 4:2 Compressor

These conventional exact 4:2 compressors use five inputs and produce three outputs. Due to the requirement for faster computer arithmetic required for rapidly developing processor architectures, research on the design of high-speed arithmetic circuits blossomed in the middle of the 1960s [1]. The full adder, which has three inputs and converts the results S into sum and carry two outputs, is the most popular compressor. The CIN leads the input carry [3] across the prior 4: 2 compressor, which steered the minor significant bits. The order '1' outputs with upper importance over the input

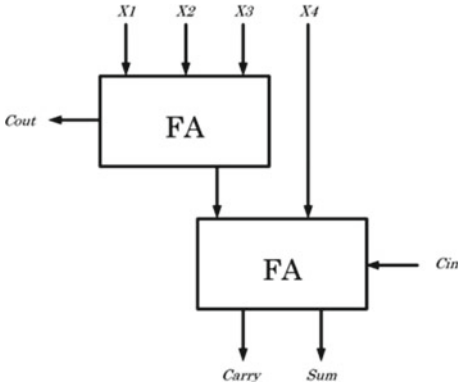


Fig. 1 Exact 4:2 compressor [1]

CIN are CARRY and COUT. To expedite the compression process of partial products, 4:2 compressors are used. Cascading two complete adders, as shown in Fig. 1, is the traditional technique to design a 4:2 compressor.

The exact 4: 2 compressor general block diagram is as shown in Fig. 1. It has five inputs, two complete adders, and two outputs that are cascaded. CIN, A1, A2, A3, and A4 be the input parameters, while COUT, CARRY, and SUM are the outputs. The outputs are given as,

$$\text{COUT} = \text{A3}\ (\text{A1} \oplus \text{A2}) + \text{A1}\ (\text{A1} \oplus \text{A2}) \tag{1}$$

$$\text{CARRY} = \text{CIN}\ (\text{A1} \oplus \text{A2} \oplus \text{A3} \oplus \text{A4}) + \text{A4}\ (\text{A1} \oplus \text{A2} \oplus \text{A3} \oplus \text{A4}) \tag{2}$$

$$\text{SUM} = \text{CIN} \oplus \text{A1} \oplus \text{A2} \oplus \text{A3} \oplus \text{A4} \tag{3}$$

With a higher importance the resultant carry is added in the next bit. The drawback of this utilizes more resource and also time consuming and also not optimized for area, power and delay.

2.2 Approximate Compressor

When these compressors are embedded in multipliers, for generating +ve error, a ceaseless logic '1' is initiated to the succeeding bit MSB of the CC (most significant bit), reducing outputs of the multiple 4:2 approximate compressors to one [1], resulting in further energy-efficiency improvements.

From a holistic aspect depending on reimbursement characteristic of accumulation approximate 4:2 compressors are designed. Figure 2 shows an 8×8 multiplication [3] process by utilizing 3 AC's. In this step, CARRY, CIN, and COUT, are all rejected.

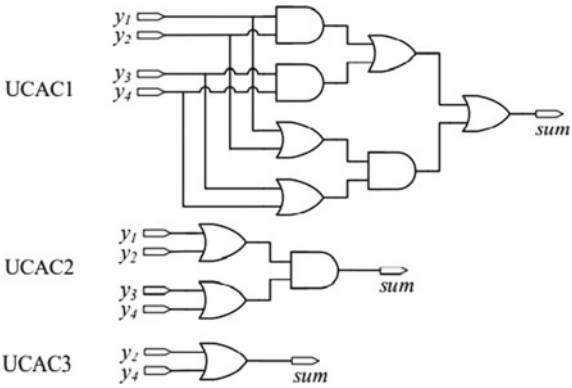


Fig. 2 Approximate 4:2 compressors [1]

And the logical based function of these approximate UCAC1, UCAC2, and UCAC3 is as follows. It is innovatively reducing the multiple 4:2 AC's outputs to 1.

$$\text{UCAC1 sum} = \text{y1y2} + (\text{y1} + \text{y2})\ (\text{y3} + \text{y4}) + \text{y3y4} \tag{4}$$

$$\text{UCAC2} \cdot \text{sum} = (\text{y1} + \text{y2})\ (\text{y2} + \text{y3}) \tag{5}$$

$$\text{UCAC3 sum} = \text{y2} + \text{y4} \tag{6}$$

2.3 Approximate Multipliers

In AI and DSP applications, multiplication is undoubtedly a performance-deciding process. The AI and DSP necessitate high-speed multiplier structures in order to perform fast-moving parallel operations with tolerable accuracy. The use of approximation in multipliers which is shown in Fig. 3. allows for faster computations with less delay and power, hardware complexity, with maintaining desirable levels of accuracy. Because of the propagation lag in adder networks, partial product addition is the speed constraining act in the multiplication. Compressors are used to reduce the propagation delays. The sum is computed by compressors and carried simultaneously to each level.

The multiplier is implemented in three steps:

- Partial products generation,
- Reduction tree of partial products,
- And finally, a vector merge inclusion is being utilized to produce the final product from the sum and carry rows which are produced from the reduction tree.

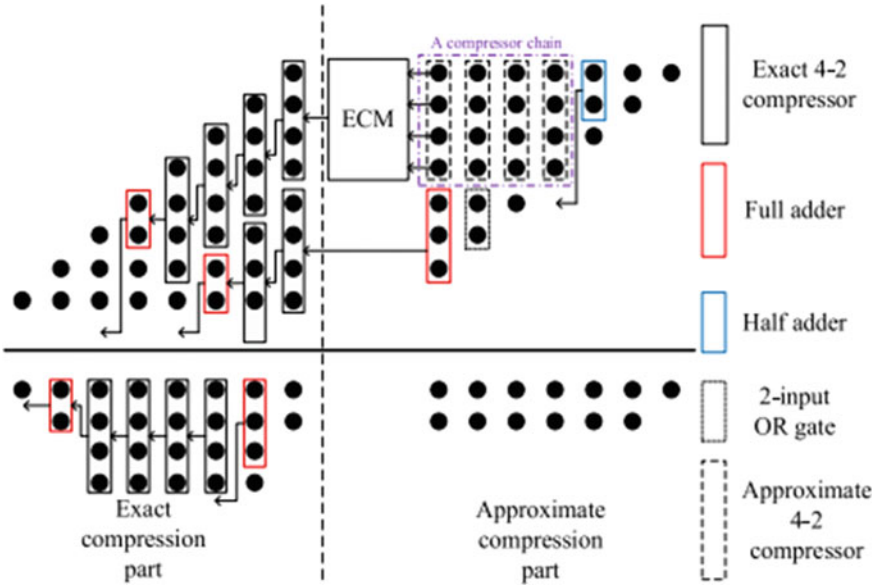


Fig. 3 8 × 8 approximate multipliers [1]

3 Proposed Work

The proposed design with block diagram of approximate multiplier with signed/unsigned implementation it works for signed as well as unsigned, and inner stage pipeline technique is used in between the partial product accumulation to decrease the multipliers critical path. The objectives of the proposed work are as follows:

- To extend the applicability of the proposed approximated multiplier design highly configurable signed/unsigned multiplication is introduced using high-level configuration parameter.
- Inner stage pipelining technique is used to maximize the operating speed with least path delay overhead to increase the performance efficiency and optimal
- Clock gating technique is utilized to decrease consumption rate of the power to enhance the energy efficiency

The block diagram which shown in Fig. 4. is proposed design of approximate multiplier in which we modified the previous dadda multiplier [1] with signed unsigned multiplier and it work for signed as well as unsigned and inner stage pipeline technique is used in between the partial product accumulation to decrease the multiplier's critical way. For reduce path delay after giving input it will take some time to output or end result that is critical path by including some register between that the critical path is reduced and overall delay also reduced that is inner stage

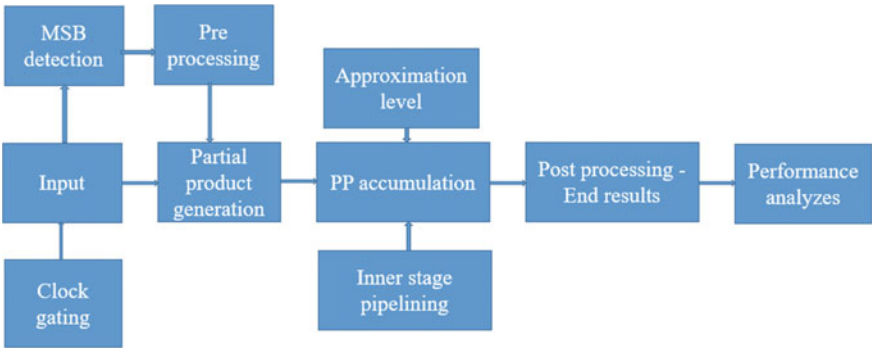


Fig. 4 Proposed approximate multiplier block diagram

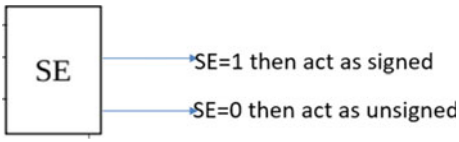


Fig. 5 Configuration parameter for signed/unsigned

pipelining technique and clock gating technique also used to reduce or narrow the power consumption rate.

Here, pre-processing and post-processing used for signed direction module based on 2s complement which is enabled by SE signal shown in Fig. 5. that is sign enable signal. When SE = 1, then it works as signed and when SE = 0 then it works as unsigned hence in this way this module is work. Clock gating is a method which decreases clock signal switching power loss. Synthesis-based methods: based on the underlying system's logic, the clock allows the signal to be created. Conditions if input one signal is zero or other is zero or else both zero then at this condition clock gate disable and the input directly redirect to output then by this, we optimized the overall power of circuit. Clock gate control signal generate by AND operation of clock and gate. Pipelining is the generic technique used widely for reducing the path delay as shown in Fig. 5. If the path delay is reduced, the frequency is increased, and hence the pipeline is used to reduce the critical path by inserting register between the path to increase the frequency of the system.

4 Implementation Details

The proposed four approximate signed/unsigned multiplier designs are done with the help of Verilog language of the Xilinx Vivado 2018.1. It is executed on Artix7 FPGA board target device xc7a35tcpg236-1 and parallel implementation of exact compressor [7]. Approximate compressor [1] and approximate multiplier [1] created

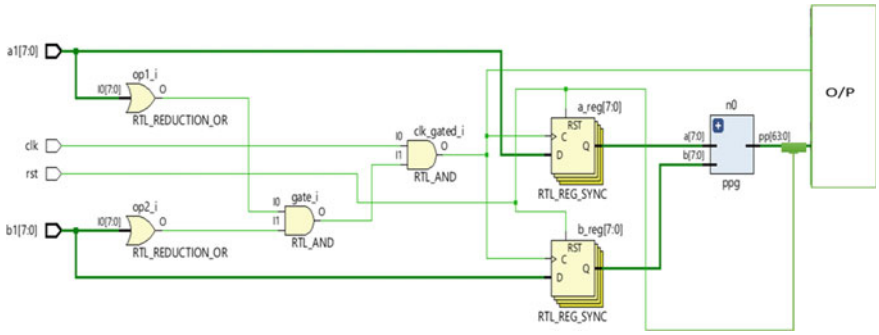


Fig. 6 RTL schematic of signed approximate multiplier

for comparison by using Virtex 6 boards, which is done with Exact multiplier and four approximate multipliers, designed by 3 approximate compressor and Ecm With the help of Xilinx Vivado 2018.1 tool. The schematic of the RTL signed approximate multiplier for multiply of two signed and unsigned 8 bit which each stage is formed by exact approximate compressor follow by half adder and full adder placed one under the other in parallel paths which act the compression process of multiplier is shown in Fig. 6. The performance analysis of the proposed designs, cadence genus also used with 45 nm CMOS technology.

5 Results and Analysis

The design of four approximate multipliers is proposed with highly configurable signed/unsigned multiplication with clock gating technique and inner stage pipelining. This section presents and discusses the results of the extended and optimized schemes simulated with Xilinx Vivado and Modelsim.

5.1 Simulation

In this section, we see the simulation result shown in Fig. 7 of signed/unsigned multipliers which shows that the proposed multiplier is work with signed and unsigned numerical values. When SE = 1 then its work like signed multiplier. When SE = 0 then it worked liked unsigned.

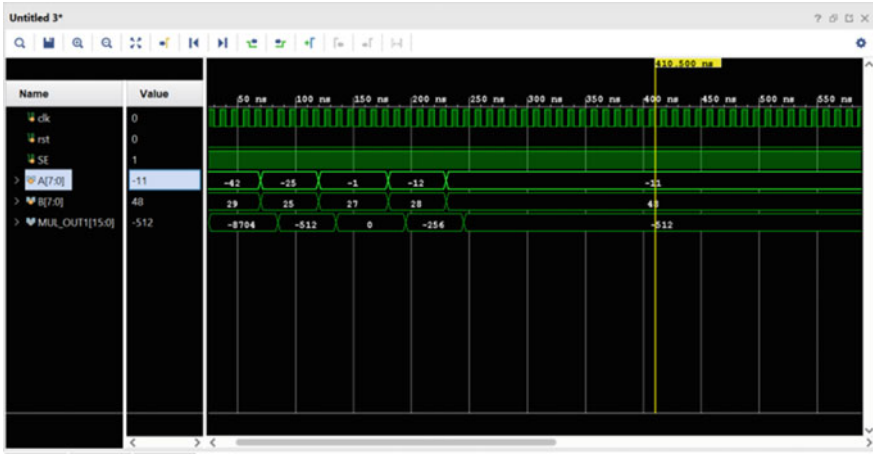


Fig. 7 Simulation of signed approximate multiplier

5.2 Power Delay and Resource Consumption Results

The designed multipliers are carefully implemented using Artix 7 FPGA boards, and by using Xilinx Vivado simulated. Their corresponding energy utilization, delay, and resource utilization details have been obtained and shown in Table 1.

Table 1 illustrates the different resource utilization, power and delay by this analysis here found that the area delay and power is reduced from exact multiplier and after implementation of signed one also the area power and delay less than exact multiplier. which is shown in Fig. 8.

Table 1 Synthesized results of multipliers (FPGA)

Multipliers	Area (LUT's)	Delay (ns)	Power (W)
EXACT MUL	79	10.218	13.898
MUL1 [1]	61	9.807	7.914
MUL2 [1]	70	9.681	12.712
MUL3 [1]	69	9.681	12.326
MUL4 [1]	69	9.681	12.284
PropMul_1	68	4.056	5.848
PropMul_2	75	5.112	6.999
PropMul_3	71	4.056	5.906
PropMul_4	71	4.056	5.906

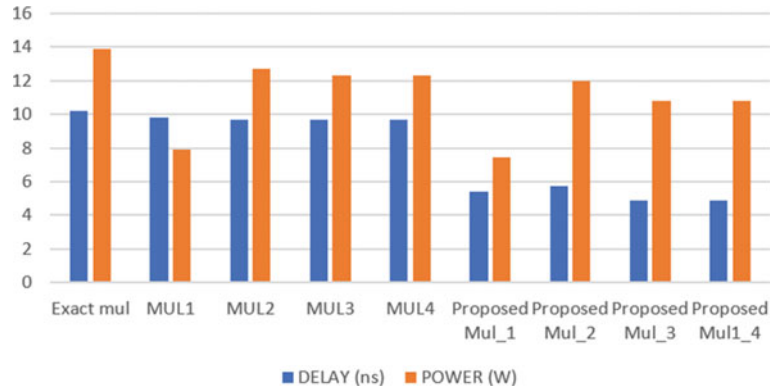


Fig. 8 Power and delay comparison of multipliers in FPGA designs

5.3 ASIC Synthesis Results

Power, delay, and hardware overhead comparison, the proposed AM, as well as the AM in [1] and the exact multiplier, have all been synthesized by using a 45 nm CMOS cell library. Cadence Genus tool is used for approximate multiplier designs synthesizing. Table 2 shows the results of post-synthesis.

Table 2 illustrates the different resource utilization, power and delay cadence genus by this analysis here found that the area delay and power is reduced from exact multiplier and after implementation of signed one also the area power and delay less than exact multiplier and previous design [1] shown in Fig. 9.

Table 2 Synthesized results of multipliers (ASIC)

Multipliers	Area (μm^2)	Delay (ns)	Power (μw)
EXACT MUL	293.291	0.357	16.424
MUL1 [1]	108.88	0.241	6.914
MUL2 [1]	116.924	0.241	7.449
MUL3 [1]	115.556	0.241	7.549
MUL4 [1]	115.555	0.241	7.548
PropMul_1	128.317	0.12	5.291
PropMul_2	132.317	0.12	5.591
PropMul_3	133.843	0.12	5.620
PropMul_4	133.598	0.12	5.660

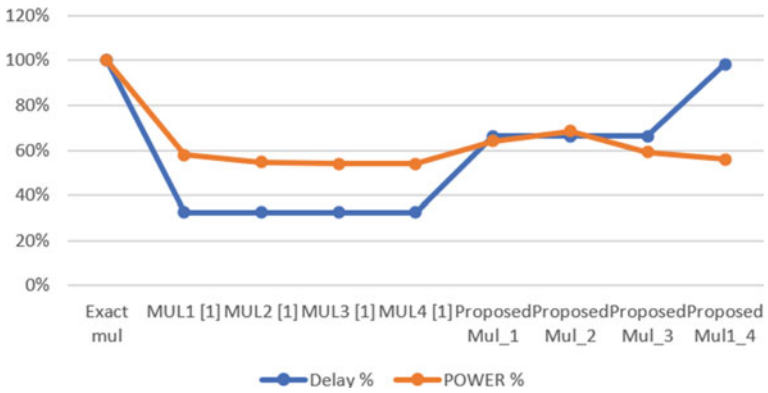


Fig. 9 Power and delay comparison of multipliers in ASIC design

5.4 Image Processing Application

All the four multipliers which are proposed are evaluated using the image multiplication in this section. A MATLAB program is used for pixel-by-pixel discretization of the images. The data is then processed by Modelsim's exact and approximate multipliers. Finally, MATLAB integrated the all outputs from the simulation tools to create a new image. The term peak signal-to-noise ratio is utilized for measuring the multipliers performance. Two original source images are represented by Object A and Object B. Both the exact and near about outcomes are showed in the Figs. 12 and 13, respectively. Despite the fact that the PSNR number shows a difference between the two images, the difference cannot be seen with the naked eye. The PSNR and SSIM (structure similarity index map) indicate different value for exact and four approximate multiplier, which shows that they are different from each (Figs. 10 and 11).

Fig. 10 Object A

Fig. 11 Object B

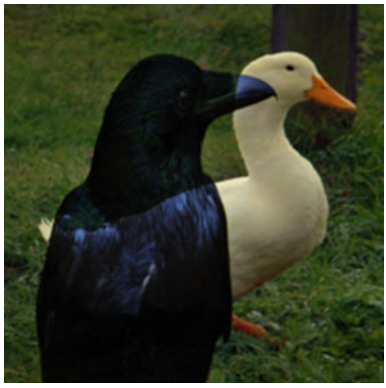


Fig. 12 Exact result

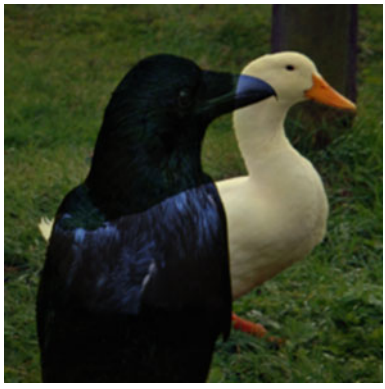


Fig. 13 Approximate result

6 Conclusion and Future Scope

This paper discusses the four signed/unsigned 8-bit approximate multipliers with three approximate 4–2 compressors design. To extend the applicability of the proposed approximated multiplier design signed/unsigned multiplication is introduced which achieve a signed as well as unsigned multiplication. Inner stage pipelining technique which brings improvements in performance efficiency and optimal clock gating technique which reduced the power consumption rate which bring improvement in energy efficiency. With the help of the proposed design approach, we have synthesized 45-nm technology library of the approximate multipliers. As a result, the area, power, and delay are less from exact multiplier and when compared with earlier presented approximated multipliers indicates that the proposed design gives much improved speed and power for a targeted accuracy and performs very well in the field of image multiplication. The approximate and exact outcomes are not identifiable by naked eyes. In this proposed method, we have implemented the multiplier design with 8-bit multiplier architecture. By replacing these 8 bits with 16-bit architecture multiply the 16-bit number and then further improvise the performance of the multiplier.

References

1. Pei, H., Yi, X., Zhou, H., & He, Y. (2021). Design of ultra-low power consumption approximate 4:2 compressors based on the compensation characteristic. *IEEE Transactions on Circuits and Systems.*
2. Ullah, S., Schmid, H., Sahoo, S. S., Rehman, S., & Kumar, A. (2021). Area-optimized accurate and approximate softcore signed multiplier architectures. *IEEE Transactions on Computers, 70.*
3. Edayoor, P. J., Raveendran, S., & Rahulkar, A. (2020). *Approximate Multiplier Design Using Novel Dual-Stage 4: 2 Compressors.* IEEE Access.
4. Liu, C., Fabrizio, J. H., & Lombardi, H. (2019). A low-power, high-performance approximate multiplier with configurable partial error recovery. *IEEE Transactions on Very Large Scale Integer. (VLSI) Syst., 25*(5), 1782–1786.
5. Ha, M., & Lee, S. (2019). Multipliers with approximate 4–2 compressors and error recovery modules. *IEEE Embedded Systems Letters, 10*(1), 6–9.
6. Hema Mithra, K. G., Priya, S. L., Lakshmirajan, K., Mohanrai, R., & Ramesh, S. R. (2018). FPGA implementation of power efficient approximate multipliers. In *2018 3rd IEEE International Conference on Recent Trends in Electronics, Information Communication Technology (RTEICT).*
7. Yi, X., Pei, H., Zhang, Z., Zhou, H., & He, Y. (2019). Design of an energy efficient approximate compressor for error-resilient multiplications. In *Proceedings of the IEEE International Symposium on Circuits Systems (ISCAS)*, Sapporo, Japan.
8. Edavoor, P. J., Raveendra, S., & Rahulkar, A. (2020). *Approximate Multiplier Design Using Novel Dual-Stage 4: 2 Compressors.* IEEE Access.
9. Esposito, D., Strollo, A. G. M., Napoli, E., De Caro, D., & Petra, N. (2018). Approximate multipliers based on new approximate compressors. *IEEE Transactions on Circuits and Systems I: Regular Papers, 65*, 4169–4182.

10. Hatti, K., & Paramasivam, C. (2021). The MUX-based PUF architecture for hardware security. In *2021 International Conference on Circuits, Controls and Communications (CCUBE).*
11. Harshitha, Y., & Paramasivam, C. (2020). Design of low complexity high performance LUT based feed-forward FFT architecture. In *2020 IEEE International Conference for Innovation in Technology (INOCON)*, Bangluru, India.
12. Saha, A., Pal, R., Naik, A. G., & Pal, D. (2019). Novel CMOS multi-bit counter for speed-power optimization in multiplier design. *AEU-International Journal of Electronics and Communication, 95*, 189–198.
13. Rose Varghese, N., & Swaminadhan, R. (2019). High speed low power radix 4 approximate booth multiplier. In *2019 3rd International Conference on Electronics, Materials Engineering Nano-Technology.* IEEE, Kolkata, India.
14. Roshni, T., Krishna, R. S., Reddy, P. K., & Vinodhini, M. (2020). Improved High speed approximate multiplier. In *2020 4th International Conference on Electronics, Materials Engineering Nano-Technology*, Kolkata, India.
15. Pattunnarajam, P., & Jackson, B. (2020). Analysis of 32×32-bit parallel pipeline multiplier using in-built register transfer level testing approach. *Journal of Computational and Theoretical Nanoscience, 17*, 1804–1811.

Design of Bio-inspired Maple Leaf-Shaped Textile Antenna for Wireless Application

R. Jothi Chitra, M. Sivarathinabala, S. Vathana Sree, S. Akshaya, and S. Rajarajeshuwari

Abstract This paper introduces a new design of bio-inspired maple leaf-shaped textile microstrip patch antenna for wireless applications. The proposed maple leaf-shaped antenna is designed to resonate in the C band frequency range of 6.6–8.9 GHz. The maple leaf-shaped radiating patch is excited with 50 Ω microstrip feed line. The proposed antenna uses a Jeans fabric substrate which has a dielectric constant of $\varepsilon_r = 1.6$ and a tangent loss of 0.003. By incorporating maple leaf-shaped structure in the radiating patch, it resonates for wideband frequencies with a fractional bandwidth of 29.67%. The maximum achievable gain of the designed antenna is 3.8 dBi. Using Ansoft HFSS software, the antenna radiation parameters such as VSWR, radiation pattern, gain, and return loss are simulated. The simulated results are examined and presented.

Keywords Bio-inspired · Textile · Maple leaf-shaped · Jeans · Wideband

1 Introduction

Researchers and scientists have recently become interested in bio-inspired antennas. Nowadays, researchers are incorporating bio-inspired geometry in textile antenna for wireless application. Bio-inspired geometries are developed using bio-inspired geometry from plants and animals. Bio-inspired antennas in plants use parts of plants such as flower, leaf, and stem to design antennas for different applications. Similarly, bio-inspired animal geometries can be obtained from external parts and internal organs of animals to design antenna for various technologies. Due to promising results, researchers have become interested in the development of bio-inspired leaf-shaped textile microstrip patch antenna for wireless application. Microstrip patch antenna is recommended for textile antenna due to its exceptional features like low cost, small weight, selection of substrate material based on the applications, easily

R. Jothi Chitra (✉) · M. Sivarathinabala · S. Vathana Sree · S. Akshaya · S. Rajarajeshuwari
Department of Electronics and Communication Engineering, Velammal Institute of Technology, Chennai, India
e-mail: sureshashika@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_26

fabricated, fabrication cost is less and support multiband application. The leaves exhibit similar fractal geometry characteristics which increases the perimeter of the antenna without increasing the antenna size. The fundamental idea and design process of microstrip patch antenna are presented in [1]. In [2], a novel maple leaf-shaped antenna for various band rejection techniques for ultra-wideband application is addressed. In this work, band notch characteristics is achieved in two different frequency bands from 3 to 14 GHz and 5 to 6 GHz by incorporating rectangular slits in the ground plane and H-shaped slot in the patch, respectively.

In [3], a bio-inspired gynkgo biloba leaf-shaped antenna is designed on textile material for wearable applications. This antenna resonates for second-generation, third-generation, and fourth-generation systems with a gain of 3.10 dBi. Further in [4], a maple leaf-shaped with two frequency band notch functionality for UWB application is designed. By incorporating a meandered slot and a U slot in the feed line, it has band notch characteristics from 1.7 to 11.1 GHz. In the literature [5], a bio-inspired antenna was designed using Carica papaya leaf-shaped radiating patch for wideband application. In this work, the circular form patch was perturbed to produce this structure. The maximum gain of the gain is 10.22 dB and quasi-omnidirectional pattern is obtained. It can be used for multiband applications.

In this review paper [6], study of various issues and challenges arises during the fabrication of wearable antennas, then range of materials, manufacturing processes, including bending scheme. In [7], an innovative omni-directional bio-inspired Linden leaf-shaped rectenna's design and implementation are described in this article for energy harvesting application in the frequencies 1.6 and 2.65 GHz. In this research paper [8], the radiating patch shape is based on semi-Vitis vinifera, a leaf-shaped semi-Carica papaya, Defected Ground Structure, an L-shaped slit technique, and a leaf-shaped semi-Monstera deliciosa structure has been addressed. A leaf-shaped vine antenna covers the frequencies at 2.5 and 5.4 GHz, a semi-Carica papaya-shaped patch radiates at 2.4 and 4.4 GHz, and the Monstera deliciosa-shaped leaf antenna operates at 2.6, 4.4, and 5.5 GHz. Consequently, this research paper [9] presents a hexa-band bio-inspired antenna and covers multi-frequencies such as 2.37 GHz then at 3.06 GHz, 3.52 GHz and also 4.28, 4.88, and 6.0 GHz, by incorporating Arc-slots, Defected Ground Structure (DGS), and a semi-vine leaf form structure in the radiating element.

Further in [10], a rectangular horn-shaped wearable antenna with Jeans substrate is designed for multiband applications. This antenna covers ISM band, Wi-Fi, WiMAX, and C band applications. In the literature [11], the proposed geometry makes use of rectangular patches built with copper foil tape, polyester as a substrate material, and a new technology of Defected Ground Structure (DGS), with an inset feed technique. The suggested antenna operates in the Industrial, Scientific, and Medical band at a frequency of 2.4 GHz.

The research work, cited above, describes the antennas designed individually using bio-inspired geometry and textile properties. In this letter, a new compact bio-inspired maple leaf-shaped textile antenna is designed by combining the textile characteristics with bio-inspired geometry is proposed for wireless application. The remaining section is structured as follows: The design bio-inspired maple leaf-shaped

textile antenna is discussed in Sect. 2. Section 3 depicts simulation results and discussions. Section 4 describes the conclusion.

2 Antenna Model

This section discusses the design process for the proposed maple leaf-shaped textile antenna. The proposed bio-inspired textile antenna model is a unique structure with radiating patch element in the form of maple leaf. The bio-inspired antenna is designed on Jeans fabric substrate with a permittivity of $\varepsilon_r = 1.6$, loss tangent of tan δ 0.003, and the thickness of substrate is 1.57 mm. A microstrip fed line with 50 Ω characteristics impedance is placed at the optimized position and connected to the radiating element. To enhance the antenna radiation characteristics, the feed line should be connected to the patch with the appropriate impedance matching. The substrate material, antenna size, and feed position all affect the antenna's characteristics. The bio-inspired maple leaf-shaped antenna has a compact size of 30 mm × 35 mm. Initially, a radiating patch is designed above the substrate with maple leaf-shaped structure, and the ground plane is etched below the substrate.

Figures 1 and 2 show the front and back view of proposed maple leaf-shaped textile antenna, respectively. The step cuts made in the rectangle patch result in maple leaf-shaped patch. The radiation characteristic of the proposed antenna model depends upon step cuts of the radiating patch. Since a maple leaf radiating patch is incorporated in a Jeans substrate, it exhibits textile antenna property. The proposed maple leaf-shaped textile antenna resonates from 6.6 to 8.9 GHz C band frequency range. Initially, width and length of ground plane, width and length of patch, and dimensions are computed using transmission line method [1]. The antenna's geometrical dimensions are computed and given in Table 1. Figure 3 shows the typical picture of maple leaf-shaped used in this work [12].

The dimensions of the step cuts of maple leaf-shaped radiating patch are depicted in Table 2.

3 Result and Discussion

The results of return loss, Voltage Standing Wave ratio (VSWR), radiation pattern, and gain of bio-inspired maple leaf-shaped textile antenna are discussed and reported in the section. Figure 4 depicts the simulated VSWR value of the proposed antenna, and it is observed that the VSWR value for the frequencies 6.6 GHz, 6.7 GHz, 7.5 GHz, 8.4 GHz, 8.7 GHz, 8.9 GHz, and 13.5 GHz are 1.3, 1.4, 1.9, 1.3, 1.2, 1.5, and 1.35, respectively. The optimum VSWR value for a good antenna should be ≤ 2. For all the above-mentioned frequency ranges, the VSWR value is optimum. Therefore, the fractional bandwidth of the designed antenna is 29.67%.

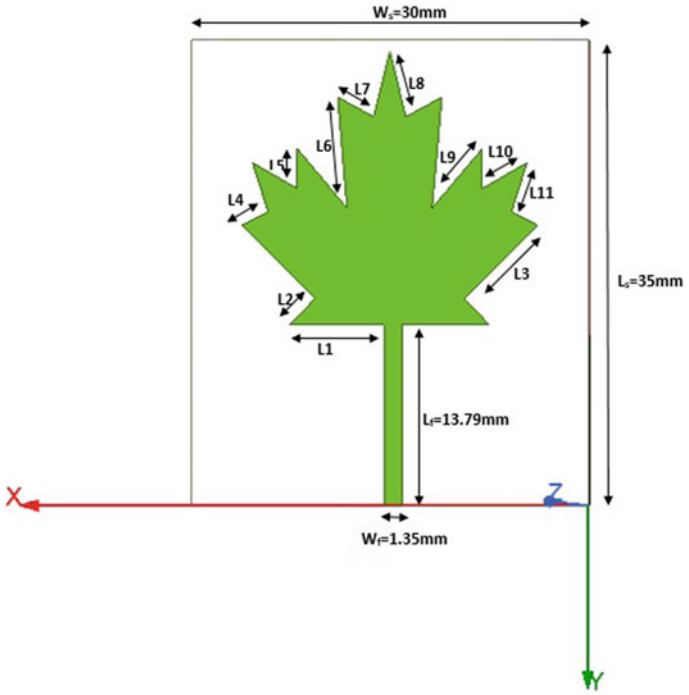


Fig. 1 Maple leaf-shaped antenna

Figure 5 illustrates the return loss (S_{11}) value of bio-inspired maple leaf-shaped textile antenna. The return value for the resonant frequencies 6.6 GHz, 6.7 GHz, 7.5 GHz, 8.4 GHz, 8.7 GHz, and 8.9 GHz are −14 dB, −34 dB, −10 dB, −31 dB, −15 dB, and −10 dB, respectively. The ideal return loss value for a good antenna is below −10 dB, and it should be more negative. For all the above-mentioned resonant frequencies, the return loss value is greater than −10 dB. Therefore, loss due to impedance match in the C band frequency range is small. From the VSWR and return loss simulation findings, it is inferred that the suggested antenna is well suited for wireless communication.

Table 3 indicates the simulated return loss and VSWR value of bio-inspired maple leaf-shaped textile antenna for different frequency range.

Figure 6(i)–(vi) shows the simulated 2D E plane and H plane radiation pattern of bio-inspired maple leaf-shaped antenna for the frequencies 6.5, 6.8, 7.5, 8.4, 8.8, and 13.5 GHz are studied and presented. The 2D radiation pattern for the entire frequency range is nearly quasi-omnidirectional, which indicates the proposed antenna is suited for wireless application [13, 14].

The 3D gain plot bio-inspired maple leaf-shaped textile antenna for different frequency ranges are illustrated inv Fig. 7(i)–(iv). From the graph, it is inferred that the maximum gain obtained over the operating frequency range is 3.7 dBi.

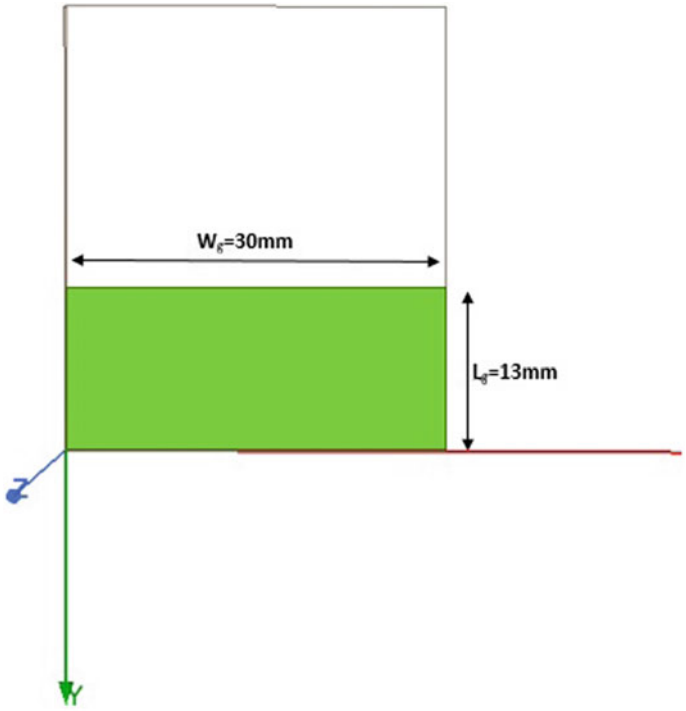


Fig. 2 Ground plane of proposed antenna

Table 1 Geometrical dimensions of maple leaf-shaped antenna

Parameter	Specifications	Dimensions in mm
L_s	Substrate length	35
W_s	Substrate width	30
L_f	Feed line length	13.79
W_f	Feed line width	1.35
L_g	Ground plane length	13
W_g	Ground plane width	30
H_s	Substrate height	1.57

4 Conclusion

A novel compact bio-inspired maple leaf-shaped textile antenna is designed for wireless application. The proposed antenna consists of maple leaf-shaped patch on the Jeans fabric substrate. The antenna resonates for 6.6–8.9 GHz C band frequency with fractional bandwidth of 29.67%. The simulated results of VSWR and return loss for the resonant frequencies meet the optimum value. The radiation pattern is nearly quasi-omnidirectional for all the frequency bands. The maximum achievable gain is

Fig. 3 Typical maple leaf

Table 2 Dimensions of step cut of maple leaf-shaped radiating patch

Design parameter	Dimensions (mm)	Design parameter	Dimensions (mm)
L1	7	L7	3.14
L2	2.73	L8	5.15
L3	7.91	L9	5.94
L4	2.23	L10	3.98
L5	3.05	L11	3.98
L6	8.53	–	–

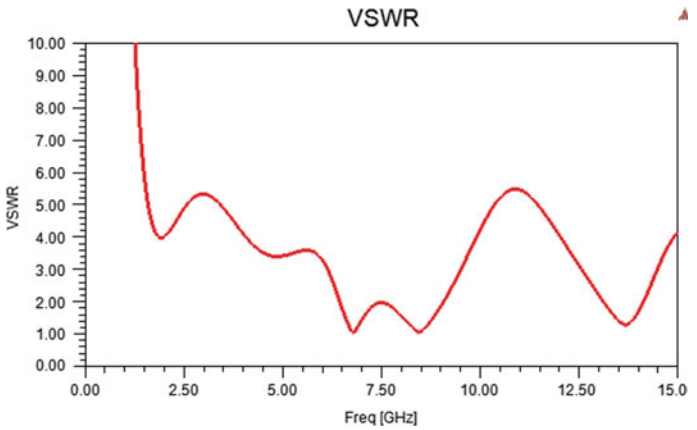


Fig. 4 Simulated VSWR of bio-inspired maple leaf antenna

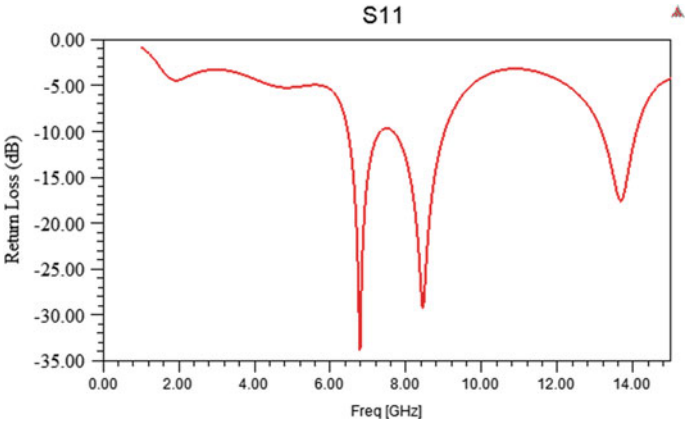
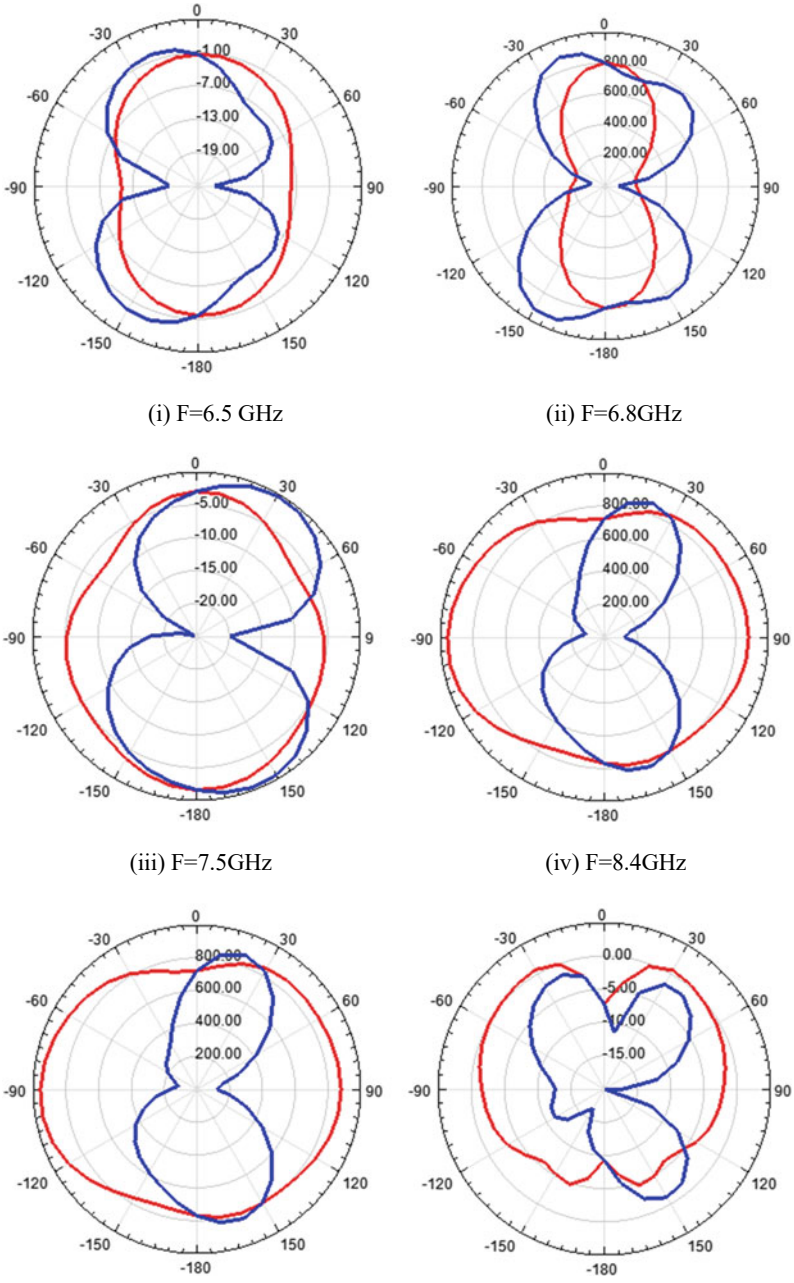


Fig. 5 Simulated return loss of bio-inspired maple leaf antenna

Table 3 Simulated VSWR and return loss value of proposed maple leaf textile antenna

Frequency range (GHz)	VSWR	Return loss (dB)
6.6	1.3	−18
6.7	1.4	−34
7.5	1.9	−10
8.4	1.3	−31
8.7	1.2	−15
8.9	1.5	−10

3.7 dBi. The proposed antenna is well suitable for wireless application. In the future work, this antenna model will be fabricated and tested in the Anechoic Chamber. SAR value will be evaluated and this bio-inspired maple leaf-shaped textile antenna can be used as wearable antenna for military and healthcare applications.



(i) F=6.5 GHz (ii) F=6.8GHz

(iii) F=7.5GHz (iv) F=8.4GHz

(v) F=8.8GHz (vi) F=13.5GHz

Fig. 6 Simulated 2D radiation pattern of bio-inspired maple leaf-shaped antenna for different frequencies

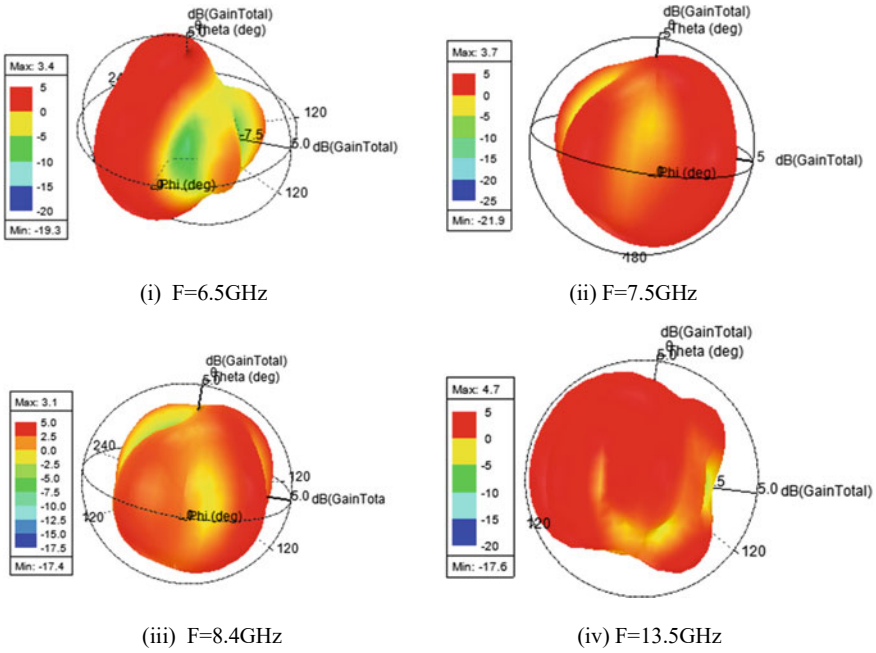


Fig. 7 Simulated 3D gain plot of bio-inspired maple leaf-shaped antenna for different frequencies

References

1. Balanis, C. A. (1997). *Antenna theory, analysis and design*. Wiley.
2. Ahmed, O. M. H., & Sebak, A. R. (2009). A novel maple-leaf shaped UWB antenna with A 5.0–6.0 GHz band-notch characteristic. *Progress In Electromagnetics Research C*(11), 39–49.
3. Silva, Jr., P. F., Freire, R. C. S., Serres, A. J. R., da F. Silva, P. H., & Silva, J. C. (2016). Wearable textile bioinspired antenna for 2G, 3G, and 4G systems. *Microwave and Optical Technology Letters* (58), 2818–2823.
4. Iqbal, A., Saraereh, O. A., & Jaiswal, S. K. (2017). Maple leaf shaped UWB monopole antenna with dual band notch functionality. *Progress in Electromagnetics Research C* (71), 169–175.
5. Abolade, J., Konditi, D., & Dharmadhikary, V. (2020). Bio-inspired wideband antenna for wireless applications based on perturbation technique. *Heliyon* (6), e04282.
6. Mahmood, S. N., Ishak, A. J., Saeidi, T., Alsariera, H., Alani, S., Ismail, A., & Soh, A. C. (2020). Recent advances in wearable antenna technologies: a review. *Progress In Electromagnetics Research B* (89), 1–27.
7. Celif, K., & Kurt, E. (2021). Design and implementation of a dual band bioinspired leaf rectenna for RF energy harvesting applications. *RF and Microwave Computer aided Engineering* (31), e22868.
8. Abolade, J. O., Konditi, D. B. O., & Dharmadhikary, V. M. (2021). A comparative study of compact multiband bio-inspired asymmetric microstrip fed antennas (BioAs-MPAs) for Wireless applications. *Journal of Engineering*.
9. Abolade, J. O., Konditi, D. B. O., & Dharmadhikary, V. M. (2021). Compact hexa-band bio-inspired antenna using asymmetric microstrip feeding technique for wireless applications. *Heliyon* (7), e06247.

10. Kaur, H., & Chawla, P. (2022). Performance analysis of novel wearable textile antenna design for medical and wireless applications. *Wireless Personal Communication, 124*, 1475–1491.
11. Harris, H. A., Anwar, R., Wahyu, Y., Sulaiman, M. I., Mansor, Z., & Nurmantris, D. A. (2022). Design and implementation of wearable antenna textile for ISM band. *Progress in Electromagnetics Research C* (120), 11–26.
12. Singh, R., & Sharma, D. K. (2020). Fault-tolerant reversible gate based sequential QCA circuits: design and contemplation. *Journal of Nano-electronics and Optoelectronics, American Scientific Publications, 15*(4), 331–344.
13. Sharma, R., Kumar, R., Sharma, D. K., Son, L. H., Priyadarshini, I., Pham, B. T., Bui, D. T., & Rai, S. (2019). Inferring air pollution from air quality index by different geographical areas: A case study in India. Air Quality, Atmosphere & Health, Springer Publication, Sept 2019
14. Sharma, D. K., Kaushik, B. K., & Sharma, R. K. (2014). Impact of driver size and interwire parasitics on crosstalk noise and delay. *Journal of Engineering, Design and Technology, 12*(4), 475–490.

Undergraduate College Admission Prediction System Using Decision Tree Classifier

Roshani Raut, Jayant Abnave, Sushil Dikondwar, Shivani Pandita, and Atharva Marudwar

Abstract In today's world, every student wants an appropriate college for their further education according to the marks they scored in the entrance exams after completing their entrance exams. This paper proposes to build a web-based application system that will predict and list the colleges according to their respective marks, secured in the entrance exams with the help of machine learning. It will not only help students know their chances of getting selected for colleges but also assist them in getting the right college. Through this system, students would get to know the appropriate college for them in any part of the country they are living in. This system will eliminate the tedious task of searching colleges manually through the Internet and also end the need of any education brokers. This system was created using the decision tree algorithm, which has a 97% accuracy. This paper proposes to make a system that is not only cost-effective but also time efficient for all the students.

Keywords Entrance exams · Web-based application · Machine learning · Classification · Decision tree classifier · K-Nearest Neighbours · Support Vector Classifier · Random Forest

1 Introduction

Machine learning is one component (possibly the most important) of AI, in which a computer is programmed to self-teach itself and improves its performance on a particular job. Machine learning impacts the world in various ways, including health care, education, transportation, food, entertainment, and more. It will have an impact on people's life [1].

R. Raut · J. Abnave (✉) · S. Dikondwar · S. Pandita · A. Marudwar
Department of Information Technology, Pimpri Chinchwad College of Engineering, Pune, India
e-mail: Jayuabnave18@gmail.com

R. Raut
e-mail: roshani.raut@pccoepune.org

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_27

Almost every element of life, including housing, automobiles, shopping, and meal ordering, is affected. It arose from the study of pattern recognition and is concerned with exploring patterns—the idea that algorithms can learn from and forecast data [2].

Every year, the college admission examination is a key tool in the country's elite selection process. Predicting the admissions line is crucial. Many schools project admission lines based on previous acceptance rates over time and students' estimated scores [3]. Many individuals refer to an admission line when filling out the annual college application form, which was the former old standard. As a result, the accuracy of prediction has a more significant impact on whether students will be able to attend the college of their choice. Predicting the admissions line is crucial [4].

Knowing College Info and their respective cut-off manually might be hectic as it consumes time and resources [5]. Also, students from remote areas find it challenging to get information about colleges, and they might miss colleges according to their capabilities. Brokers demand a lot of money suggest the best colleges as cut-offs could be unaffordable for poor people. Aspirants might get misguided and confused by other people (relatives, competitors, etc.), so we created a system which is helpful for students in the admission process in Pune, Maharashtra [6].

Our objective is to provide a system which can predict the appropriate colleges. Also, Provide Transparency in Information about Organisations like fees, structures and benefits for particulars [7]. It also gives reviews and further information on the students from those organisations in which the applicants are meant to seek admissions. It alerts students when their marks match the current year cut-off during the ongoing admission procedure.

2 Literature Survey

S. Fong et al. created a decision tree classifier and neural networks hybrid model that forecasts a student's chances of admission to a particular university based on academic qualifications and history. The suggested method was evaluated using real-time data from 2400 Macau Secondary School pupils. It considered thirteen factors such as origin, major, class rank, grades, etc. The suggested method's results demonstrate that a hybrid classifier comprising decision trees and neural networks outperforms a single feed-forward neural network or decision tree in predicting whether or not a student will be admitted to a certain university.

In the study, a stacked ensemble model for predicting a student's odds of admission to a certain university is suggested. The suggested model considers various aspects of the student, such as their research background, industrial experience, etc. Furthermore, the suggested system has been compared to a variety of different machine learning techniques, including deep learning methods [8]. This article analysed a data set that contains useful information about the candidates, such as their undergraduate major, TOEFL and GRE test scores, number of publications, programme

of application, and so on. It has been discovered that the suggested model beats all other models and has a high level of accuracy [9].

Text categorisation (also known as text class section) determines which class a text document belongs to. This paper proposes the usage of a basic non-linear model. T traits that are weighted text categorisation using the K-NN algorithm. They suggest using a feature selection method to find the essential features using the qualities necessary to the learning job at hand interaction with features (based on word interdependencies). This will allow us to minimise the amount of people we need to hire significantly. The K-NN is made up of carefully chosen aspects from which to learn [10].

An algorithm can be used in situations where there is a large volume of data and a small amount of data. The number of papers and the size of the vocabulary are large, such as using the World Wide Web. As a result, the K" method that we propose becomes effective (in terms of predictability) for classifying text articles in that setting. It has become the company's most valuable assets for on-the-field applications [11].

This paper used machine learning models to predict a student's chances of being accepted into a master's programme. The data set provided in this study is for educational purposes only. The machine learning models feature Support Vector Classifier (SVC), K-Nearest Neighbour, Random Forest, and decision tree. It concludes that multilayer perceptron surpassed other models and gave a better accuracy than others [12]. Weka is used to test various regression models on the admission data set to determine which model performs the best based on mean absolute error and which multilayer perceptron is the best model [13].

The admission process begins when the results of various entrance exams get out. Students with high hopes get admission, primarily unaware of most colleges and confused. They try to seek help from multiple people and relatives. Some get adequate information about colleges, but some remain dissatisfied.

In this scenario, brokers come into the role of providing help to students in finding their appropriate colleges and information about them. Brokers offer the colleges list according to students' expected marks and help them to find right college but to fulfil this demand, and students provide personal data to brokers. The data demanded by brokers include all the biodata and details, including marks of all the given exams. Most of the time, they also demand some sensitive data like caste, religion, address, gender, phone number, etc. A list of colleges is provided based on student data input. This list is the tentative one, which gets reviewed by the broker. After the list gets checked, the broker offers the list of best possible colleges according to the student's marks. Some brokers also provide all the required information about the colleges to the candidate so that he gets clarification about his final college preference list, which he can use in the admission process [14]. Brokers know the current admission scenario and the previous year cut-off marks of some institutions under their network. The broker shortlists the colleges according to the candidate marks, given biodata and handovers the final list of colleges to the candidate [15].

In all the steps in this process, there might be the chances of vulnerabilities. It might be possible that broker might not have adequate information, and students

may get spammed. In some cases, brokers provide only those colleges list where he would get his high commission which would lead to misguidance [16] for students. In some cases, brokers demand higher cost for this service, and as it is a manual process, chances of getting cheated gets higher [17].

3 Algorithms

Algorithms used.

3.1 K-Nearest Neighbour Algorithm

The K-Nearest Neighbour technique use supervised learning-based machine learning to classify data. The K-NN approach keeps track of all available data and categorises incoming data points based on how similar to previous data. New data can be quickly sorted into a suitable category using the K-NN method. The K-NN technique can be used for regression and classification as per Fig. 1. However, classification is the most typical application. As new information is obtained, it is updated and placed into a group similar to the further information. Let's pretend where two groups, A and B, with a new data item x1 thrown in for good measure. In which category does data point x1 fall? K-NN algorithms are used to solve problems like these [18]. We can quickly find the category or class of a data set using K-NN, as shown in Fig. 1

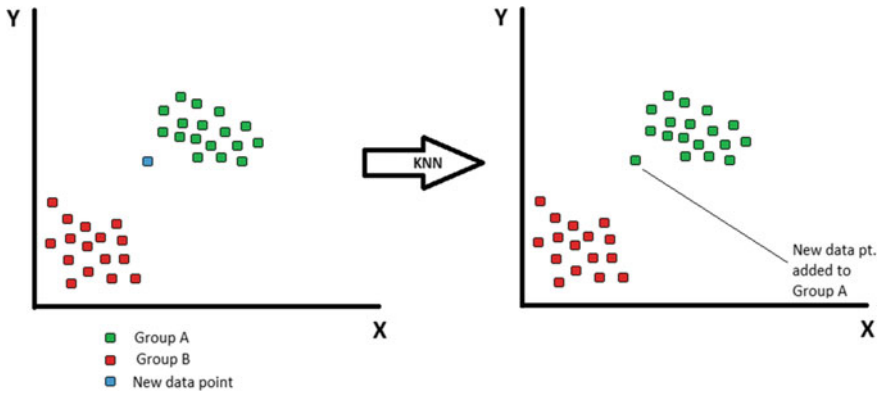


Fig. 1 K-Nearest Neighbour technique

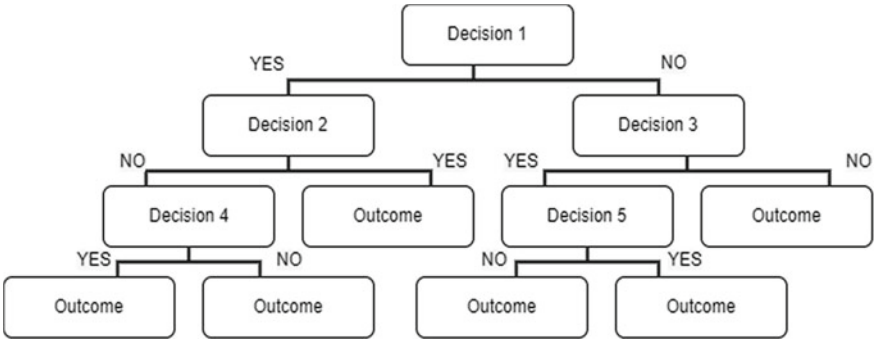


Fig. 2 Decision tree

3.2 Decision Tree Classifier

Decision tree classifier is mainly used for classification purposes. The leaf node and the decision node are two essential types of nodes in this classifier. The tree structure classifier contains internal nodes that retain a branch that shows the rules for the decisions and features of the data set and a terminal node that provides the result, as shown in Fig. 2. The quality of the data has an impact on the test or assessment results. Here, the logic for selecting the class starts at the root node. In this algorithm, the comparison takes place between record values of the attributes of the actual data set to the values of properties of the root node, then it jumps to the next node by the following branches [19]. In this classifier, decision rules are represented by the branches, the internal node denotes the attribute of the data set, and each terminal node provides the conclusion. Terminal nodes give the results of such decisions and have no further branches [20].

3.3 Random Forest Algorithm

Random Forest is a supervised learning strategy using the Random Forest learning algorithm used in machine learning for solving problems like regression and classification. Ensemble learning is a concept that involves merging many classifiers to tackle a complex problem and improve the working of the model. Using different subsets of the provided data set, the classifier "Irregular Forest" has a large number of option trees, and, as the name suggests, takes the normal to work on the prescient exactness of that data set". Instead of depending on one choice tree, the arbitrary backwoods take the expectation from each tree, and in view of the greater number of votes of forecasts, it predicts the last result.

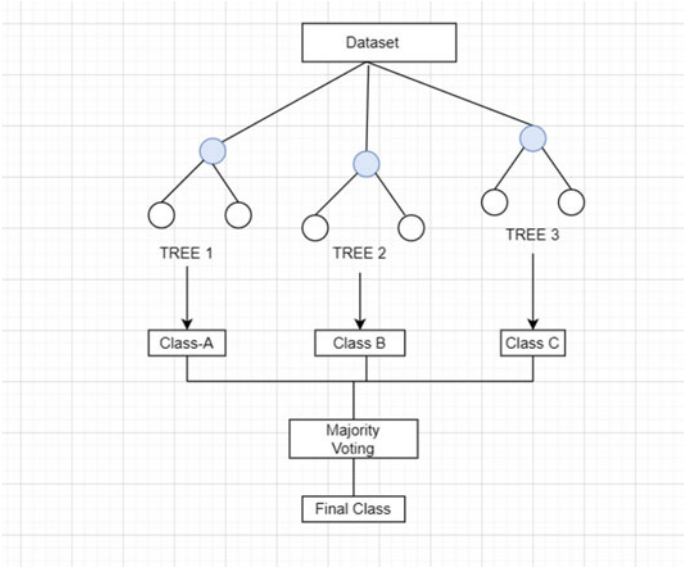


Fig. 3 Random Forest

The higher number of trees in the backwords leads to greater precision and avoids the overfitting issue. The graph makes sense of the working of the Random Forest calculation. Figure 3 shows the representation of the decision tree classifier.

3.4 Support Vector Classifier (Linear Kernel)

A Support Vector Classifier (SVC) is a machine learning technique that fits your data and generates a "best fit" hyperplane that divides or categorises it as illustrated in Fig. 4. Beyond that, you may pass some features to your classifier to determine what the "predicted" class is after you've acquired the hyperplane. A support vector machine is a supervised learning tool for categorising data into two groups. It is trained using a set of data that has already been divided into two categories, and it generates the models as it is trained.

SVM is characterised as a non-binary linear classifier in the end. LinearSVC is built on liblinear and only supports a linear kernel, whereas the SVM module (SVC, NuSVC, and so on) encapsulates the libsvm library and supports various kernels.

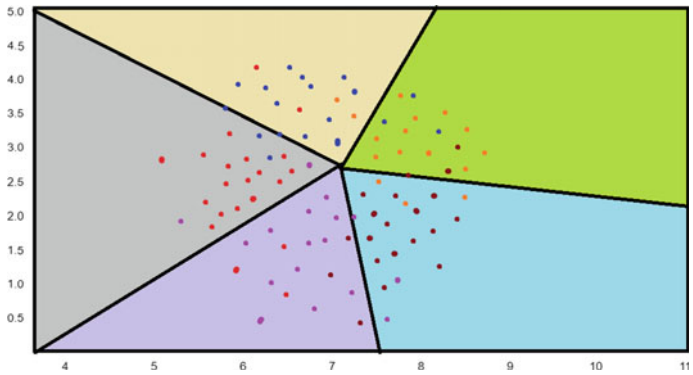


Fig. 4 Support Vector Classifier

4 Proposed Work

The system is a machine learning prediction system. In this approach, students will be the primary actors. The learner will be able to use the system after logging in. Figure 5 illustrates the flow of the system. The student will be able to login to the system. After login, student is supposed to the profile information, information includes Name, DOB, SSC Marks, HSC Marks, Obtained/Tentative CET Score, Category, Religion, and Residence Address (City, District and State).

When a student clicks the save profile button, the information from their profile is saved in a database.

While filling the form, the entered marks (SSC, HSC) will be checked if the marks achieved by the student are greater than the CET cell administration's eligibility criterion.

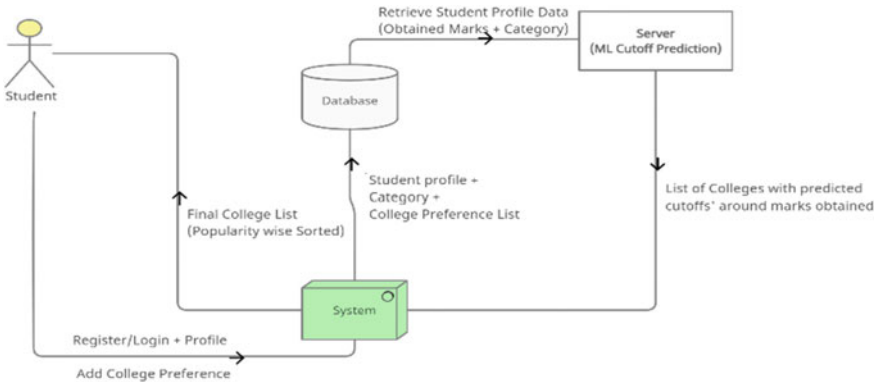


Fig. 5 System flow diagram

Table 1 Difference between traditional and automated process

Parameters	Traditional process	Automated process
Method	Manual	Automatic
Time consumption	More	Less
Biodata storage	No	Yes
Assistance/consultancy	No	Yes
Success notification	Parameters	Yes
Past attempted exam history	No	Yes

Then, the College Preference Form is introduced, which is an added feature that can be used by the student.

The student will also get the privilege of getting the predictions according to their branch preference. If students want to get this feature included in the feature, a Branch Preference Form, similar to College Preference Form, can be submitted, so that the more intuitive and more desired outcome can be catered to the student.

Our machine learning model residing on the server will be trained with the previous year's college cut-offs. The model will be trained such that the student will probably get pretty accurate predictions.

When students proceed for the outcome of our service, the process will get started. The system will pull up all of the data for that particular kid. All college predictions will be provided by the trained model. The Student CET obtained marks will be evaluated with the predicted marks. If the student opted to use the branch preference feature, then the branch wise predicted cut-offs will be compared with the obtained marks. If the difference is nearly around or equal to 0, then those colleges will get shortlisted.

Then, the system will obtain all the possible colleges the student can opt according to his preference lists, or else, if the student will not opt for any preference lists, then all the colleges with the predicted cut-offs near to the obtained marks will get shortlisted.

The server will generate a list of colleges. Then, the list will get sorted according to the overall popularity of the colleges, and the final list of colleges will be displayed to the student. Table 1 describes the set of parameters which differs in traditional and automated processes.

5 Results and Analysis

As the data set was not pre-existing, we created a data set. Our data set consists of the result data of MHT-CET (2017, 2018, 2019). The data we collected was retrieved from MHT-CET official website. The data set consists of attributes such as college names, caste, cut-off scores for each college according to the branches and admission round. As given in Table 2, we considered top 20 colleges as the main entities of

Table 2 Data set information

No. of classes	No. of samples	No. of attributes
20	180	3

Table 3 Sample data set

College name	Branch	Category	Avg3	Avg1	Avg2	Final Avg
PCCOE	CS	Open	143.66	135	140.33	139.66
PCCOE	CS	OBC	129	124	125	126
PCCOE	CS	SC	89	84	87.33	86.77
PCCOE	IT	OPEN	1117.66	112	115	114.8113.88
PCCOE	IT	OBC	114.33	113.44	113.25	
PCCOE	IT	SC	86	85.33	85.11	85.48

our data set, of which, we extracted branch-wise and category-wise cut-off of those considered colleges. We considered three categories (Open, OBC, SC) and branches (CS, IT, MECH, CIVIL).

Our data set consists of 30 classes consisting college names, and three attributes (Branch, Category and Average Marks). Sample data set is given in Table 3.

$$\begin{aligned}\text{Avg Marks} = \text{AVG}\big[&\text{avg.marks of round1, round2, round3 for 2017),}\\ &\text{(avg.marks of round1, round2, round3 of 2018),}\\ &\text{avg.marks of round1, round2, round3 of 2019)}\end{aligned} \tag{1}$$

We considered the following algorithms for testing on our data set:

Decision tree, K-Nearest Neighbours, Support Vector Classifier, and Random Forest.

Support Vector Classifier consists of four major kernels, linear, polynomial, radial-based function (RBF), and sigmoidal.

When we trained our data set using these kernels, we got the following results:

The accuracy score of linear kernel found much higher, i.e. 17.12 as compared to the other kernels, as shown in Fig. 6.

Then, we trained K-Nearest Neighbour model on our data set. We tested this algorithm by varying the neighbours. Where we found that when n_ neighbours = 5, the accuracy was higher as compared with other n_ neighbours. The best accuracy found using K-NN model was 79%. Figure 7 shows that accuracy behaviour.

Later, we trained our data set with decision tree classifier and Random Forest. While checking for hyperparameters for decision tree classifier as shown in Fig. 8, we found that the accuracy found in Random Forest was 59% and that of decision tree classifier was 97.4%.

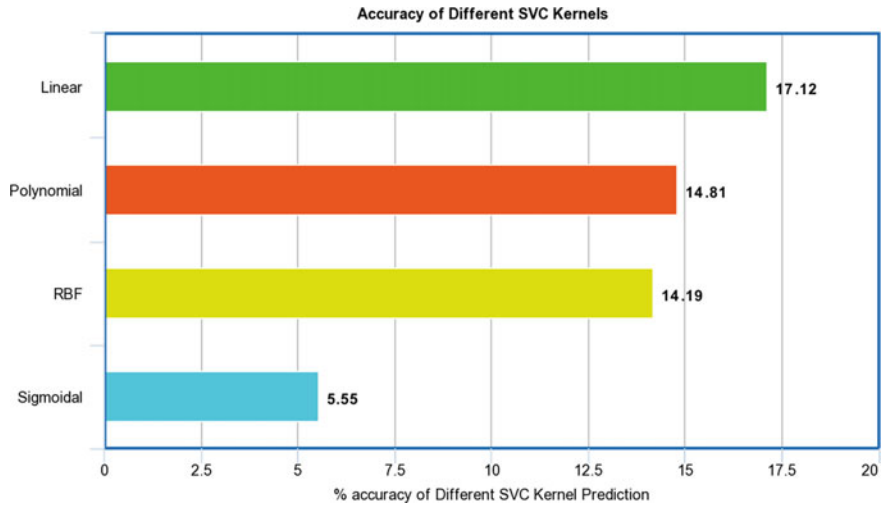
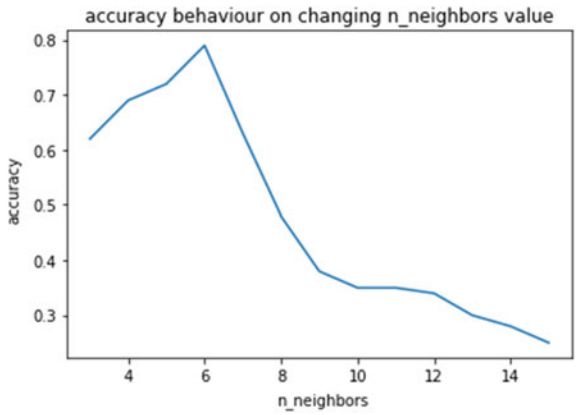


Fig. 6 Kernel results

Fig. 7 Accuracy behaviour



6 Applications

1. Students can get notifications regarding the cut-off of their college.
2. This application will be handy to both students and parents; there is no need to invest time on the Internet to get manual information about colleges.
3. Students can store their respective marks in the database and get into college accordingly.
4. There will be one extra feature for students, like if they want college in other states of India or their state.

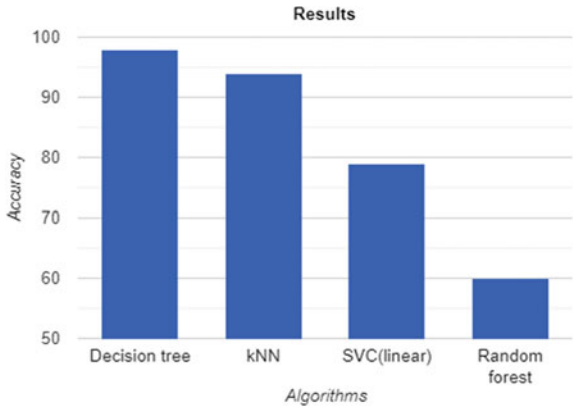


Fig. 8 Algorithms and accuracy

7 Conclusion

This paper proposes web-based application for students as they are busy for entrance papers and board exam. It will help them to get to the best college according to their marks. In the study presented, an attempt was made to establish a system that is cost-effective, easy to use, and time efficient. In this research paper, four machine learning algorithms are used to calculate the probability/chances of getting an admission in the college, i.e. K-NN, SVC, Random Forest, and decision tree algorithm. Among all four, a decision tree is the best algorithm technique for predicting college because its accuracy is more than other algorithms and is simple.

The proposed web-based application built will mainly be used for predicting Engineering colleges, but this application can be further modified and built for predicting undergraduate colleges for more different streams based on respective entrance tests conducted in the country, which will benefit every student in the country and make their lives easier.

References

1. Wang, Z., & Shi, Y. (2016). Prediction of the admission lines of college entrance examination based on machine learning. In *2016 2nd IEEE International Conference on Computer and Communications (ICCC)* (pp. 332–335).
2. Begam S. S., Selvachandran, G., Ngan, T. T., & Sharma, R. (2020). Similarity measure of lattice ordered multi-fuzzy soft sets based on set theoretic approach and its application in decision making. *Mathematics, 8*, 1255.
3. Chithra Apoorva, D. A., Chandu Nath, M., Rohith, P., Bindu Shree, S., & Swaroop, S. (2020). Prediction for university admission using machine learning. *International Journal of Recent Technology and Engineering (IJRTE)* (Vol. 8, Issue 6) ISSN: 2277-3878, March 2020
4. Vo, T., Sharma, R., Kumar, R., Son, L. H., Pham, B. T., Tien, B. D., Priyadarshini, I., Sarkar, M., & Le, T. (2020) *Crime rate detection using social media of different crime locations and Twitter part-of-speech tagger with brown clustering*, 1 Jan 2020 (pp 4287–4299).

5. Freund, Y., & Schapire, R. E. (1996). Experiments with a new boosting algorithm. In *ICML.*
6. Nguyen, P. T., Ha, D. H., Avand, M., Jaafari, A., Nguyen, H. D., Al-Ansari, N., Van Phong, T., Sharma, R., Kumar, R., Le, H. V., Ho, L. S., Prakash, I., & Pham, B. T. (2020). Soft computing ensemble models based on logistic regression for groundwater potential mapping. *Applied Sciences, 10*, 2469.
7. Wang, P., & Jia, Y. (2020). Research on prediction of college student's performance based on support vector machine. In *Proceedings of the 2020 International Conference on Advanced Education, Management and Information Technology* (AEMIT 2020)
8. Ade, R. (2019). Students performance prediction using hybrid classifier technique in incremental learning. *International Journal of Business Intelligence and Data Mining, 15*(2), 173–189.
9. Jha, S., et al. (2019). Deep learning approach for software maintainability metrics prediction. *IEEE Access, 7*, 61840–61855.
10. Acharya, M. S., Armaan, A., & Antony, A. S. (2019). A comparison of regression models for prediction of graduate admissions, ICCIDS 2019
11. Sharma, R., Kumar, R., Sharma, D. K., Son, L. H., Priyadarshini, I., Pham, B. T., Bui, D. T., & Rai, S. (2019). Inferring air pollution from air quality index by different geographical areas: Case study in India. *Air Qual Atmos Health, 12*, 1347–1357.
12. Chakrabarty, N., Chowdhury, S., & Rana, S. (2020). *A Statistical Approach to Graduate Admissions' Chance Prediction.*
13. Sharma, R., Kumar, R., Singh, P. K., Raboaca, M. S., & Felseghi, R.-A. (2020). A systematic study on the analysis of the emission of CO, CO_2 and HC for four-wheelers and its impact on the sustainable ecosystem. *Sustainability, 12*, 6707.
14. Ade, R., & Deshmukh, P. R. (2014). Incremental learning in students classification system with efficient knowledge transformation. In *2014 international conference on parallel, distributed and grid computing* (pp. 181–185). https://doi.org/10.1109/PDGC.2014.7030738
15. Dansana, D., Kumar, R., Das Adhikari, J., Mohapatra, M., Sharma, R., Priyadarshini, I., & Le, D.-N. (2020). Global forecasting confirmed and fatal cases of COVID-19 outbreak using autoregressive integrated moving average model. *Frontiers in Public Health, 8*, 580327. https://doi.org/10.3389/fpubh.2020.580327
16. Protikuzzaman, Md., Baowaly, M., Kumar, M., & Singh, B. (2020). Predicting undergraduate admission: A case study in Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Bangladesh. *International Journal of Advanced Computer Science and Applications, 11*. https://doi.org/10.14569/IJACSA.2020.0111217.
17. Malik, P. K., Sharma, R., Singh, R., Gehlot, A., Satapathy, S. C., Alnumay, W. S., Pelusi, D., Ghosh, U., & Nayak, J. (2021). Industrial Internet of Things and its applications in industry 4.0: State of the art, computer communications (Vol. 166, pp. 125–139). ISSN 0140-3664. https://doi.org/10.1016/j.comcom.2020.11.016.
18. Sharma, R., Kumar, R., Satapathy, S. C., Al-Ansari, N., Singh, K. K., Mahapatra, R. P., Agarwal, A. K., Le, H. V., & Pham, B. T. (2020). Analysis of water pollution using different physicochemical parameters: A study of Yamuna River. *Frontiers in Environmental Science, 8*, 581591. https://doi.org/10.3389/fenvs.2020.581591
19. Wu, H.-Q., Chen, Y.-W., & Liu, R. (2020). College education outcome expectation and proactive personality as predictors of Chinese college students' learning motivation, career adaptability as a mediator. In *2020 International Conference on Modern Education and Information Management (ICMEIM).*
20. Dansana, D., Kumar, R., Parida, A., Sharma, R., Adhikari, J. D., et al. (2021). Using susceptible-exposed-infectious-recovered model to forecast coronavirus outbreak. *Computers, Materials & Continua, 67*(2), 1595–1612.

Early Detection of Heart Disease Using Multilayer Perceptron

Priyanka Gupta and D. D. Seth

Abstract Cardiovascular diseases (CVDs) or heart diseases are the major concern as they are responsible for large number of deaths globally. So timely detection of heart disease is important for saving the lives of patients. The model should be developed which predicts the cardiovascular diseases early and accurately. In this work, a Neural Network-based approach Multilayer Perceptron (MLP) was proposed for predicting the heart disease. Neural Networks are considered as the most efficient techniques for disease prediction. They can analyze the data efficiently. The performance of Multilayer Perceptron was compared with two traditional Machine Learning algorithms, K-Nearest Neighbors (KNN) and Decision Tree (DT) algorithm. Among all the classifiers, Multilayer Perceptron has shown the best performance with an accuracy of 86.8%. The proposed model helps in predicting the cardiovascular disease in an efficient and accurate manner. It can help to save the time of doctors and medical staff to a great extent.

Keywords Machine Learning · Cardiovascular disease · Multilayer Perceptron

1 Introduction

Cardiovascular diseases (CVDs) are major concern as they account for large number of deaths worldwide. Prediction of heart disease is a big challenge. If the detection is performed earlier, then lives of patients can be saved [1]. Some automated system is required for detecting CVDs so that the time of doctors and physicians can be saved.

Machine Learning techniques and Neural Networks provide a solution to this. Neural Networks are considered as the most efficient technique for prediction of diseases like heart disease. Neural Network is a subset of Machine Learning. In the healthcare domain, Neural Networks play a most important role in prediction. It can analyze large amount of medical data in an efficiently.

P. Gupta (✉) · D. D. Seth
SRM Institute of Science and Technology, Ghaziabad, India
e-mail: lpriyanka6gupta@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_28

Multilayer Perceptron (MLP) is a kind of Neural Network which contains various layers. Each layer consists of nodes (or neurons). It comprises one input, one output layer, and between input and output layer one or more hidden layers are present.

The paper is arranged in the following sequence. Section 2 focuses on the work related to the literature. In Sect. 3, the dataset description and proposed methodology is given. In Sect. 4, performance evaluation metrics is given. In Sect. 4, the results of the experimental results are given. Lastly, in Sect. 5, conclusion is given.

2 Related Work

In [1, 2], authors have proposed the data mining techniques for predicting the heart disease. Kim and Kang [3] have proposed the risk of predicting of coronary heart disease on the basis of Neural Network approach. They performed the analysis of correlation between various features accuracy. The accuracy attained by the model was 82.51%. Maheshwari et al. [4] have proposed the approach of combining neural network with logistic regression in predicting the heart disease. The accuracy achieved by the model was 84%.

Maji and Arora [5] have presented the hybrid model combining Artificial Neural Network and Decision Tree. The performance of the hybrid model was found better as compared to individual classifiers. The prediction accuracy achieved by the hybrid model was 78.14%. In [6–9], comparison of different classifiers was done for prediction of heart disease. Kirmani [10] has used the MLP for detecting heart disease. The prediction accuracy of the model was less. Dutta and Bandopadhyay [11] have proposed stacked Gated Recurrent Neural Network for predicting heart disease. The model was compared with SVM and K-Nearest Neighbor (KNN). The proposed model has shown best performance with a prediction accuracy of 84.37%.

In this work, Neural Network approach Multilayer Perceptron was used for predicting the heart disease. This approach helps in prediction of heart disease more effectively and accurately.

3 Material and Methods

3.1 Dataset Description

The dataset used in this study was Cleveland heart disease dataset [12] obtained from UCI Machine Learning depository. It contains 303 records and 13 columns or attributes. The explanation of dataset is given in Table 1.

The heart disease diagnosis attribute is categorized into either presence or absence of heart disease. Presence is denoted by ‘1’ and absence of disease is denoted by ‘0’.

Table 1 Description of dataset attributes

S. no.	Attributes
1	Age—Patient age is considered in years Sex/Gender
2	Male is taken as 1 and Female is taken as 0
3	Blood pressure at rest (Trestbps)
4	Maximum attained value of heart rate (Thalach)
5	Chest pain (Cp)—Chest pain is classified into 4 categories 1. Typical angina, 2. Atypical angina, 3. Non-anginal pain, 4. Asymptomatic
6	Fasting blood sugar If the serum level of fasting blood sugar is more than 120 mg/dl, it is taken as 1 else it is taken as 0
7	Serum cholesterol levels (in mg/dl) (Chol)
8	Resting ECG (Restecg)- Normal is taken as 0, ST–T wave abnormality (T-inversion, ST-elevation or depression of more than 0.05 mV) is taken as 1 Left Ventricular Hypertrophy by Ester's criteria is taken as 2
9	Oldpeak-ST depression induced by exercise in comparison with the state of heart
10	Exercise induced angina (Exang)-If present it is taken as 1 else 0
11	Slope of ST segment at peak exercise (Slope) Upsloping is taken as 1. Flat as 2. Downsloping as 3
12	Number of major vessels colored by Fluoroscopy (Ca) ranges from 0 to 3
13	Obtained Defect (Thal) It depicts status of heart by three different values Normal is taken as 3. Fixed defect is taken as 6. Reversible defect is taken as 7

3.2 Multilayer Perceptron

In this work, the Neural Network-based approach utilized was Multilayer Perceptron (MLP) to predict the heart disease. Neural Network mimics the structure of human brain which has very high processing power. It consists of neurons which communicate with each other like biological neurons in human brain. MLP works in the same manner as the human brain. It analyzes the information and processes it. It comprises mainly three layers—input, hidden, and output layer. Each layer consists of varied number of neurons. The activation function helps to transform the input into output. In these networks, the output of previous layer acts as an input for next layer (Fig. 1).

In the proposed system, first the data was collected. After that, the data was preprocessed for handling missing and null values. Multilayer Perceptron was utilized for predicting the heart disease. The proposed methodology is given in Fig. 2.

The ratio of 80–20 was used for splitting training and testing dataset.

The architecture used in this work consists of two hidden layers, each consisting of 16 neurons. The activation function used at the hidden layer is 'tanh.' The parameter

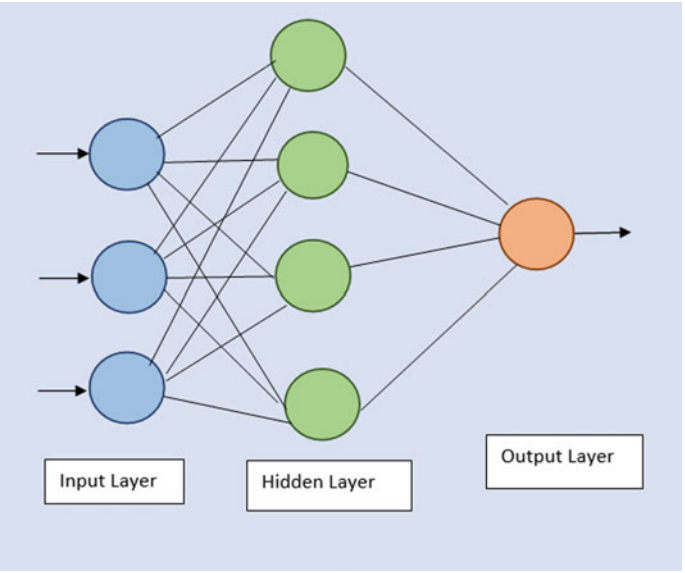


Fig. 1 Basic structure of Multilayer Perceptron

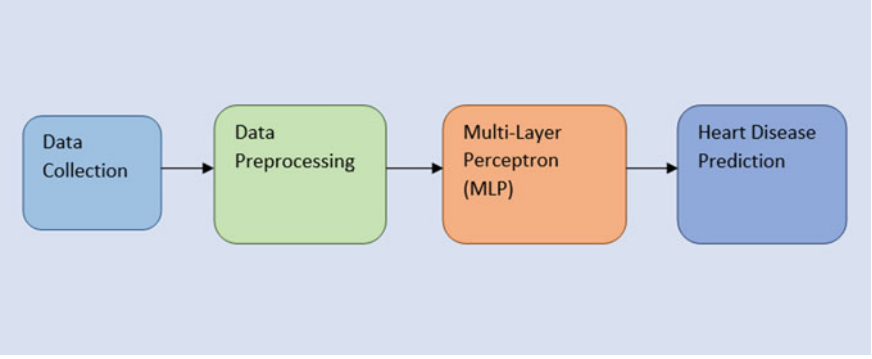


Fig. 2 Architecture of proposed methodology

of maximum iterations contains the value 200, i.e., max_iter = 200. The maximum iterations utilized were 200. The solver utilized in this work was 'lbfgs' solver.

The implementation of the system was done in Python. Anaconda Navigator was installed which is having inbuilt Python packages. It is easy to set up and use. It is very user-friendly.

Table 2 Comparison of algorithms for their performance measures

Algorithms	Precision	Recall	F1-Score	Accuracy (%)
K-Nearest Neighbor	0.77	0.72	0.74	73.7
Decision Tree	0.84	0.81	0.83	81.9
Multilayer Perceptron (Proposed)	0.85	0.91	0.88	86.8

3.3 Models Used for Classification

K-Nearest Neighbor Classifier

Decision Tree Classifier

Multilayer Perceptron

4 Result and Discussion

The two Machine Learning (ML) classifiers K-Nearest Neighbors (KNN) and Decision Tree (DT) along with Multilayer Perceptron (MLP) were applied on the dataset for detecting the heart disease. The comparison of algorithms was made on the basis of various performance measures. The summarized results of the experiments are displayed in the table (Table 2).

From Table 2 and Figs. 3 and 4, it can be examined that the Multilayer Perceptron has shown the best performance measures and accuracy as compared to other traditional Machine Learning classifiers for predicting the presence of heart disease. Multilayer Perceptron has shown the best performance measures in terms of precision, recall, F1-score and accuracy for predicting the heart disease.

5 Conclusion

Heart or cardiovascular diseases are major concern as large numbers of deaths occurring worldwide are due to CVDs. In this work, Multilayer Perceptron approach was utilized for predicting the heart disease. The performance of the Multilayer Perceptron-based system was compared with two traditional Machine Learning classifiers, K-Nearest Neighbor and Decision Tree for detecting the heart disease. From the result, it is observed that the Multilayer Perceptron has shown the best results with an accuracy of 86.8%. Moreover, the proposed system is more accurate and efficient.

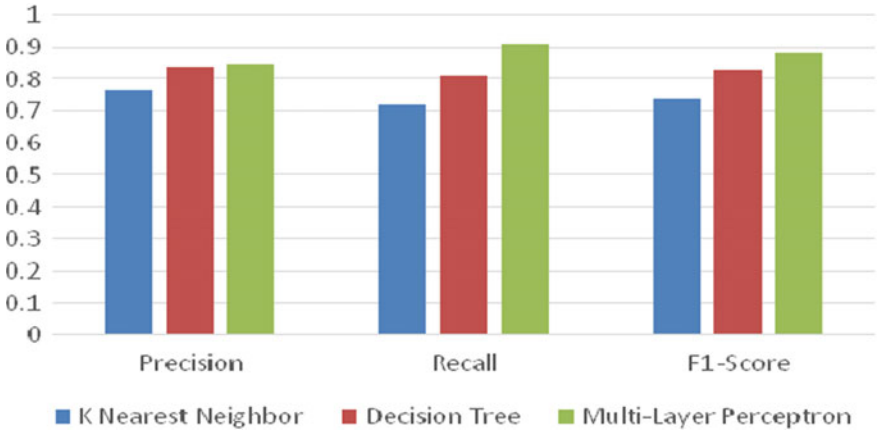


Fig. 3 Algorithms comparison for their performance measures

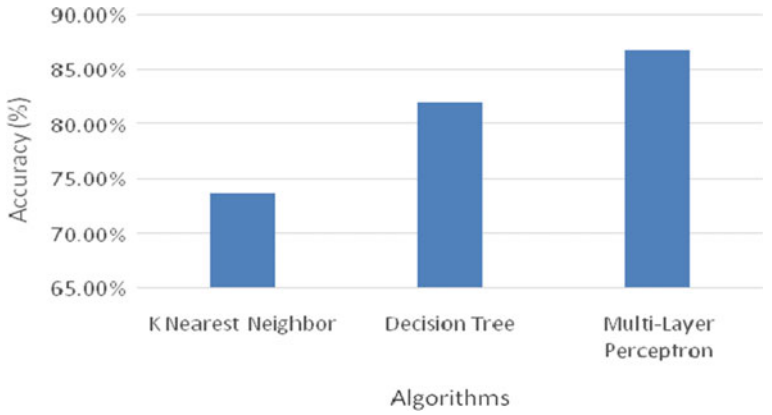


Fig. 4 Algorithms comparison for their accuracies

References

1. Patel, A., Gandhi, Shetty, S., & Tekwani, B. (2017). Heart disease prediction using data mining. *International Research Journal of Engineering and Technology (IRJET), 04*(01 Jan) e-ISSN: 2395-0056.
2. Reddy, P. S. C., Palagi, & P., Jaya. (2017). Heart disease prediction using ANN algorithm in data mining. *International Journal of Computer Science and Mobile Computing, 6(*4), 168–172.
3. Kim, J. K., & Kang, S. (2017). Neural network-based coronary heart disease risk prediction using feature correlation analysis. *Journal of Healthcare Engineering, 2017*, Article ID 2780501, pp. 1–13
4. Maheshwari, K. U., & Jasmine, J. (2017). Neural network based heart disease prediction. *International Journal of Engineering Research & Technology (IJERT), 5*(2017), ISSN: 2278-0181 RTICCT—2017 Conference Proceedings.

5. Maji, S., & Arora, S. (2019). Decision tree algorithms for prediction of heart disease. In Information and communication technology for competitive strategies (pp. 447–454). Springer.
6. Shylaja, S., & Muralidharan, R. (2018). Comparative analysis of various classification and clustering algorithms for heart disease prediction system. *Biometrics Bioinformation, 10*, 74–77.
7. Rajdhan, A., Agarwal, A., Sai, M. & Dundigalla Ravi, P. G. (2020). Heart disease prediction using machine learning. *International Journal of Engineering Research and Technology (IJERT), V9*(04).
8. Kannan, R., & Vasanthi, V. (2019). Machine learning algorithms with ROC curve for predicting and diagnosing the heart disease (pp. 63–72).
9. Sri, B. U. (2020). Effective heart disease prediction model through voting technique. *International Journal of Engineering Technology and Management Sciences, 4*(5), 10–13.
10. Kirmani, M. M. (2017). Heart disease prediction using multilayer perceptron algorithm. *International Journal of Advanced Research in Computer Science, 8*(5), 1169–1172.
11. Dutta, S. Bandyopadhyay, S. K. (2020). Early Detection of heart disease using gated recurrent neural network. *Asian Journal of Cardiology Research,* pp. 8–15, (June 2020). Heart Disease Prediction using Multilayer Perceptron Algorithm
12. Link for UCI heart disease dataset-http://archive.ics.uci.edu/ml/datasets/Heart+Disease -UCI repository of machine learning databases having Cleveland Dataset.

Task Scheduling Algorithm Using Improved PSO in Dew Computing

B. Gomathi, S. Lokesh, and J. Antony Vijay

Abstract IoT devices must have more resources to keep up with the growing needs across a variety of application areas as the Internet of Things (IoT) is growing exponentially. Modern IoT devices do not fully utilize highly over-provisioned processing resources as a result of increasing requirements. This paper proposes a task scheduling approach based on Improved Particle Swarm Optimization (IPSO) for real-time applications in the cloud–fog–dew environment. By dispatching edge operations to adjacent IoT devices, it uses consolidated idle resources in IoT devices for edge services. Task scheduling is formulated as an optimization issue using permutations in the proposed scheduling technique. Afterward, tasks are assigned to enough resources in the order determined by the optimal permutation, resulting in the least amount of network traffic and power usage. The simulation results show that the proposed method uses less power than other algorithms and can reduce Internet traffic while completing tasks at the dew computing layer.

Keywords Dew computing · Task scheduling · Internet of Things · Improved Particle Swarm Optimization · Power consumption · Internet traffic

1 Introduction

Due to the huge increase in usage of smartphones, a wide range of sensors, actuators, robots, sensors, and single-board computers, Internet of things (IoT) has become part of many advanced computing. Since the usage of sensors and smart devices have increased, these devices generate huge amounts of data. However, there is a limitation to store the big data on these devices. To address this issue, IoT is integrated with cloud technology to store and process the huge data in recent years.

B. Gomathi (✉) · S. Lokesh
PSG Institute of Technology and Applied Research, Coimbatore, India
e-mail: gomathi.babu@gmail.com

J. Antony Vijay
Hindusthan College of Engineering and Technology, Coimbatore, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_29

Nowadays, the demand of the IoT devices is increasing which causes failures to produce better performance in cloud environments due to unpredictable network connection and higher latency. Hence, the IoT needs a more trustworthy infrastructure that gets around cloud computing limitations in order to satisfy real-time requirements. As a result of these necessities, fog computing has been introduced which supports the computation, storage, and communication near the edge of the network. This computing environment exists between IoT devices and cloud environments to reduce the network latency for real-time applications. While reducing the network issues by fog computing [1], it is still based on the Internet which may not be available in certain circumstances. Unfortunately, real-time applications still have the same challenges. Hence, a new dew computing [2, 3] paradigm has been introduced where the low processing power of larger smart devices which are closer to users are used for computation. Dew computing overcomes the network latency issue and reduces the remote communication cost. Devices in dew environment are involved in computation offline.

By giving quick response to the real-time applications in dew environment, we need to consider other metrics like energy efficiency, network latency, and deadline when scheduling the tasks. While executing real-time applications, task scheduling in dew environment will become optimization problem. Therefore, for cloud–fog–dew environments, a PSO-based [4] real-time task scheduling technique is proposed. The objective of the PSO is to offer several permutations for the real-time tasks that end users have given. The tasks are then allocated to the resources with the minimum power consumption in the proposed order. The proposed scheduling technique fully satisfies the requirements of various users by achieving a good balance between network traffic and power consumption, where some users prefer to give higher priority to the power consumption and others prefer to execute their tasks within less network traffic.

The remainder of this paper is divided into the following sections: The relevant cloud–fog–dew environment is covered in Sect. 2. Section 3 shows the proposed system model. The proposed task scheduling algorithm is described in Sect. 4. The performance evaluation is introduced in Sect. 5. In Sect. 6, the paper is concluded.

2 Related Work

To improve the performance of time sensitive tasks, various strategies based on edge computing environment have been used. The latest task scheduling techniques used in the edge computing have been summarized. The main conditions of the algorithm along with strength and weakness are outlined.

The model proposed in this paper [5] is recommended for the resource allocation technique that takes place in the fog computing layer. While scheduling the tasks in the dew computing environment, the time sensitive tasks are given priority by a scheduler. The model compares the network utilization for cloud, fog, and dew computing. The comparison shows that the tasks carried out in the dew computing layer have not

consumed the network bandwidth. Execution time and average latency are additional criteria in this method. The proposed model in this paper supports multi-objective optimization as proposed in [6]. The most remarkable aspect of the concept is that service continuity, rather than Internet disconnection, is the most significant justification for using the resources in the dew computing layer. Even if network usage has decreased, there is still a dependence on the network. One shortcoming of the paradigm is that resource allocation takes place in the fog environment. Sometimes it leads to unavailability of resources due to network interruption.

Iterative Heuristic Mobile Edge Computing Resource Allocation (IHRA) [7] has been introduced as a resource allocation scheme to off-load the partial computation for real-time tasks in cloud and edge computing environment. The proposed allocation scheme was used to improve resource utilization and reducing the makespan by considering local tasks in the IoT devices while off-loading the new tasks. The resource conflict problems are identified by using feedback function in edge servers. It would be preferable to talk about power consumption, network latency, and security.

By using Lyapunov optimization technique [8], the computational offload mode has been selected at runtime in the Mobile Edge Computing Environment based on the latency constraints. The proposed social awareness resource management technique has been used to off-load tasks to IoT devices as well as to the edge environments while considering the energy consumption of the devices. But it fails to consider local tasks while off-loading the new tasks to IoT devices. It does not check the completion status of the tasks which were off-loaded earlier.

An ad hoc network [9] has been framed to implement the computing capabilities using smartphones. These smartphones differed in their computational capabilities and energy usage. These features were considered when tasks were scheduled to the cluster of smartphone. The metrics like computational time and total number of jobs completed were considered to compare the performance of proposed work with existing task scheduling scheme. A difficult problem is the lack of methods for encouraging citizen participation, maintaining computation contribution among smartphones, and protecting consumers in reporting outcomes.

The Ant Colony Optimization (ACO) [10, 11] technique was put forth in the context of work scheduling using blockchain technology. Blockchain miners were used in this work to allocate tasks efficiently in a cloud environment and were rewarded by miner nodes for their contribution to the development of a successful schedule. The outcomes demonstrated that the suggested algorithm provides noticeable gains in terms of privacy, overall execution time, and network load. However, the suggested technique resulted in static scheduling because it assumed that each task would arrive at the same time.

3 System Model

First, the proposed system model is illustrated in this section. Three layers such as cloud server, fog servers, and dew servers with dew nodes make up the suggested

system paradigm. IoT devices often have limited storage and computing capabilities and are connected to edge servers via wireless networks. Through the internet, the edge server is connected to the cloud environment. Every time a user sends a request, the edge server receives it and then delivers the request to the appropriate cloud server, fog servers, dew node, or IoT device depending on the task's requirements and the device's limitations. Through the edge server, the results are returned to the user.

The main objective of the proposed technique is to minimize the power consumption and network traffic [12] when we increasing the number of tasks in the proposed environment. In the proposed work, scheduler has to assign each task on only one node in only one hierarchical layer. Each machine in each layer except cloud layer has limited memory and power capacity. By considering all the constraints mentioned above, the objective function is expressed as in Eq. (1).

$$\text{Power Consumption} = \forall i \sum_{i} \left(W_i^C * J_i^C + W_i^F * \sum_{i} J_{ik}^F + W_i^D * \sum_{l} J_{il}^D \right) \tag{1}$$

where W_i^C is a power usage of the ith task on the cloud environment, W_i^F is a power usage of the ith task on the Fog environment, W_i^D is a power usage of the ith task on the dew environment, J_i^C represents that ith is off-loaded on cloud environment, J_{ik}^F represents that ith task is off-loaded at kth layer on fog environment, J_{il}^D represents that ith task is off-loaded at lth layer on dew environment. We assumed that power usage is homogeneous in each layer. Moreover, nodes in dew computing are placed in local network. Hence, it doesn't generate any network traffic. As in Eq. (2), Internet traffic is only computed for cloud and fog layers.

$$\text{Network Traffic} = \left(\sum_{i} \left(\text{TS}_i * \text{TC}^C * J_i^C \right) \right) + \left(\sum_{i} \left(\text{TS}_i * \text{TC}^F * J_i^F \right) \right) \tag{2}$$

where TS_i is the ith task size, TC^C is the Internet traffic usage cost on the cloud layer, TC^F is the Internet traffic usage cost on the fog layer. The fitness function is calculated by using Eq. (3), which makes trade-off between the power consumption and network traffic.

$$\begin{aligned} \text{Minimize } f(x) = {} & w(\text{Power Consumption}) \\ & + (1 - w)(\text{Network Traffic}) \end{aligned} \tag{3}$$

where w is weight value to balance between power consumption and network traffic. We can assign 0.5 to w to assign same priority for both power consumption and network traffic.

4 Proposed Task Scheduling Algorithm for Dew Environment

This section provides more information about task scheduling using PSO algorithm and explains how to allocate user tasks to the nodes that are present in the three tiers. Particle representation is the first stage in the job scheduling problem utilizing PSO solution. The particle representation for the Task-Environment assignment is shown in Fig. 1.

Particles gathered together form a population. The number of tasks equals the particle's length.

4.1 Improved Particle Swarm Optimization for Task Scheduling

The algorithm for Improved PSO for Task-Environment mapping is listed below.

1. Initialize population size as PS and length of particle as number of tasks.
2. Initialize the position, velocity, and emotional status of the particles in swarm by random permutation of Task-Environment assignment.
3. Evaluate fitness of each particles using Eq. (3.1) through Eq. (3.3).
4. Separate the particles as subgroups like weak, normal, and strong by considering the current attainment of the particles [4].
5. Based on the subgroup, velocity, position and emotional status of the particle are updated [4].
6. Particles are evaluated based on the fitness function.
7. Update the personal best, global best, and emotional status of all the particles.
8. If maximum iteration is not reached, then go to step 3. Otherwise optimal Task-Environment mapping is produced.

The proposed algorithm is listed above. The population size PS is initialized as 40. The initial population of Improved PSO is generated at random. The fitness value per individual particle is then computed. Hence, each individual has two metrics. These metrics include power consumption and Internet traffic. As shown in the algorithm, the five steps from 3 to 7 are repeated after truncation at the end of the offspring generation section. The reason for this repetition is that to provide optimal solution.

J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8
Dew1	Fog1	Fog2	Dew2	Dew3	Cloud1	Cloud2	Dew4

Fig. 1 Representation of the particle

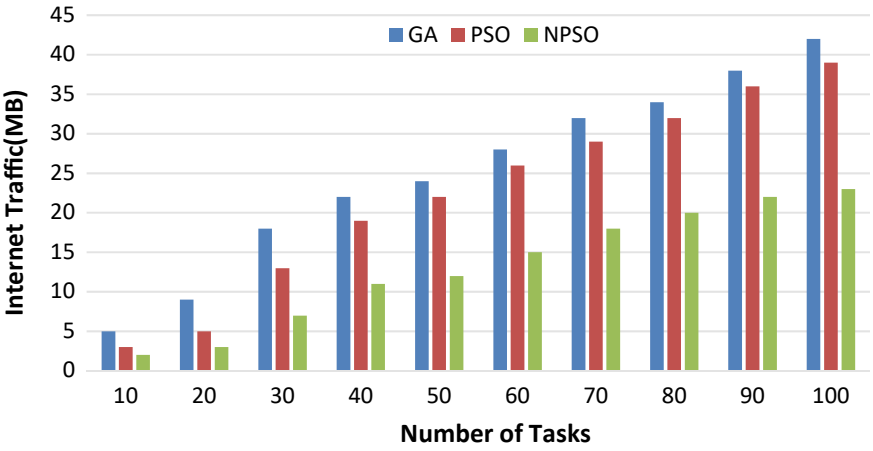


Fig. 2 Internet Traffic of different algorithms

5 Performance Evaluation

MATLAB was used to implement the proposed algorithms. The same computer running with Windows 7, an Intel Core processor, and 8 GB of RAM was used for all of the experiments. It is now time to examine the proposed model after it has been mathematically defined. The model was developed using Improved PSO, as was already mentioned, and assessed using a simulation environment. According to this study, the proposed model increases the degree of Internet dependence, responsiveness to real-time applications, and power consumption by taking the dew computing layer into account and carrying out schedule in this layer. The acquired results are covered in more detail below.

5.1 Internet Traffic

When tasks are assigned to cloud environment, they consume Internet bandwidth. But when tasks are executed in dew environment, it doesn't always require internet. Additionally, Internet traffic in Fig. 2 is larger in GA and lower in the proposed algorithm by using emotional status of each particle in Improved PSO.

5.2 Power Consumption

Based on Fig. 3, it can be seen that all algorithms use more power as the number of tasks increases. The Improved PSO, however, uses the least amount of power

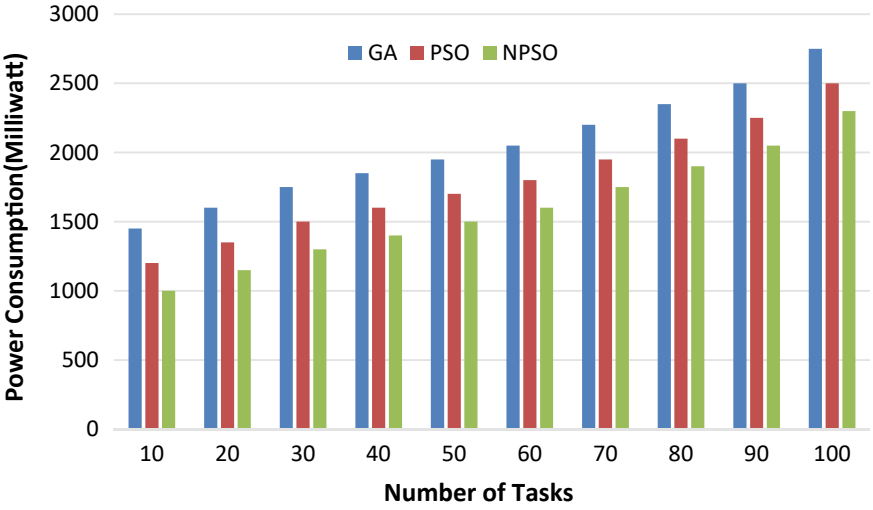


Fig. 3 Power consumption of different algorithms

compared to previous algorithms. The proposed algorithm produced better schedules than the existing scheduling algorithm given the extra time it has taken to effectively explore and exploit the search space, which had a beneficial impact on the other performance metrics**.**

6 Conclusion

IoT technology provides a wide range of applications, such as Industrial IoT, Smart Cities, Smart Agriculture, and Smart Transportation, which contribute substantially in many aspects of modern life. Many of these apps need reduced network traffic and less power usage, which the overburdened cloud resources are unable to provide. The needs of real-time IoT applications are met using cloud resources as well as fog and dew resources. The proposed scheduling algorithm treats task scheduling as an optimization problem based on permutations. In order to schedule real-time tasks of IoT applications in the cloud–fog–dew environment, an Improved PSO technique is therefore presented. The results collected show that the suggested algorithm can balance power consumption and network traffic better than the other algorithms. Future research can evaluate further task scheduling optimization techniques in a cloud–dew computing paradigm. Finally, deep learning techniques can be used to address the dynamic scheduling problem.

References

1. Arul Mozhi Pradeepa, M., & Gomathi, B. (2017). Towards fog computing based cloud sensor integration for the internet of things. *International Journal of Computer Science and Engineering Communications, 5*(6), 1761–1773.
2. Sojat, Z., & Skala, K. (2016). Views on the role and importance of dew computing in the service and control technology. In *39th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)* (pp. 164–168).
3. Ray, P. P. (2018). An introduction to dew computing: Definition, concept and implications. *IEEE Access, 6*, 723–737.
4. Gou, J., Lei, Y.-X., Guo, W.-P., Wang, C., Cai, Y.-Q., & Luo, W. (2017). A novel improved particle swarm optimization algorithm based on individual difference evolution. *Applied Soft Computing, 57*, 468–481.
5. Hossain Khan, M. S., Roy, P., Khanam, F., Hera, F. H., Das, A. K. (2019). An efcient resource allocation mechanism for time-sensitive data in Dew computing, In *International conference of artificial intelligence and information technology (ICAIIT)* (pp. 506–510).
6. Gomathi, B., Saravana Balaji, B., Krishna Kumar, V., Abouhawwash, M., Aljahdali, S. et al. (2022). Multi-objective optimization of energy aware virtual machine placement in cloud data center. *Intelligent Automation & Soft Computing, 33*(3), 1771–1785.
7. Ning, Z., Dong, P., Kong, X., & Xia, F. (2019). A cooperative partial computation offloading scheme for mobile edge computing enabled Internet of Things. *IEEE Internet of Things Journal, 6*(3), 4804–4814.
8. Gao, Y., Tang, W., Wu, M., Yang, P., & Dan, L. (2019). Dynamic social-aware computation offloading for low-latency communications in IoT. *IEEE Internet of Things Journal, 6*(5), 7864–7877.
9. Hirsch, M., Mateos, C., Zunino, A., Majchrzak, T. A., Gronli, T. M., Kaindl, H. (2021). A task execution scheme for Dew computing with State-of-the-Art Smartphones. Electronics. https://doi.org/10.3390/electronics10162006
10. Baniata, H., Anaqreh, A., & Kertesz, A. (2021). PF-BTS: A privacy-aware fog-enhanced blockchain-assisted task scheduling. *Information Processing and Management*. https://doi.org/10.1016/j.ipm.2020.10239332
11. Gomathi, B., Krishnasamy, K., & Balaji, B. S. (2018). Epsilon-fuzzy dominance sort-based composite discrete artificial bee colony optimisation for multi-objective cloud task scheduling problem. *International Journal of Business Intelligence and Data Mining, 13*(1–3), 247–266.
12. Javadzadeh, G., Rahmani, A. M., & Kamarposhti, M. S. (2022). Mathematical model for the scheduling of real-time applications in IoT using Dew computing. *The Journal of Supercomputing, 78*, 7464–7488. https://doi.org/10.1007/s11227-021-04170-z

A Review Analysis on Measuring the Soil Characteristic in Agriculture Using Artificial Intelligence and IOT

Sapna Dewari, Meenu Gupta, Rakesh Kumar, Ahmed J. Obaid, and Mazin R. AL-Hameed

Abstract The requirement for food has ascended couple with the ascent in the populace. Thus, our horticulture area needs to keep up with the food prerequisite of a person. Crop creation relies upon many variables like the climate, soil quality, temperature, water, and some more. Regular water doesn't fulfill the water necessary for the harvests, so a water system was presented. From that point forward, the water system advanced to the brilliant water system process for better yield by getting the information of soil. Today farming with the association of the Internet of Things (IoT), distributed computing, and artificial intelligence has made do to improve the result. Indeed, even in the spots where water is scant, the development of yields is made conceivable by estimating the attribute of soil. Additionally, the expectation of sicknesses and wild creatures can help in going to some preventive lengths. The yields can be furnished with the ideal sensible construction with the assistance of administration or information given by innovations. Here, we will examine the new manners by which cultivating is done, the boundaries considered for the water system, the advances used to accomplish better yields and what are the difficulties confronted as of late, and the future work.

Keywords IoT · Distributed computing · Artificial intelligence · Irrigation · Smart farming

S. Dewari · M. Gupta (✉) · R. Kumar
Department of Computer Science and Engineering, Chandigarh University, Chandigarh, Punjab, India
e-mail: meenu.e9406@cumail.in

R. Kumar
e-mail: rakesh.e8623@cumail.in

A. J. Obaid
Faculty of Computer Science and Mathematics, University of Kufa, Kufa, Iraq
e-mail: ahmedj.aljanaby@uokufa.edu.iq

M. R. AL-Hameed
National University of Science and Technology, Nasiriyah, Iraq
e-mail: mazin-r.al-hameed@nust.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_30

1 Introduction

Today, the world is pushing ahead at a quicker rate with the contribution of new advancements. The horticulture area in India utilizes nearly 263 million individuals in what must be considered the World's biggest farming. India positions second on the planet's farming, and the creation has expanded from USD 87 billion to USD 459 billion somewhat recently. Around the world, India positions 10th in farming products. India's absolute region with the land is around 3.287 million km^2, while the land for development is 159.7 million hectares that are positioned second on the planet. Be that as it may, the inundated harvest region for cultivating is simply 82.6 million hectares [1]. Worth $2.1 trillion, India is the third-largest economy in the world after the USA and China. India's agricultural production of food is highly dependent on monsoons. With the world's highest mountains, the Himalayas to the north, the Thar Desert to the west, the Ganges Delta to the east, and the Deccan Plateau to the south, the country is home to a vast agroecological diversity [2]. The various soil types assist with determining the kind of crop that should be grown. The soil's quality is also crucial; it will increase productivity and boost the nutritional value of the harvests. Thus, it's important to know the characteristic of the soil and also the surroundings (Fig. 1).

Precision farming is a newer approach that emerged a few decades ago. Rather than considering the entire farm as a homogeneous piece of soil that absorbs moisture differently, the assumption is that some areas of the farm are more productive than others. The core issue in smart farming includes collecting data from the farm which is still prohibitively expensive, and installing sensors is difficult.

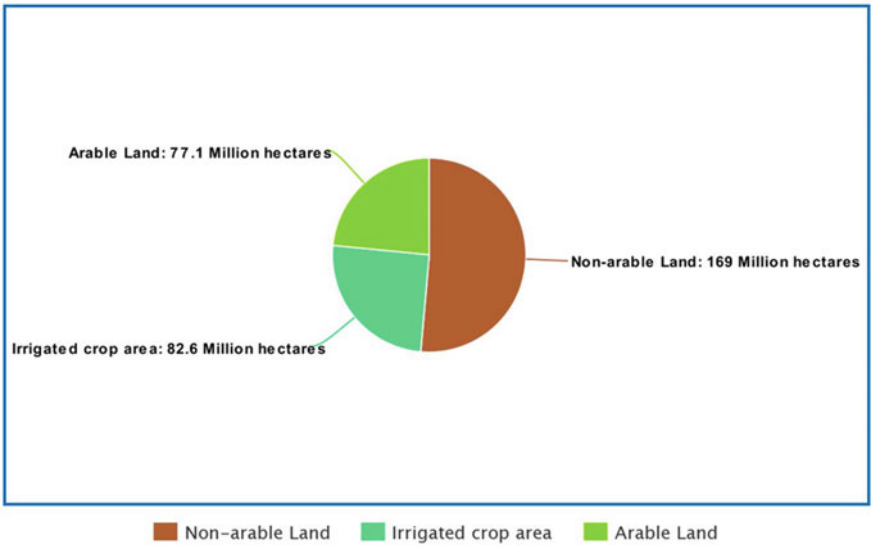


Fig. 1 Agricultural land in India

2 Background Study

The study [3] emphasized the benefits of smart farming and included a compelling debate about socioeconomic barriers. They have described the advantages and developments needed in a certain area of the smart agricultural system. Detector technology and wireless IoT technology system connectivity have been researched and described in the paper [4] depending on the current state of the agriculture system. The Remote Monitoring System (RMS) is offered as a hybrid system integrating Internet and radio transmission [5]. An article [6] proposed a smart GPS-enabled remote-control robot for spraying, weeding, moisture sensing, frightening birds and animals, vigilance, and other duties. A sharp watering system is integrated, as well as intelligent control and judgment based on exact information present in field data. [7] was mostly dependent upon the check humidity and temperature in agricultural settings which utilize the sensors which are based on the CC3200 single chip. CC3200 which is connected to the camera takes pictures and transmits them to the farmers' mobile phones through Wi-Fi MMS technology.

The suggested wireless flexible robot in [8] was tested in the field, readings were taken, and good results were obtained, demonstrating that this technology is particularly useful for smart agricultural systems. [9] proposes an Agro-logger system that can send and receive data from sensors as well as collect up-to-date and important data from the cloud. Depending on the feedback supplied by farmers and Agro-loggers, this data is further evaluated for the best selection criteria, after which the cloud will update the same data to the Agro-logger and alter the threshold value based on the selection criteria to enhance crop production and soil fertility. Using the World Bank's framework, research [10] investigates the ideas and concepts that underpin Climate-Smart Agriculture (CSA). While CSA allows for more holistic approaches to agriculture, it says that it functions within an apolitical framework that is exclusively focused on technical modifications at the production level.

The feature in [11] comprises the creation of a system capable of monitoring temperature, moisture, humidity, and even the mobility of animals utilizing sensing as well as an Arduino in farming activities. With the combined features of on-board microelectronics and low-power short-range RF communications in [12], solar radiation has the potential to offer sensor fusion and actuator control at a cheap price. The issue is that monitoring and evaluating in near real-time is difficult. The present endeavor focuses on monitoring within the framework of the IoT. The earliest attempts to regulate data flow using a convolutional neural network are described in detail. Paper [13] provides some amount of mechanization, allowing the notion of seeing the field and product conditions within certain long-distance extents utilizing cloud administrations. There are still a lot many unaddressed problems in [14] Smart Sustainable Agriculture (SSA) for managing IoT or AI machinery, e.g., sharing of information and management, compatibility, and large amounts of storage and computation.

Exploration of current IoT or AI technologies that are being utilized in SSA and which are followed by identification of IoT/AI technical architecture is capable of

enabling the SSA platform evolution. Water utilization efficiency has grown steadily with the ample number of techniques for irrigation in [15], as evaluated by seasonal consumptive water consumption. Two mustard-type irrigations produced a larger produce crop return and cost-effective ratio than one irrigation, which produced a huge net cost-effective return than no irrigation. Sulfur treatment rates increased dry matter buildup in Indian mustard, seed, biological yield, and harvest index. As the sulfur application amount grew up, the crop's seasonal consumptive water demand and water usage efficiency steadily increased. As sulfur application levels increased, so did the amount of soil moisture remove from the deeper layer. This study aimed to determine how supplemental watering using drip, sprinkler, and furrow systems influenced the development, yield, and quality of two watermelon cultivars, as well as their economic viability in Kenya's semi-arid environment [16]. Supplemental types of irrigations were discovered to influence watermelon cultivar development, productivity, and quality.

In [17], a crossbreed profound learning indicator was proposed, and to break down environment information into predetermined part bunches having various recurrence attributes, the Experimental Mode Deterioration (EMD) strategy was used after which a Gated Intermittent Unit (GRU) network was developed for every gathering as the sub-indicator, and lastly, the output from the GRU was amended to add the acquired the forecast result. The administration moves the program of the Kahramanmaras Irrigation Scheme was reviewed in this evaluation. According to the findings, the trade relationship was not helpful to ranchers; eventually, government expenses were reduced [18]. Ranchers required adequate knowledge about the water system. The transition to Agriculture 5.0 is on the docket of the majority of crucial agricultural apparatus manufacturers over the next decade [19]. The task of the paper [20] was about IoT sensors or gadgets and their application to make tough cultivating. As indicated by the writing, reexamining food adequacy is conceivable if everybody embraces brilliant agribusiness using IoT. Brilliant agribusiness utilizing IoT is recommended for all area partners as a procedure to build food supply [21].

Isotopes have been utilized to part evapotranspiration into its two significant parts (dissipation and harvest happening) in paper [22]. The proficiency of water use was determined, and the level of penetrated return water was inspected in the water system. This data is basic for superior information on water balance, the compelling administration of hydrological cycles, and ideal water use. Authors [23] performed a survey to examine the adoption, discontinuation, and non-adoption of the sprinkler irrigation systems among farmers instructed to use them in Iran's Ardabil Province. Farmers were divided into three groups: adopters, abandoners following adoption, and non-adopters. An article [24] offered an outline for predictive investigation, the Internet of Things (IoT) devices that have cloud administration, and safety units for multilateral in the agriculture business. It emphasizes the problems and issues that may arise when combining modern technologies with ancient farming techniques. Depending on the feedback supplied by farmers and Agro-loggers, this data is further evaluated for the best selection criteria, after which the cloud will update the same data to the Agro-logger and alter the threshold value based on the selection criteria to enhance crop production and soil fertility. Table 1 offers an outline for predictive

Table 1 Research work by authors

Year	Authors	Summary
2018	Fiehn, Heinz B, Lewis S, Arturo F. Avila, Arturo Freydig Avila, Alan Mickelson, and Bennett M [12]	A convolutional neural network is described to regulate data flow in detail. Even though the brain is convolutional, training requires a huge number of photos of the item to be identified under various situations
2019	Naresh, Muthunoori, and P. Munaswamy [13]	This farming modernization proposal is straightforward, rational, and feasible. Ranchers may readily pick which fungicides and pesticides to employ to boost crop output based on these parameter values
2019	Alreshidi, Eissa [14]	Artificial intelligence or IoT technical structure for SSA is the major contribution solve the problems generated by the agricultural process's fragmented nature
2020	Jin, X. Bo, Nian X. Yang, Xiao Y. Wang, Yu-T Bai, Ting-Li S, and J-Lei Kong [17]	A hybrid deep learning determinant wherein an empirical mode decomposition process has been used and a gated recurrent unit (GRU) network is introduced to get the prediction result
2021	Vadlamudi, Siddhartha [20]	They have used a Methodical Literature Assessment (MLA) to ask and answer particular research questions that can increase food sufficiency if handled effectively
2021	Haque, Md Alimul, Deepa Sonal, Kailash Kumar, Shameemul Haque and Ejaz Shakeb [21]	Discovered suitable IoT challenges and solutions which are dependent upon application needs. Furthermore, the significance of Data Analytics and IoT in smart agriculture systems has been greatly emphasized

investigation of the administration and safety units for multilateral in the agriculture business.

3 Framework for Smart Agriculture System

Precision farming is a relatively new technique that was developed a few decades ago. Rather than viewing the entire farm as a homogenous piece of soil that absorbs moisture differently, the idea is that some portions of the farm are more fruitful than others. Precision agriculture was invented a few decades ago, but it has failed to gain traction. The fundamental problem is that obtaining data from the farm is still

prohibitively expensive, and putting sensors is not simple. Figure 2 shown below has the framework for a smart agriculture system.

Sensors: Soil characteristics are identified using sensors. Figure 3 shows how the various detectors in farms measure the soil moisture, humidity, warmth, volume of water, and animal encroachment. As a result, the land's humidity or the degree of moisture content in the soil, as well as animal intrusion, are recognized. This described system is the Smart Farming System's heart.

- **Gas Sensor**: The device that has the potential of detecting the presence or concentration of gases in the surrounding environment is known as a Gas Sensor. By changing the resistance of the material inside the sensor, the sensor can create a corresponding potential difference which depends upon the concentration of the gas and is recognized as output voltage.
- **Soil Moisture Sensor**: Farmers can take actions depending upon the values obtained from the sensors when a field situation, such as low water levels, starts causing a stress reaction. Based on the dielectric constant of the soil, soil moisture sensors assess the volume of water content.

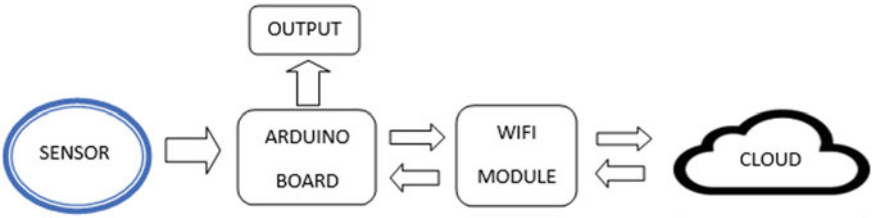


Fig. 2 Framework of smart agriculture system

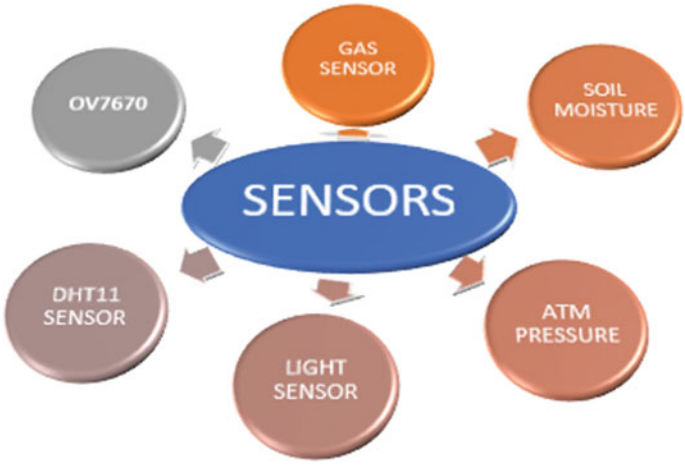


Fig. 3 Sensors used in collecting data in precision farming

- **ATM Pressure Sensor**: An imported high-precision measurement unit is used in this atmospheric pressure sensor. The gadget features high-precision temperature adjustment, high stability, minimal drift, and high repeatability built-in.
- **OV7670**: The OV7670 Camera Module is generally a tiny image sensing device that has a low operating voltage like a VGA camera and an image processor on a single chip. The product VGA picture has the potential of achieving a commendable frame rate of 30 frames per second. The quality of the image, data format, and transmission manner can be altered by the user as per his/her choice.
- **DHT11 Sensor**: The sensing device which is known as the DHT11 sensor is generally a relatively cheaper digital temperature and humidity sensor. The temperatures vary from $-55°$ to $+150°$ Fahrenheit. It consumes the least amount of energy and consumes the least amount of power.
- **Light Sensor**: A light sensor is a device that detects the quantity of light received. The light that falls on a patch of land may be measured using a photoresistor or an LDR. The resistance value of the LDR fluctuates depending on how much light is shined on it. The amount of light is translated to a 10-bit digital number, then to a percentage out of 100.

The sensor data needs to be processed and utilized to ensure smarter answers during real-time farming. The forecast is generated by accessing data on soil temperature, humidity, moisture, etc., comparing it with the data we receive from agricultural research institutions so that it gives a proper maturity time and seasonal crop cycle pattern. Data analytics is critical in delivering precision agriculture, which aids in the management of farmed land. The Wi-Fi module (ESP2866) with embedded sensors collects raw data from the farms and then uses cloud technology to gather the information and transfer it to the database for comparison. During this process, a massive amount of data is collected from the farms and transported to the application, where it is evaluated, and all possible outcomes are displayed.

4 Challenges Faced in Smart Agriculture System

An irrigation system is required for any homeowner's landscape. Rivers and streams may be managed by smart irrigation systems relying on factors such as soil moisture and weather forecasts. A substantial amount of money can be saved on water bills because a smart irrigation system may increase the resources so that each and everything receives what it needs wasting nothing. Challenges faced while setting up an irrigation system are.

- **The curves of learning**: Precision farming comprises the application of avant-garde technologies to increase agricultural productivity. Surrounding up the appropriate IoT architecture and detector webwork for the respective field might be a difficult task for the average farmer. It must be remembered that the margin for failure in a technologically advanced 'smart farm' is tiny—as is the margin for

poor management. Before farmers can begin to apply smart farming, they must first get completely familiar with the idea of smart farming and the tools/devices involved. Uncertainty may be hazardous.

- **Inadequate understanding of many agricultural production functions**: To assure enhanced farming yields, in-depth economic research can be used in addition to internet resources. Precision agriculture is all about improving output levels by making the greatest use of available, restricted inputs—and tracking the factor of production is essential for this.
- **Inadequate scalability and configuration issues**: IoT tools must be supplied to farmers (access points, gateways, etc.) In other words, the same technology and advantages should be available on both an enormous merchant farm and a little portion of their own garden/cropland. A further potential source of worry is the requirement to set up the architecture and sensors explicitly. For agriculture to become genuinely self-sufficient, technology must be self-configurable.

The proposed system will be made so by taking into consideration the problem given above. This concept employs the Internet of Things and Data Science innovation to conduct a continuous study of obtained data. Numerous sensors are established in the field to provide a result of the dataset that is then uploaded to the cloud framework [19]. The cloud framework extracts the necessary data from the meteorological focus and compares it to the on-field informative index. The analysis is then carried out using information science concepts to determine the amount of water to be provided following each harvest type in the field. The suggested structure is both highly productive and financially feasible [8].

5 Conclusions and Future Work

IoT-based smart agriculture systems can be very beneficial to farmers because both too much and too little irrigation is bad for agriculture. This technology can advise farmers on whether or not irrigation is required. This technology can advise farmers on whether or not irrigation is required. As a result, the study provides a method for merging the most recent innovation in the agricultural area to transform traditional water system tactics into modern strategies, resulting in simple profitable, and temperate trimming. Some level of automation is provided, enabling the concept of viewing the field and product circumstances over large distances by employing cloud administrations.

References

1. Ministry of Agriculture and Farmers Welfare Posted On: 11 AUG 2021 8:30 PM by PIB Delhi. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1744934

2. Agriculture and Food Management. https://www.indiabudget.gov.in/economicsurvey/doc/vol2chapter/echap07_vol2.pdf
3. Rehman, A. (2015). *Smart agriculture: An approach towards better agriculture management*. Omics Group. ebooks.
4. Patil, K. A., & Kale, N. R. (2016). A model for smart agriculture using IoT. In *2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication (ICGTSPICC)* (pp. 543–545). IEEE.
5. Tech-Student, M. (2016). A literature study on agricultural production system using IoT as inclusive technology. *International Journal of Innovative Technology*, *4*(1).
6. Gondchawar, N., & Kawitkar, R. S. (2016). IoT-based smart agriculture. *International Journal of Advanced Research in Computer and Communication Engineering*, *5*(6), 838–842.
7. Prathibha, S. R., Hongal, A., & Jyothi, M. P. (2017). IoT based monitoring system in smart agriculture. In *2017 International Conference on Recent Advances in Electronics and Communication Technology (ICRAECT)* (pp. 81–84). IEEE.
8. Krishna, K. L., Silver, O., Malende, W. F., & Anuradha, K. (2017). Internet of Things application for implementation of smart agriculture system. In *2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics, and Cloud) (I-SMAC)* (pp. 54–59). IEEE.
9. Patil, G. L., Gawande, P. S., & Bag, R. V. (2017). Smart agriculture system based on IoT and its social impact. *International Journal of Computer Applications, 176*(1), 0975–8887.
10. Taylor, M. (2018). Climate-smart agriculture: what is it good for?. *The Journal of Peasant Studies, 45*(1), 89–107.
11. Sushanth, G., & Sujatha, S. (2018, March). IOT based smart agriculture system. In 2018 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET) (pp. 1–4). IEEE.
12. Fiehn, H. B., Schiebel, L., Avila, A. F., Miller, B., & Mickelson, A. (2018, October). Smart agriculture system based on deep learning. In Proceedings of the 2nd International Conference on Smart Digital Environment (pp. 158–165).
13. Naresh, M., & Munaswamy, P. (2019). Smart agriculture system using IoT technology. *International journal of recent technology and engineering, 7*(5), 98–102.
14. Alreshidi, E. (2019). Smart sustainable agriculture (SSA) solution underpinned by internet of things (IoT) and artificial intelligence (AI). arXiv preprint arXiv:1906.03106.
15. Piri, I., Nik, M. M., Tavassoli, A., Rastegaripour, F., & Babaeian, M. (2011). Effect of irrigation frequency and application levels of sulphur fertilizer on water use efficiency and yield of Indian mustard (Brassica juncea). *African Journal of Biotechnology, 10*(55), 11459–11467.
16. Wakindiki, I. I. C., & Kirambia, R. K. (2011). Supplemental irrigation effects on yield of two watermelon (Citrulus lanatus) cultivars under semi-arid climate in Kenya. *African Journal of Agricultural Research, 6*(21), 4862–4870.
17. Jin, X. B., Yang, N. X., Wang, X. Y., Bai, Y. T., Su, T. L., & Kong, J. L. (2020). Hybrid deep learning predictor for smart agriculture sensing based on empirical mode decomposition and gated recurrent unit group model. *Sensors, 20*(5), 1334.
18. Tanriverdi, C., & Degirmenci, H. (2011). Assessment of management transfer of Kahramanmaras irrigation system. *Scientific Research and Essays, 6*(3), 522–528.
19. Saiz-Rubio, V., & Rovira-Más, F. (2020). From smart farming towards agriculture 5.0: A review on crop data management. *Agronomy, 10*(2), 207.
20. Vadlamudi, S. (2021). Rethinking food sufficiency with smart agriculture using Internet of things. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(9), 2541–2551.
21. Gavrilović, N., & Mishra, A. (2021). Software architecture of the internet of things (IoT) for smart city, healthcare and agriculture: analysis and improvement directions. *Journal of Ambient Intelligence and Humanized Computing, 12*(1), 1315–1336.
22. Gupta, S. K., Goyal, M. R., & Singh, A. (Eds.). (2018). Engineering practices for management of soil salinity: agricultural, physiological, and adaptive approaches. CRC Press.

23. Bagheri, A., & Ghorbani, A. (2011). Adoption and non-adoption of sprinkler irrigation technology in Ardabil Province of Iran. *African Journal Agriculture Research, 6*(5), 1085–1089.
24. Suma, V. (2021). Internet-of-Things (IoT) based smart agriculture in India-an overview. *Journal of ISMAC, 3*(01), 1–15.

5G as a New Phase of Wireless Network Technology

Saima Naaz, Hamnah Rao, Parul Aggarwal, and Ahmed J. Obaid

Abstract The beginning of the twenties has brought up a new era of technology with wireless network technology allowing the globe to move faster. Starting from radio waves to telegraph and switching from mobile phones to smartphones, growth has been evident as the need for seamless communication has risen. Earlier generations of cellular technology focus on connectivity, whereas 4G and 5G experience another phase of evolution connecting people, machines, objects, and devices for faster information access and secure connections. This study emphasizes the advancement shown in whole network architecture by the fifth generation as we notice visualization and digital experience of artificial intelligence and machine learning which promotes automation in industry. Applications and use cases with challenges faced by 5G and some future trends are also discussed.

Keywords 5G Technology · Wireless technology · Telecommunication · Cellular networks

1 Introduction

In recent years, technology has evolved tremendously, and Internet has revolutionized the way we work and live [1]. It has become a vital part of our life, allowing us to communicate with individuals all over the world. It is comprised of a huge number of autonomously operated networks and is completely decentralized, with no central control. It is an astonishing technology that will soon rule the globe, and this network has a good impact on a range of fields.

In comparison with earlier networks, 5G is expected to deliver much higher connection speeds with faster reaction times. In the field of telecommunications,

S. Naaz · H. Rao · P. Aggarwal
Jamia Hamdard, New Delhi, India

A. J. Obaid (✉)
Faculty of Computer Science and Mathematics, University of Kufa, Kufa, Iraq
e-mail: ahmedj.aljanaby@uokufa.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_31

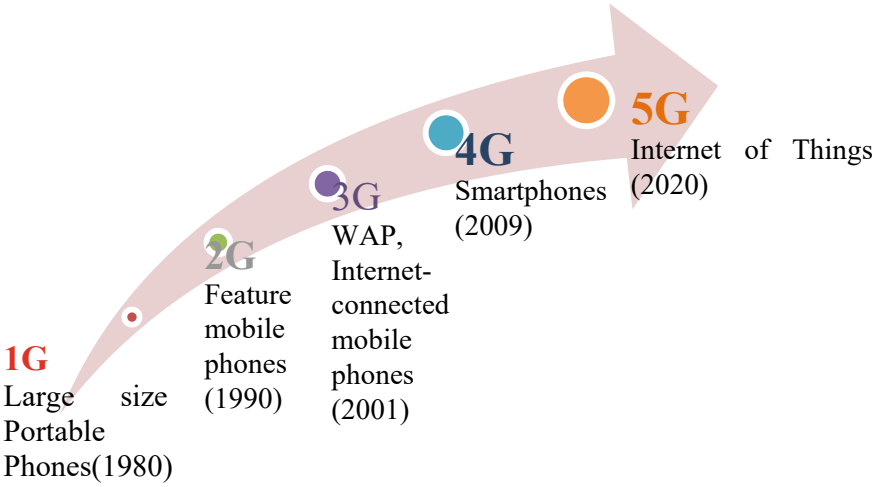


Fig. 1 Evolutions of 1G–5G

there have been several advancements starting from 1G up to 5G [2]. For every generation, there exists a set of norms, capabilities, procedures, and characteristics that make it different from the preceding one [3]. 1G was analog and was the initial step on the route to publicly or commercially available mobile telephony. 2G signaled the shift from analog to digital speech transmission. 3G has a Wide Brand Wireless Network, which improves clarity [4]. For phone and data services, multimedia, and Internet over IP, 4G technology provides high capacity, high security, high bandwidth, and low-cost services [5]. Figure 1 demonstrates the evolution of 1G to 5G technologies.

With the tremendous advancements and growth in the mobile and telecommunications sectors, the advancement of generation bands has proven to be one of the best technologies ever seen [6]. Fifth-generation (5G) technology is a massively scalable, high-data-throughput technology, and it is an emerging generation of mobile networks in the field of wireless communication. [7]. Smart cities and their domains [8–11] will be capable of sharing data at greater data transmission speeds than ever before because of 5G.

2 Literature Review

In [12], the authors provide a detailed overview of several emerging technologies with emphasis on 5G mobile networks, which are expected to handle exponential traffic growth and enable the Internet of Things and in [13] an overview of the most recent research on both green 5G technologies and communication energy harvesting.

In [14], the authors discuss some of the challenges in implementing 5G-IoT due to the elevated data rates, which involve both cloud-based services and edge computing on IoT devices. The services and application concepts of 5G are discussed in [15]. In research, [16] authors examine the impact of 5G technology on-demand response (DR). In [17], the authors examine the technology that will facilitate future fifth generation (5G) networks to achieve multiple Gbps speeds.

In [18], authors examine the effect of 5G on AI, IoT, and self-driving vehicles. In [19], several generations of wireless mobile technologies are compared on several parameters like accessibility, efficiency, growth, development, significance, and benefits. In [20], they discuss the security and privacy needs of 5G industrial applications, its network design, and air interface. The study's [21] main goal is to provide a broader perspective on a wide range of projects linked to advanced technologies for the next evolution of cellular systems and networks, with a particular focus on 5G mobile communications.

In [22], researchers examine the role of smart and precision farming in the agricultural sector, its benefits, as well as 5G applications in precision farming. In [23], they present an introduction to cloud security, virtualization, as well as the problems of user privacy, moreover [24] they show two scenarios that are explored, that is channel modeling and antenna system over-the-air (OTA) testing. The authors aim to discuss a framework for resolving the contributions of countries, research centers, and universities in innovations in a technological area [25], also authors [26] examine the progression of the Industrial Revolution as well as the technologies that have influenced its development.

3 The Architecture of 5G

Figure 2 shows the system model of 5G, and it is an IP-based paradigm that is built for wireless communication networks [27]. The system is made up of a core user terminal and many separate and self-contained technologies for radio access. It works like an IP link to the outer world of the Internet. The IP technology provides control data so as to enable proper routing of IP packets and establishing sessions between client apps and servers located anywhere on the Internet.

4 The Application of 5G

5G has provided a worldwide standard that has benefited everyone. Users can use their computer mobile devices anywhere, at any time, because network connectivity is globally easier to use. Soon 5G will turn the entire planet into a Wi-Fi hotspot.

New 5G applications are emerging, supported by national strategies:

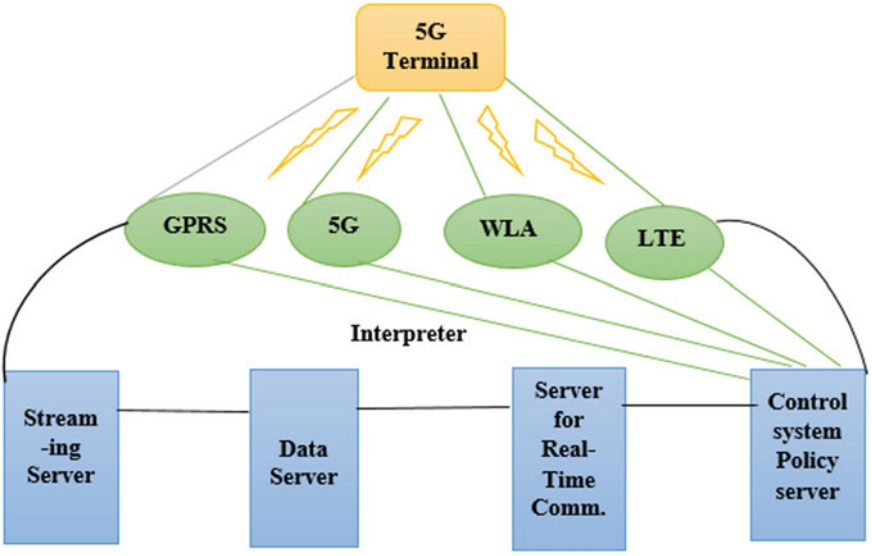


Fig. 2 Architecture of 5G [28]

- **Multi-Media, advertising, and multi-broadcasting**: The advanced version and high-efficiency media can be seen smoothly on smartphones or TV, etc. [29].
- **Public healthcare services**: In this sector, telemedicine and telehealth using telecommunications technology can help in saving thousands of lives by providing the facilities of online checkups [30].
- **Autonomous Vehicles**: Vehicle technology is progressing rapidly and shall define the way autonomous vehicles shall drive the future. Portable computer systems are matchable to the processing capability of data centers [31].
- **5G for Smart Cities and Traffic Management**: Intelligent transportation systems are being implemented around the globe to monitor traffic [32].
- **Industrial Automation**: 5G in the industries shall offer flexibility, lower prices, and reduced costs, as compared to the present wireless technology. These are not achievable with the present wireless technologies and have been discussed in [33].
- **Augmented Reality (AR) and Virtual Reality (VR)**: AR and VR applications, enabled by 5G and the reduced latency it offers, can make them highly interactive. There exist several opportunities that support several complicated activities [34].
- **5G IoT Applications for Drones**: Drones are nowadays not just limited to photography or filmmaking, rather their applications are wide. Utilities, for example, are already utilizing drones for examining equipment. Drone delivery of goods shall be the future and offer more range and interaction [32]
- **Massive IoT—Wearables and Mobile**: Massive IoT element of 5G will be a huge market for wearables, trackers, and sensors. In any given location, 5G will allow significantly more devices to work smoothly without apparent delays and lost signals [35].

Table 1 **5G** use cases

Smart vehicles	Internet of Things	Entertainment and gaming	Critical operations and remote devices
Public transport systems and vehicles	Smart automobiles	Live TV [29]	Remote control of heavy machines
Vehicle management	Sensors	On-demand TV	Real-time monitoring of industrial plants [33]
Traffic-related data [32]	Automation systems	High video quality everywhere	Factory automation
Public safety responders	Connected health care	AR and VR enabled enhanced entertainment	Remote surgery
Inter-vehicles exchange of information	Drones for delivery of goods		Smart grids

5 5G Use Cases

The fifth-generation wireless communication technology makes a shift in communication. Everyone, from gamers to governments, will benefit from a new set of 5G use cases that combine connectivity, intelligent edge, and Internet of Things (IoT) technology. Table 1 clearly shows the different use cases of 5G. A huge number of future technical innovations will rely on 5G connections, from the expansion of IoT to significant advancements in how AI is applied in the real world.

6 Advanced Features of 5G

The implementation of 5G is like the realization of a dream. 5G is undoubtedly equipped with advanced functions [36, 38] in comparison with the prior ones. 5G has advanced in the following ways:

- It is practically conceivable to obtain super-fast speeds of 1–10 Gbps.
- Connection to hundreds and thousands of devices.
- Global coverage.
- A 90% decrease in network energy use.
- The battery performance will be significantly increased.

Though we realize that 5G promises to enable contemporary and upcoming wireless communication applications, despite its benefits and promises, 5G comes with several drawbacks as summarized in Table 2.

Table 2 Pros and cons of 5G

Pros of 5G	Cons of 5G
It is possible to obtain data rates of up to 10 Gbps. This gives the consumer a better experience, as well as faster download and upload rates	5G technology is expensive and installing and maintaining a 5G network requires trained engineers. This raises the costs of 5G implementation and maintenance
With the carrier aggregation capability, more bandwidths can be used	Smartphones with 5G technology are pricey. As a result, the common man will have to wait for 5G technology to become available
5G millimeter wave can reach a latency of less than 1 ms	Expensive infrastructure development for 5G
Offers uniform and consistent global connectivity	5G technology is still progressing, and having an operational scenario is the thing of the future

7 Challenges of 5G

This section presents a few notable technological challenges and a few common ones.

7.1 Technological Challenges

- **Inter-cell Interference**: It is a concern that needs to be addressed, traditional macro-cells and contemporaneous small cells, having different sizes, might pose interference.
- **Efficient Medium Access Control**: Huge deployment of access points, and terminals shall bring high latency, and poor throughput, and will result in hotspots being unable to deliver the services. To maximize the benefits, thorough exploration is required.
- **Traffic Management**: Machine-to-Machine (M2M) devices pose major system issues, such as huge congestion. This is not a major one for human-to-human traffic.

7.2 Common Challenges

- **Multiple Services**—5G is entrusted to provide services to varied networks, technologies, and devices across the world. Thus, standardization of dynamic, user-centric, and data-rich wireless services to meet people's expectations [37] becomes significant.
- **Infrastructure**—the standardization and application of 5G networks are posing technological obstacles for researchers.

- **Communication, Navigation, and Sensing**—signals delivery relies on the radio spectrum. It is crucial for these services and requires much more infrastructure for support.
- **Security, and Privacy**—the security of data is a significant and major issue that 5G poses. Trust, privacy, and security, in particular, cyber-security is on the rise throughout the world [26].
- **Legislation of Cyberlaw**—with 5G's high speed and widespread availability, cybercrime and other forms of fraud may arise. As a result, Cyberlaw regulation is a critical topic, and a worldwide concern.

8 Future Scope and Summary

5G is here to stay and would largely and dominantly define the future with its extraordinary data capabilities, unrestricted call volumes, and unmeasurable data broadcast. It shall drive our lives by providing the globe with unrestricted access to information, communication, and entertainment. This paper discusses how 5G with higher network speed led to the next-generation technology revolution phase mentioning the advantages, disadvantages, applications, and limitations of 5G. We can conclude that automation with IoT growth and AI implementation in the real world, 5G connectivity will be essential for technological advancements. We can analyze the effects of 5G on people's physical and mental health using machine learning algorithms as part of our future work because IT has its own negative effects on health.

References

1. Zhang, T., Li, Y., & Chen, C. P. (2021). Edge computing and its role in Industrial Internet: Methodologies, applications, and future directions. *Information Sciences, 557*, 34–65. https://doi.org/10.1016/j.ins.2020.12.021
2. Bhalla, M. R., & Bhalla, A. V. (2010). Generations of mobile wireless technology: A survey. *International Journal of Computer Applications, 5*, 26–32.
3. Vora, L. J. (2015). Evolution of mobile generation technology: 1G to 5G and review of upcoming wireless technology. *5G International Journal of Modern Trends in Engineering and Research, 2*, 281–290.
4. Sharma, P. (2013). Evolution of mobile wireless communication networks-1G to 5G as well as future prospective of next generation communication network. *International Journal of Computer Science and Mobile Computing, 2*, 47–53. https://www.ijcsmc.com/
5. Gawas, A. U. (2015). An overview on evolution of mobile wireless communication networks: 1G–6G. *International Journal on Recent and Innovation Trends in Computing and Communication, 3*, 3130–3133.
6. Mehta, H., Patel, D., Joshi, B., & Modi, H. (2014). 0G to 5G mobile technology: A survey. *Journal of Basic and Applied Engineering Research, 1*, 56–60.
7. Dangi, R., Lalwani, P., Choudhary, G., You, I., & Pau, G. (2021). Study and investigation on 5G technology: A systematic review. *Sensors, 22*, 26. https://doi.org/10.3390/s22010026
8. Agarwal, P., Mittal, M., Ahmed, J., & Idrees, S. M. (2021). *Smart technologies for energy and environmental sustainability*. Springer.

9. Gaba, G. S., Kumar, G., Kim, T. H., Monga, H., & Kumar, P. (2021). Secure device-to-device communications for 5g enabled internet of things applications. *Computer Communications, 169*, 114–128. https://doi.org/10.1016/j.comcom.2021.01.010
10. Tatari, M., Agarwal, P., Alam, M. A., Ahmed, J. (2022). Review of smart building management system. In *ICT Systems and Sustainability* (pp. 167–176). Springer.
11. Agarwal, P., Hassan, S. I., Mustafa, S. K., Ahmad, J. (2020). An effective diagnostic model for personalized healthcare using deep learning techniques. In *Applications of deep learning and big IoT on personalized healthcare services* (pp. 70–88). IGI Global.
12. Akpakwu, G. A., Silva, B. J., Hancke, G. P., & Abu-Mahfouz, A. M. (2017). A survey on 5G networks for the Internet of Things: Communication technologies and challenges. *IEEE Access, 6*, 3619–3647. https://doi.org/10.1109/ACCESS.2017.2779844
13. Wu, Q., Li, G. Y., Chen, W., Ng, D. W., & Schober, R. (2017). An overview of sustainable green 5G networks. *IEEE Wireless Communication, 24*, 72–80. https://doi.org/10.1109/MWC.2017.1600343
14. Shafique, K., Khawaja, B. A., Sabir, F., Qazi, S., & Mustaqim, M. (2020). Internet of things (IoT) for next-generation smart systems: A review of current challenges, future trends, and prospects for emerging 5G-IoT scenarios. *IEEE Access, 8*, 23022–23040. https://doi.org/10.1109/ACCESS.2020.2970118
15. Yifei, Y., & Longming, Z. (2014). Application scenarios and enabling technologies of 5G. *China Communication, 11*, 69–79. https://doi.org/10.1109/CC.2014.7004525
16. Hui, H., Ding, Y., Shi, Q., Li, F., Song, Y., & Yan, J. (2020). 5G network-based Internet of Things for demand response in smart grid: A survey on application potential. *Applied Energy, 257*, 113972. https://doi.org/10.1016/j.apenergy.2019.113972
17. Al-Falahy, N., & Alani, O. Y. (2017). Technologies for 5G networks: Challenges and opportunities. *IT Professional, 19*, 12–20. https://doi.org/10.1109/MITP.2017.9
18. Pisarov, J., & Mester, G. (2020). The impact of 5G technology on life in 21st century. *IPSI BgD Transactions on Advanced Research (TAR), 16*, 11–14.
19. Kachhavay, M. G., & Thakare, A. P. (2014). 5G technology-evolution and revolution. *International Journal of Computer Science and Mobile Computing, 3*, 1080–1087.
20. Ji, X., Huang, K., Jin, L., Tang, H., Liu, C., Zhong, Z., You, W., Xu, X., Zhao, H., Wu, J., & Yi, M. (2018). Overview of 5G security technology. *Science China Information Sciences, 61*, 1–25. https://doi.org/10.1007/s11432-017-9426-4
21. Le, N. T., Hossain, M. A., Islam, A., Kim, D. Y., Choi, Y. J., & Jang, Y. M. (2016). Survey of promising technologies for 5G networks. *Mobile Information Systems*. https://doi.org/10.1155/2016/2676589
22. Tang, Y., Dananjayan, S., Hou, C., Guo, Q., Luo, S., & He, Y. (2021). A survey on the 5G network and its impact on agriculture: Challenges and opportunities. *Computers and Electronics in Agriculture, 180*, 105895. https://doi.org/10.1016/j.compag.2020.105895
23. Ahmad, I., Kumar, T., Liyanage, M., Okwuibe, J., Ylianttila, M., & Gurtov, A. (2018). Overview of 5G security challenges and solutions. *IEEE Communication Standards Magazine, 2*, 36–43. https://doi.org/10.1109/MCOMSTD.2018.1700063
24. Zhang, P., Yang, X., Chen, J., & Huang, Y. (2019). A survey of testing for 5G: Solutions, opportunities, and challenges. *China Communications, 16*, 69–85. https://doi.org/10.12676/j.cc.2019.01.007
25. Felita, C., Suryanegara, M. (2013). 5G key technologies: Identifying innovation opportunity. In *2013 International Conference on QiR* (pp. 235–238). IEEE. https://doi.org/10.1109/QiR.2013.6632571
26. Rao, S. K., & Prasad, R. (2018). Impact of 5G technologies on industry 4.0. *Wireless Personal Communication, 100*, 145–159. https://doi.org/10.1007/s11277-018-5615-7
27. Tudzarov, A., & Janevski, T. (2011). Functional architecture for 5G mobile networks. *International Journal of Advanced Science and Technology, 32*, 65–78.
28. Tutorialspoint. https://www.tutorialspoint.com/5g/5g_architecture.htm
29. Tran, T., Navrátil, D., Sanders, P., Hart, J., Odarchenko, R., Barjau, C., Altman, B., Burdinat, C., & Gomez-Barquero, D. (2020). Enabling multicast and broadcast in the 5G core for

converged fixed and mobile networks. *IEEE Transactions on Broadcasting, 66*, 428–439. https://doi.org/10.1109/TBC.2020.2991548

30. Ahad, A., Tahir, M., Aman Sheikh, M., Ahmed, K. I., Mughees, A., & Numani, A. (2020). Technologies trend towards 5G network for smart healthcare using IoT: A review. *Sensors, 20*, 4047. https://doi.org/10.3390/s20144047
31. Ullah, H., Nair, N. G., Moore, A., Nugent, C., Muschamp, P., & Cuevas, M. (2019). 5G communication: An overview of vehicle-to-everything, drones, and healthcare use-cases. *IEEE Access, 7*, 37251–37268. https://doi.org/10.1109/ACCESS.2019.2905347
32. Pawłowicz, B., Salach, M., Trybus, B. (2018). Smart city traffic monitoring system based on 5G cellular network, RFID and machine learning. In *KKIO S/w engineering conference* (pp. 151–165). Springer, Cham. https://doi.org/10.1007/978-3-319-99617-2_10
33. Mistry, I., Tanwar, S., Tyagi, S., & Kumar, N. (2020). Blockchain for 5G-enabled IoT for industrial automation: A systematic review, solutions, and challenges. *Mechanical Systems and Signal Processing, 135*, 106382. https://doi.org/10.1016/j.ymssp.2019.106382
34. Siriwardhana, Y., Porambage, P., Liyanage, M., & Ylianttila, M. (2021). A survey on mobile augmented reality with 5G mobile edge computing: Architectures, applications, and technical aspects. *IEEE Communications Surveys & Tutorial, 23*, 1160–1192. https://doi.org/10.1109/COMST.2021.3061981
35. Liu, S., Liu, L., Yang, H., Yue, K., Guo, T. (2020). Research on 5G technology based on Internet of things. In *ITOEC* (pp. 1821–1823). IEEE. https://doi.org/10.1109/ITOEC49072.2020.9141671
36. Patel, S., Chauhan, M., Kapadiya, K. (2012). 5G: Future mobile technology-vision 2020. *International Journal of Computer Application, 54*.
37. Siriwardhana, Y., Gür, G., Ylianttila, M., & Liyanage, M. (2021). The role of 5G for digital healthcare against COVID-19 pandemic: Opportunities and challenges. *ICT Express, 7*, 244–252. https://doi.org/10.1016/j.icte.2020.10.002
38. Agarwal, P., Idrees, S. M., & Obaid, A. J. (2021). Blockchain and IoT technology in transformation of education sector. *International Journal of Online and Biomedical Engineering (iJOE), 17*(12), 4–18. https://doi.org/10.3991/ijoe.v17i12.25015

Machine Learning-Based Comparative Analysis of COVID-19 Infected Cases with GDP and World Happiness Report

Meenu Gupta, Rakesh Kumar, Shanon Sharma, Mitashi Bansal, and Ahmed J. Obaid

Abstract Today, the world has been struck by an indomitable virus and an unprecedented situation arising due to COVID-19 sickness. The current circumstance is an extremely extraordinary circumstance, and each country in this world is attempting to relieve and reduce its spread. In this paper, we will research on how to pre-process and combine datasets to ascertain required measures and set them up for an investigation. This paper aims at reviewing the correlation between the above-mentioned factors. COVID-19 dataset was imported and set up for examination by dropping segments and collecting columns. After deciding on and computing a decent measure, the examination results were visualized using seaborn. The factors like gross domestic product (GDP), happiness, and social support are the factors that played a decisive role in the impact of the coronavirus on a nation.

Keywords COVID-19 world happiness report · Correlation · GDP per capita · Pearson coefficient · Life expectancy

1 Introduction

Coronavirus began tainting individuals in Wuhan city in China in 2019's second half of December [1]. In only a single month, approximately 10k individuals were

M. Gupta (✉) · R. Kumar · S. Sharma
Chandigarh University, Mohali, India
e-mail: meenu.e9406@cumail.in

R. Kumar
e-mail: rakesh.e8623@cumail.in

M. Bansal
Amity School of Engineering and Technology, Noida, India
e-mail: mitashi.bansal@s.amity.edu

A. J. Obaid
Faculty of Computer Science and Mathematics, University of Kufa, Kufa, Iraq
e-mail: ahmedj.aljanaby@uokufa.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_32

contaminated and hundreds had passed on [2]. In the initial fourteen days, the passing rate was about 16.0%; however, by mid-February, it diminished to about 4.0% [3] and presently remains equal to approximately 2.0% [4]. The specified flare-up made several people bite the dust who in this event had taken treatment. Sadly, the framework of Wuhan in providing treatment could not handle the huge number of truly sick people who needed treatment [5]. This number which comprised sick people significantly crossed the limit of the hospitals [6]. Thus, numerous individuals who required fundamental consideration for parchedness and fever couldn't discover health care. The Republic of China presently gathers a demise pace of 0.7% that is outside the Province Hubei [7]. Demise pace of 2.0% which is around multiple times more prominent than the rate of death that occurred from occasional influenza [8]. During the last influenza season, 2018–2019, CDC has allegedly reported 35 million American citizens who got this season's virus [9] and around 56,000 individuals kicked the bucket building up a passing pace of 0.15% [10]. In this way, the 2.0% rate of demise has been presumably high because of many non-reporting of individuals essentially not represented inside information [11].

Further, this paper is discussed in many different parts such as Sect. 2 will brief about background work related to COVID-19, Sect. 3 will tell about the material and methods used, Sect. 4 will tell about the results of the experiment and discussions while Sect. 5 will give the conclusion and also the future scope [12].

2 Background Study

The current circumstance is an extremely extraordinary circumstance, and each country in this world is attempting to relieve and reduce its spread. As of now, it is vital to investigate the information of the spread of COVID-19 in this world to know an example or to discover any errors done by any specific country. The Centers for Disease Control and Prevention (CDC) is reacting to a flare-up of respiratory infection brought about by another COVID-19 variant that was first distinguished in China [13] and has now been identified in more than 70 areas universally [14], remembering for the United States of America [15]. This infection is given the name Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and apart from this, the illness that it causes has been named "COVID-19 Disease 2019" (curtailed "coronavirus") [16].

Furthermore, there is widespread agreement among economists that coronavirus has had severe negative impacts on the global economy. Early estimates showed that, should the virus become a global pandemic, most major economies will lose at least 2.9% of their gross domestic product (GDP) over 2020. This forecast was already restated to a GDP loss of 3.4%. According to the World Happiness Report 2021, there was a significant reduction in the life expectancy in many countries. The economically disadvantaged in many countries faced the greatest chances of illness and death from COVID-19 [17]. COVID-19 is a gigantic gathering of diseases that are customary in people and a wide scope of sorts of animals, including dairy cows, cats,

camels, and bats [18]. Every so often, COVID-19 can spoil people and subsequently spread between people, for instance, with SARS-COV, MERS-COV, and now with this new contamination, SARS-CoV-2 [19, 20].

3 Materials and Methods

This section will discuss the dataset that has been used for analysis, the proposed model formulation, and apart from this, the proposed algorithm.

3.1 Dataset Used

In this section, the COVID-19 dataset available online and distributed by John Hopkins University has been considered that comprises the information identified with the total number of affirmed cases, each day, in every country [11]. Additionally, we have another dataset composed of different life factors, scored by individuals living in every country throughout the planet [21, 22]. Figure 1 discusses the graph that shows the pattern of rising and fall of COVID-19 cases concerning three countries China, Italy, and Spain. China and Italy were hotspots of the corona pandemic. However, in comparison, Spain didn't have many cases considering both developed and developing countries [23].

As of now, it is vital to investigate the information of the spread of COVID-19 in this world to know an example or to discover any errors done by a specific country. Through this investigation, we can realize where a specific nation remains taking everything into account [24].

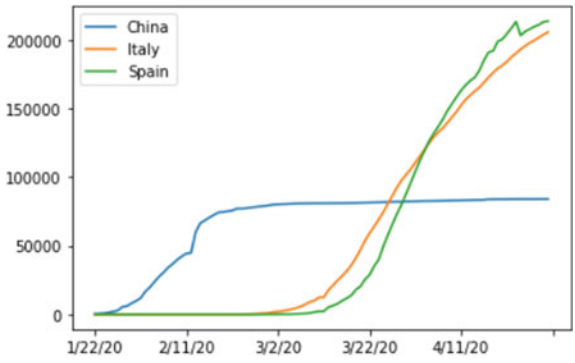


Fig. 1 Pattern of rising and fall of COVID-19 cases in China versus Italy versus Spain

Table 1 Correlation matrix between all indices

	GDP per capita	Social support	Healthy Life expectancy	Freedom to make life choices	Max infection rate
GDP per capita	1.000000	0.754906	0.835462	0.379079	0.250118
Social Support	0.754906	1.000000	0.719009	0.447333	0.191958
Healthy Life expectancy	0.835462	0.719009	1.000000	0.390395	0.289263
Freedom to make life choices	0.379079	0.447333	0.390395	1.000000	0.078196
Max infection rate	0.250118	0.191958	0.289263	0.078196	1.000000

3.2 Proposed Model Formulation

In this work, the two datasets (World Happiness Report and COVID-19 death cases) were considered to check whether there is any connection between the spread of the infection in a country and that country's happiness index. Data was extracted to a table showing the maximum infection rate (per day) for each country. Then, the World Happiness Report was imported. The emphasized report shows various factors such as freedom to make life choices, GDP per capita, healthy life expectancy, social support, etc. [25]. After pre-processing this data and readying it for processing, both the data were joined to form a single table that displays the average infection rate and the various happiness indices around the world. The correlation matrix for all indices was formed as given in Table 1.

Table 1 shows the correlation matrix between all the factors that were taken into study.

3.3 Proposed Algorithm

Correlation coefficients are utilized to gauge how solid the relationship is between two factors taken into consideration as presented in Eq. (1). There are several types of relationship coefficients, yet the most well-known is Pearson's as given in Eq. (2). Pearson's relationship (additionally called Pearson's R) is a kind of connection coefficient that is usually utilized in straight relapse. Dataset underwent feature extraction by country/region [26].

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 \sum_{i=1}^{n}(y_i - \overline{y})^2}} \tag{1}$$

where r_{xy} = coefficient of correlation, x_i = x-variable values, $\overline{x}$ = mean of x-variable values, y_i = y-variable values, and $\overline{y}$ = mean of y-variable values.

$$\sigma(x, y) = \frac{\sum[(x_i - x) * (y_i - y)}{\sigma x * \sigma y} \tag{2}$$

where σx = Standard Deviation of x and σy = Standard Deviation of y.

4 Experiment and Result Discussion

Table 1 shows the infection rate and the various happiness indices of each country, the happiness indices with maximum infection rate were individually compared.

4.1 GDP Versus Maximum Infection Rate Analysis

In this section, the GDP of the developing and the developed nations are compared with the maximum infection rate. The GDP is an important factor in indicating how the country will be handling the coronavirus and how their health care system and facilities are and how prepared they are to face the deadly virus [27].

Figure 2 shows that the increase in GDP was referenced by an increase in the maximum infection rate. This proves that the more developed countries were hit much worse than the underdeveloped countries which were thought to be the opposite [28].

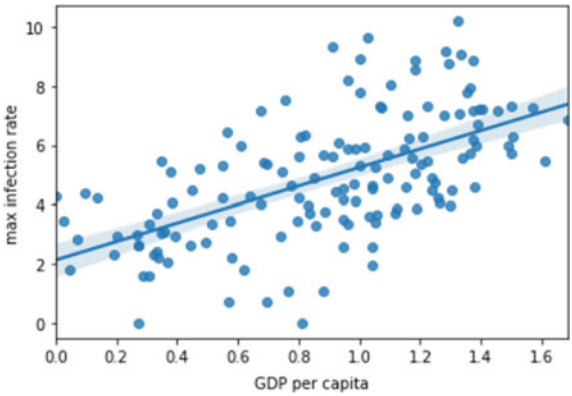


Fig. 2 GDP versus maximum infection rate analysis

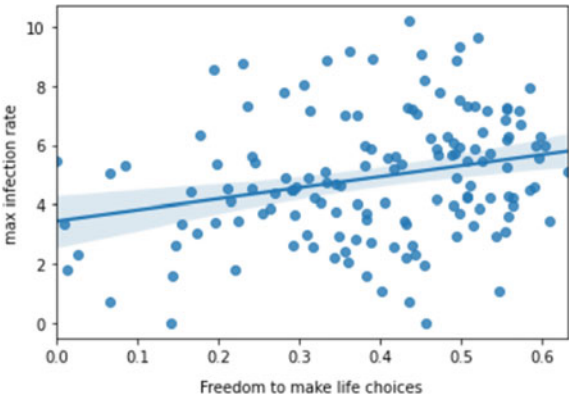


Fig. 3 Freedom to make life choices versus maximum infection rate analysis

4.2 Freedom to Make Life Choices Versus Maximum Infection Rate

Here, the work analyzed and compared the freedom index that the people have to make life choices in a country with the maximum number of cases in the country. The freedom to make life choices shows how much the people of the country are independent and self-dependent.

Figure 3 also provides evidence to the fact that the people in the developed countries where they have significant freedom to make life choices suffered more as opposed to the nations where freedom to make life choices was comparatively less. This can be understood by considering the case of USA, the European, and Arab nations.

4.3 Healthy Life Expectancy Versus Maximum Infection Rate

In this sub-section, the proposed work analyzed and compared the healthy life expectancy of the people of a country with the maximum infection rate in the country. Healthy life expectancy indicates how healthy and active the people are living in the country and this indirectly shows how the immunity of the people of the country is.

Figure 4 again shows that the countries which have a high healthy life expectancy were forward in getting the maximum number of COVID-19 cases. High healthy life expectancy can be understood by various factors such as the people of that nation might have good immunity, the nation might have good healthcare services, good medical care would have been there, etc. Despite this, these nations suffered much more cases than the nations where the healthcare facilities were comparatively underdeveloped. This indicates that healthy life expectancy is just a numerical fact, and it does not mean to stop the spread of the deadly coronavirus, and it also proves that a high healthy life expectancy is not enough for a new virus.

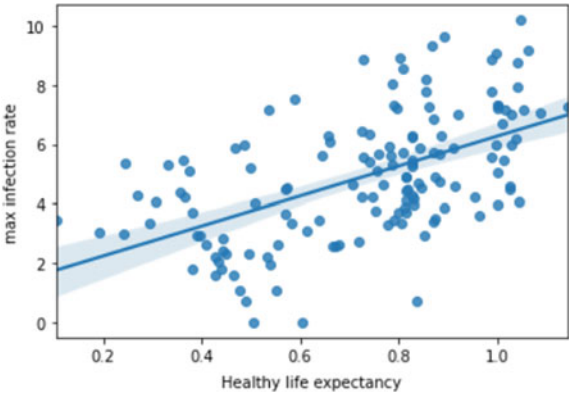


Fig. 4 Healthy life expectancy versus maximum infection rate analysis

4.4 Social Support Versus Maximum Infection Rate

In this sub-section, the work is analyzed and the social support of the people of a country with the maximum infection rate in the country is compared. Social support helps in indicating how mentally healthy and confident the people are living in the country, and this also indirectly shows how the people perceive COVID-19.

Figure 5 depicts that the countries which have a high social support were forward in getting the maximum number of COVID-19 cases. High social support can be referenced by various factors such as the people of that nation might have a good community, the nation might have the good mentality of its citizens, the parents and relatives might be supportive and motivating good social care would have been there, etc. The above figures collectively show that coronavirus hit every corner of the world irrespective of their GDP and their happiness index.

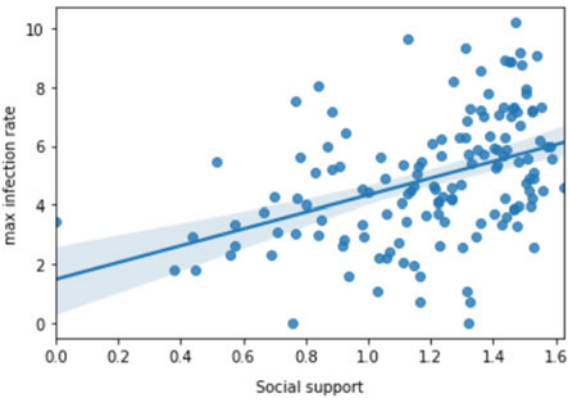


Fig. 5 Social support versus maximum infection rate analysis

4.5 COVID-19 Infected Case: Country-Wise Comparison

The four factors that were the indices and the basis of the results and analysis in the World Happiness Report are as follows: freedom to make life choices, GDP per capita, social support, and healthy life expectancy. These factors are used in analysis with the COVID-19 cases. Figure 6 shows a comparison between the countries that had the highest outburst. The figure shows how the COVID-19 cases increased with time for these countries. It is seen that the US had the highest slope, that is, the cases increased drastically as compared to the other developed country China.

In Fig. 7 shown, the countries, the Scandinavian countries such as Sweden and Finland are taken. They are also ranked as some of the happiest countries to live in this world. The figure shows how the COVID-19 cases increased with time for these countries. It is seen that India was performing poorly from the start as compared to these countries.

In Fig. 8 shown, two countries with some of the highest cases are taken (China and Spain) with another country which also performed poorly (Italy). However, Italy

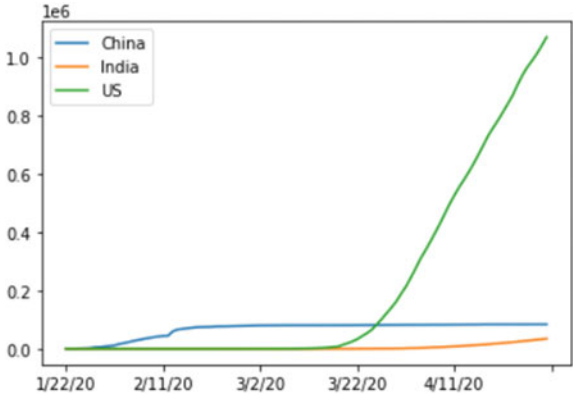


Fig. 6 Growth of COVID-19 cases every 20 days in China, India, and USA

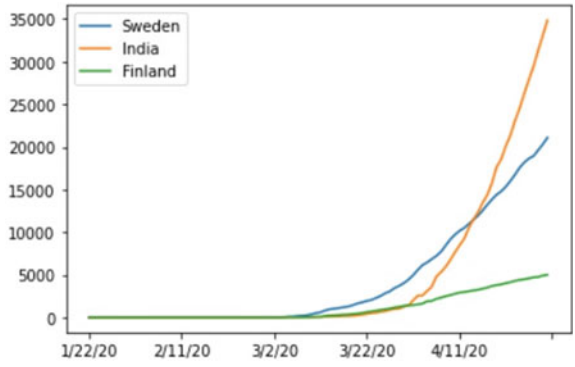


Fig. 7 Growth of Covid-19 cases every 20 days in Sweden, India, and Finland

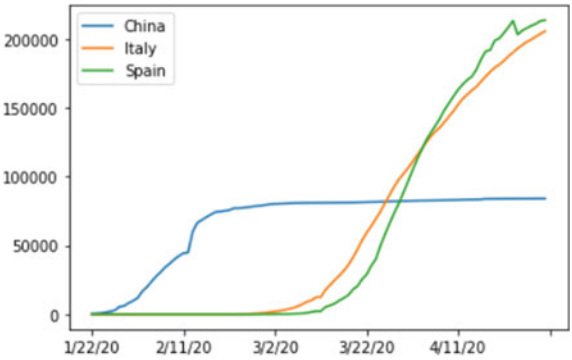


Fig. 8 Growth of COVID-19 cases every 20 days in China, Italy, and Spain

was able to curb the number of cases till the end of the year. The figure shows how the COVI-19 cases increased with time for these countries.

5 Conclusions and Future Work

The conclusions of this study show more developed countries were hit much worse than the underdeveloped countries which were thought to be the opposite. People in the developed countries where they have significant freedom to make life choices suffered more as opposed to the nations where freedom to make life choices was comparatively less. There was an insignificant relation between life expectancy and maximum infection rate. Finally, the countries which have high social support were forward in getting the maximum number of COVID-19 cases. In the future, this will most likely force the deployment of multi-disciplinary methodologies where medicine can be linked to domains of engineering, mathematical modeling, and machine learning to increase the efficacy of control, prevention, and treatment of diseases and other pandemics.

References

1. Tan, M., Liu, Y., Zhou, R., Deng, X., Li, F., Liang, et al. (2020). Immunopathological characteristics of coronavirus disease 2019 cases in Guangzhou, China. *Immunology, 160*(3), 261–268.
2. Bedford, T., & Hodcroft, E. (2020). *Phylogeny of SARS-like beta corona viruses including novel coronavirus SARS-CoV-2.* https://nextstrain.org/groups/blab/sars-like-cov
3. Salgotra, R., Gandomi, M., & Gandomi, A. H. (2020). Time series analysis and forecast of the COVID-19 pandemic in India using genetic programming. *Chaos, Solitons & Fractals, 138*, 109945.
4. WHO. (2019). *Middle East respiratory syndrome coronavirus (MERS-CoV).* [Online]. Available: https://www.who.int/health-topics/middle-east-respiratory-syndrome-coronavirus-mers#tab=tab_1

5. Liu, J., Li, S., Liu, J., Liang, B., Wang, X., et al. (2020). Longitudinal characteristics of lymphocyte responses and cytokine profiles in the peripheral blood of SARS-CoV-2 infected patients. *EBioMedicine, 55*, 102763.
6. Vo, M. T., Vo, A. H., Nguyen, T., Sharma, R., & Le, T. (2021). Dealing with the class imbalance problem in the detection of fake job descriptions. *Computers, Materials & Continua, 68*(1), 521–535.
7. Richardson, P., Griffin, I., Catherine, T., Smith, D., Oechsle, O., et al. (2020). Baricitinib as potential treatment for 2019-nCoV acute respiratory disease. *Lancet (London, England), 395*(10223), e30.
8. Zarikas, V., Poulopoulos, S. G., Gareiou, Z., & Zervas, E. (2200). Clustering analysis of countries using the COVID-19 cases dataset. *Data in Brief, 31*, 105787.
9. Guan, C. S., Lv, Z. B., Yan, S., Du, Y. N., Chen, H., et al. (2020). Imaging features of coronavirus disease 2019 (COVID-19): Evaluation on thin-section CT. *Academic Radiology, 27*(5), 609–613.
10. WHO. (2020). *Coronavirus disease (COVID-19) pandemic*. World Health Organization. [Online]. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019
11. Hopkins, J. (2021). *Coronavirus Resource Center*. [Online]. Available: https://coronavirus.jhu.edu/
12. Sachan, S., Sharma, R., & Sehgal, A. (2021). Energy efficient scheme for better connectivity in sustainable mobile wireless sensor networks. *Sustainable Computing: Informatics and Systems, 30*, 100504.
13. Yuki, K., Fujiogi, M., & Koutsogiannaki, S. (2020). COVID-19 pathophysiology: A review. *Clinical Immunology, 215*, 108427.
14. Ghaebi, M., Tahmasebi, S., Jozghorbani, M., Sadeghi, A., Thangavelu, L., *et al.* (2021). Risk factors for adverse outcomes of COVID-19 patients: Possible basis for diverse responses to the novel coronavirus SARS-CoV-2. *Life Sciences, 277*, 119503.
15. Ghanem, S., Kanungo, P., Panda, G., et al. (2021). Lane detection under artificial colored light in tunnels and on highways: An IoT-based framework for smart city infrastructure. *Complex & Intelligent Systems*. https://doi.org/10.1007/s40747-021-00381-2
16. Dansana, D., Kumar, R., Parida, A., Sharma, R., Adhikari, J. D., et al. (2021). Using susceptible-exposed-infectious-recovered model to forecast coronavirus outbreak. *CMC-Computers Materials & Continua, 67*(2), 1595–1612.
17. Sachan, S., Sharma, R., & Sehgal, A. (2021). SINR based energy optimization schemes for 5G vehicular sensor networks. *Wireless Personal Communications*. https://doi.org/10.1007/s11277-021-08561-6
18. Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., et al. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet, 395*(10223), 497–506.
19. Veronese, S., & Sbarbati, A. (2021). Chemosensory systems in COVID-19: Evolution of scientific research. *ACS Chemical Neuroscience, 12*(5), 813–824.
20. Kautish, S., Peng, S.-L., & Obaid, A. J. (2021). *Computational intelligence techniques for combating COVID-19*. Springer International Publishing.
21. Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., et al. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. *The Lancet, 395*(10223), 507–513.
22. Priyadarshini, I., Mohanty, P., Kumar, R., et al. (2021). A study on the sentiments and psychology of twitter users during COVID-19 lockdown period. *Multimed Tools Appl*. https://doi.org/10.1007/s11042-021-11004-w
23. Helliwell, J. F., Richard, L., Jeffrey, S., & Jan-Emmanuel, D. N. (2021). *World happiness report 2021*. Sustainable Development Solutions Network, New York. [Online]. Available: https://worldhappiness.report/ed/2021/
24. Azad, C., Bhushan, B., Sharma, R., et al. (2021). Prediction model using SMOTE, genetic algorithm and decision tree (PMSGD) for classification of diabetes mellitus. *Multimedia Systems*. https://doi.org/10.1007/s00530-021-00817-2

25. Priyadarshini, I., Kumar, R., Tuan, L.M., et al. (2021). A new enhanced cyber security framework for medical cyber physical systems. *SICS Softw.-Inensiv. Cyber-Phys. Syst*. https://doi.org/10.1007/s00450-021-00427-3
26. Priyadarshini, I., Kumar, R., Sharma, R., Singh, P. K., Satapathy, S. C. (2021). Identifying cyber insecurities in trustworthy space and energy sector for smart grids. *Computers & Electrical Engineering, 93*, 107204.
27. Singh, R., Sharma, R., Akram, S. V., Gehlot, A., Buddhi, D., Malik, P. K., & Arya, R. (2021). Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. *Safety Science, 143*, 105407. ISSN 0925-7535.
28. Sahu, L., Sharma, R., Sahu, I., Das, M., Sahu, B., & Kumar, R. (2021). Efficient detection of Parkinson's disease using deep learning techniques over medical data. *Expert Systems*, e12787. https://doi.org/10.1111/exsy.12787

Enhancing the Protection of Information in Digital Voting Using Application of Block Chain Technology

K. Saikumar, Faiza Iram, A. Sampath Dakshina Murthy, Ahmed Kareem Alzeyadi, and Sarah A. Al-Ameedee

Abstract Electronic voting has evolved as a substitute for paper-based balloting in order to reduce redundancies and inconsistencies. In recent years, it has been found that paper-based balloting fails owing to security and privacy concerns, and it has been recommended that electronic balloting be used instead. To guarantee the security of the data, we devised and implemented an efficient hashing utilising SHA-256. The use of the block sealing idea aids in the adjustment of the block chain. The consortium block chain idea is utilised so that the block chain may only be accessed by authorised users/candidates and is maintained by the election commission. The architecture described in this article may give reliable polling technique results. The hashing technique (SHA-256), block generation, information collection, and final result declaration were the approaches used in this study. The block chain technique will be used to carry out all of the operations. The use of block chain in voting systems may improve information security and make maintaining sensitive data easier in the electronic voting process.

Keywords Block chain · Hashing · SHA-256 · Electronic voting · MySQL

K. Saikumar (✉)
School of Engineering, Department of CSE, Malla Reddy University, Maisammaguda, Dulapally, Hyderabad, Telangana 500043, India
e-mail: saikumarkayam4@gmail.com

F. Iram
Department of Computer Science and Engineering, JNTUH College of Engineering, Sultanpur, Sangareddy, Telangana 502273, India

A. Sampath Dakshina Murthy
Department of ECE, Vignan's Institute of Information Technology (A), Duvvada, Visakhapatnam, Andhra Pradesh, India

A. K. Alzeyadi
National University of Science and Technology, Nasiriyah, Iraq
e-mail: Ahmed.kadhim@nust.edu.iq

S. A. Al-Ameedee
Department of Computer Technical, Al-Mustaqbal University College, Hillah, Iraq
e-mail: sarah.abdulridha@uomus.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_33

1 Introduction

An electronic voting system may help you run elections in a more efficient and transparent manner. This voting method may be used to vote in elections conducted at universities, private organisations, and other places. In this method, the voter may cast his vote from anywhere in the world. The following are the problems that are causing voter mistrust in the voting process: pre-poll rigging is the act of dishonestly organising an election to obtain a particular outcome. Voters may choose not to vote because polling places are too far away in the villages, and their ballots may be influenced. Second, interfering with the actual vote count, such as altering the number of votes cast in favour of one party over another, registering duplicate votes in any election involving two or more jurisdictions, and so forth. From the outset, the primary goal of the voting method has been to keep voting private. Many instances show that the voting process was not transparent and was riddled with issues. Paper-based voting is prone to fraud, wastes paper, and takes a long time to announce the results. Institutions such as the "Electoral Commission" were created with the goal of improving the voting process. The election commission's main responsibilities include establishing election standards, creating voting districts, and overseeing electoral procedures in order to ensure transparent and fair elections. If the system is linked to the block chain, it is protected by a feature known as immutability. Only new data may be added to the block chain; it cannot be changed or deleted. It's an ever-growing collection of stumbling obstacles. Except for the first block, each successive block holds the preceding block's hash value. The genesis block is the first in a chain of blocks. All votes on the block chain are cryptographically connected block by block. Each block contains the voter's ID, timestamp, and digest (hash) from the previous block. The block chain-supporting distributed ledger technology is known as distributed ledger technology (DLT). Elections have long been a source of societal concern since they are a reliable mechanism of making democratic choices. This procedure's effectiveness is influenced mostly by the degree of confidence that people have in the electoral process. An established trend is the establishment of legislative institutions in order to express the will of the people. Student unions and constituencies are two types of political organisations.

Specifically, the purpose of this research study is to summarise and draw relevant conclusions from the literature on the deployment of the block chain and comparable digital ledger systems in a variety of different sectors outside its application to crypto-currency. Because block chain is a relatively new technology, a representative selection of research is offered that spans the past 10 years, beginning with the first work in this subject and progressing to the most recent. It was determined what sorts of block chain and other digital ledger technologies were being used and what obstacles they presented.

2 Literature Survey

To meet the project's objectives and conduct in-depth study of the technique used in the idea of block chain technology, a literature review was conducted by investigating various publications based on similar methods. As suggested in "Waiting in Line to Vote" [1], an article explaining the difficulties that voters face during an election and how this affects voter turnout, with the help of the Internet, overall comfort levels have greatly increased, so waiting in line for hours to cast a single vote is no longer necessary. Many malpractices such as rigging, bribery, hacking, data manipulation, and misbehaviour occur during general elections, according to a research article titled "Trusting e-voting among experiences of electoral malpractice: The case of Indian elections" [2], preventing a fair, transparent, and precise election. Freya Sheer Hardwick's research paper "E-Voting with Block chain: An E-Voting Protocol with Decentralization and Voter Privacy" when compared to the traditional opaque one-sided voting system, Gritzalis [3] suggest a voting protocol that compares block chain to a transparent ballot-box used for voting, which was a promising attempt but lacked sufficiently for long-term usage with complicated features. In this assessment presents a digital voting system with a lower computational model explained by Anane et al. [4] incorporate the work of King-Hang Wang and Subrota K. Mondal. They do not, however, provide any new features. The block chain utilises distributed consensus methods [5] to retain every voter as a node, and the leader will be selected by a majority of votes. As stated in [6] tallying results, when we declare a district leader, we only enable corresponding people to vote for them. There had been no evidence of tampering with votes at that time. The block chain technology can verify that no single vote has been changed or deleted [7]. Block chain allows voters to create tamper-proof audit trails while casting their votes. Because our architecture enables anybody to use the platform from anywhere, we can term it public [8]. Appalaraju et al. [9] developed a customizable block chain using hashing method as a server-side validation solution. The results may be properly recorded utilising the block chain [10] idea of adjustable nodes property by making the voter's Aadhaar number one unique characteristic. The hashing method [11] minimises data duplications to the point where no more chain-breaking actions are necessary. The information is automatically saved in our Oracle database MySQL once we get the voter's information. Block chain property is kept in the database [12] via hashing [13], so that each voter will be linked by a single generated hash, with which we can verify whether the previous (hash) is equal to the present (hash) (hash). Ajay et al. [14] utilised side chain technology to keep votes secret amongst voters in their research paper "Crypto-voting, a block chain-based e-Voting System". This implies that voters are unable to see or change the information of other voters, which is known as the secrecy property. Using block chain technology, we can guarantee that no virus [15] will damage our system/application. Using block chain technology, we can guarantee that no virus [16] will damage our system/application. To guarantee not just openness but also privacy, all essential information must be made available when it comes to maintaining a trustworthy E-voting system [17]. This feature of

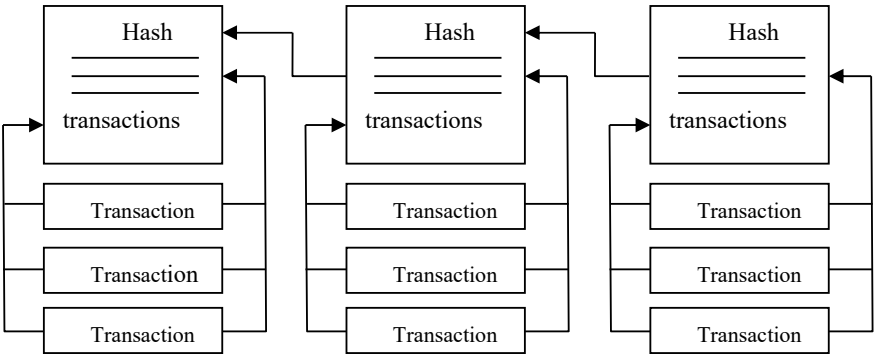


Fig. 1 Block chain structure

block chain technology also leads to tamper-proof [18] data quality while we build this framework, this helps us reduce not just the cost [19] of holding a national election, but also the privacy and security of our data [20]. In the case of block chain, a succession of blocks is duplicated on a peer-to-peer network as seen in Fig. 1.

Several transactions are included inside a block, as well as the Merkle tree block header. Cryptography is a secure networking approach that uses a combination of computer science and mathematics to keep data and information hidden from others, and it is used to protect financial information. It enables data to be transported securely over an unsecured network, in both encrypted and decrypted formats, while maintaining its integrity.

3 Implementation

This article's primary goal is to make the election process more transparent. This paper is divided into two sections. A. Commissioner of Elections B. Voter/User. Commissioner of Elections: Candidates and voters (the general public) must first be registered before an election can be held. We need an authorised individual to maintain all of the data up to date, which in our situation is the election commissioner. As a consequence, a separate module called an election commissioner or administrator is required. The election commissioner must first register himself, but first he must verify that he is the real election commissioner by entering the unique identifying number and key given to him. No one else can log in as an election commissioner because of this one-of-a-kind code and key. The election commissioner must now register himself by giving his name, phone number, email address, and password. He may log in to the electoral commission module using his username, which is his email address and password after registration.

User/Voter: Before voting in an election, a voter must first verify that his name appears on the list of eligible candidates, with their account credentials set to null.

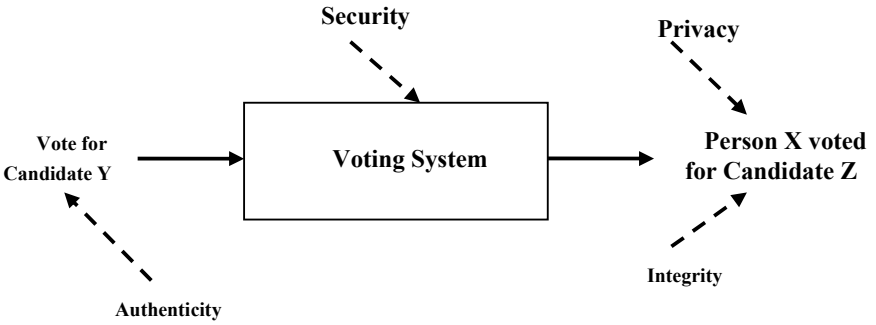


Fig. 2 Proposed e-voting system

The election commissioner next verifies the voter's eligibility to vote in the election. He may now update his credentials linked with the unique number that is attached to his or her cell phone number or card number by going to the site. Voters may then see the parties in his constituency (seen in Fig. 3). We may restrict a voter's capacity to vote just for candidates in the jurisdiction in which he or she is registered. After then, the voter may verify whether or not his vote was correctly cast for a legitimate candidate, as well as see how the election is progressing. The block containing his/her vote will be uploaded to the block chain as a consequence of the SHA-256 algorithm being used to produce a hash value based on his/her unique identification coupled with his/her voted party unique number. The voter will be unable to vote in the election more than once after the block has been applied.

Prior to designing an electronic voting system, it is necessary to compile a complete and clear list of specifications (seen in Fig. 2). These needs may be divided into three categories: general requirements, system-specific requirements, and election-specific requirements. Following that, we'll look at some examples of these kinds.

4 Electronic Voting on Block Chain

Information about electronic voting systems is provided in this section to offer some context. In electronic voting, votes are recorded or tallied using electronic equipment, which is referred to as a voting technology. Generally speaking, electronic voting is described as voting that is backed by some kind of electronic technology or software.

Those in charge of such regularities should be capable of supporting/implementing a wide range of tasks, spanning from election preparation through vote storage.

For example, voting machines, laptop computers, and more recently mobile devices are all instances of different sorts of systems. Registering and authenticating voters, casting ballots, and counting results must all be included in electronic voting systems (see Fig. 3).

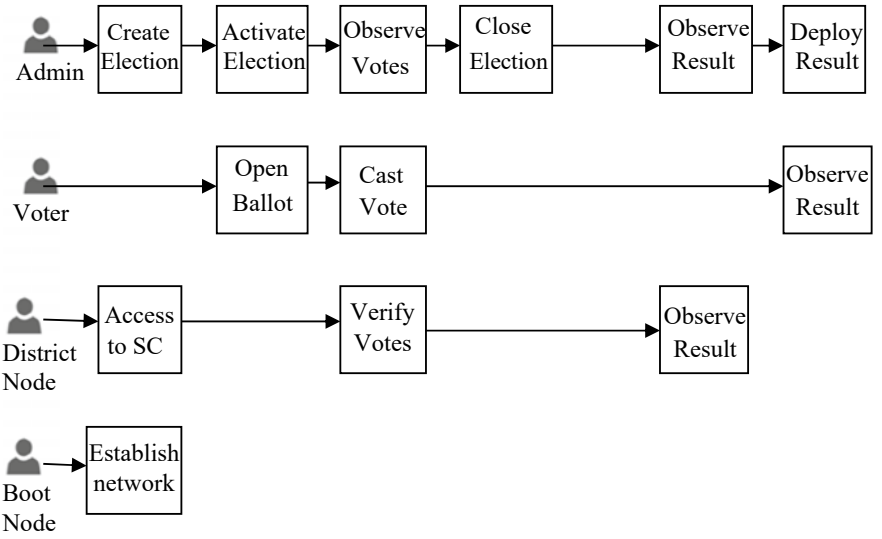


Fig. 3 E-voting process

5 Results

In terms of redundancy, the framework for combining block chain with e-voting may be beneficial. Because the block chain idea is not used in paper-based voting, security may be compromised. In paper-based voting, a voter may cast several ballots; however, this is not possible in this system owing to the powerful hashing technique established at the time of voting. The voter's power to change the electoral commission's procedures will be limited. The voter will only be allowed to vote and verify whether his or her vote was cast in support of the party of his or her choice. As a consequence, the whole process will be open to the public. The Election Commissioner will only be allowed to declare the results once the deadline has passed after the election. The block chain idea will help to ensure that vote accuracy is maintained. As a consequence, we will be able to combat pre-poll fraud, voter manipulation, and duplicate voting. For each election vote cast, a unique hash generated in the backend using the SHA-256 technique will be chained on the block chain. As a consequence, the vote's next block will be connected to the preceding block's hash in the block chain. As a result, utilising the block chain method, duplication of votes will be impossible. As a consequence, if someone tries to vote again, this approach will deny them a second opportunity, limiting them to just voting once. As illustrated in the diagram, the hash value for the previous voter is identical to the hash value for the current voter. Hash codes are generated using the SHA-256 algorithm. We can guarantee that individuals will only vote once and not numerous times by creating these hash values for each voter.

We discovered that about one out of every three use cases is related to decentralised energy trading, which includes wholesale, retail, and peer-to-peer energy trading efforts (P2P energy trading initiatives). Currencies, tokens, and investment are the second most prevalent type of applications, accounting for one out of every five use cases. The Internet of Things, smart devices, automation and asset management, as well as metering, billing, and security, are the next most popular use cases, accounting for 11% and 9% of all use cases, respectively. Other initiatives account for around 6–7% of the total (see Fig. 4).

Whenever information has been made publicly accessible on block chain activities, we categorise them according to the platform and consensus techniques that were used (see Fig. 5). 60% are designing solutions based on Ethereum as a starting point, while 55% are using proof-of-work (PoW) techniques.

id	hcode	voter	vote	phcode	dt
1	4069f0b11661a3eefacbba918	1	2	0	18-06-2021 11:29:10
2	785f3ec7eb32f30b90cd0fcf36	2	2	6b51d431df5d7f141cbececcf7	18-06-2021 11:34:15
3	c6f3ac57944a531490cd39902	3	3	785f3ec7eb32f30b90cd0fcf36	18-06-2021 12:18:11
4	434c9b5ae514646bbd91b5001	8	6	c6f3ac57944a531490cd39902	18-06-2021 12:19:07
5	6e4001871c0cf27c7634ef1dc4	9	3	434c9b5ae514646bbd91b5001	19-06-2021 05:47:23
6	454f63ac30c8322997ef025ed	10	3	6e4001871c0cf27c7634ef1dc4	19-06-2021 05:48:42
7	44cb730c420480a0477b505ae	4	3	454f63ac30c8322997ef025ed	19-06-2021 05:50:02
8	f74efabef12ea619e30b79bdd	7	6	44cb730c420480a0477b505ae	19-06-2021 05:51:31
9	6208ef0f7750c111548cf90b6e	5	8	f74efabef12ea619e30b79bdd	19-06-2021 06:28:38
10	7611f1a57f80b0a87b4178e2e	13	11	6208ef0f7750c111548cf90b6e	19-06-2021 06:30:42

Fig. 4 Table showing the creation of blocks for the user

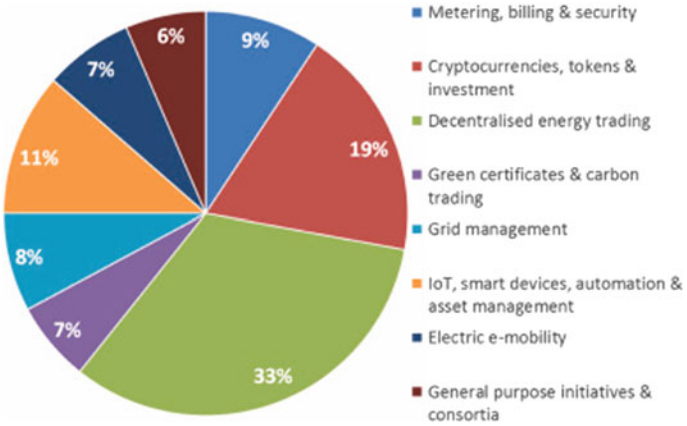


Fig. 5 Classification of 140 block chain efforts in the energy sector by companies, start-ups, and research organisations

6 Conclusion

Although electronic voting is still an option for voting, it is not extensively utilised in many countries owing to data security and voting processes issues. Data security was improved, and redundancy was reduced as a consequence of integrating the block chain idea with the e-voting process. As a consequence, it will be able to satisfy all of the criteria of the electoral commission. The authenticity of the voting process will be determined by the hash methods used. The results of this study have resulted in the development of a block chain-based architecture that may solve polling issues. When tested with sample data, the results of our proposed model are remarkable. We will be able to get better results if this idea is utilised in the real-time voting process in the future. In the future, this technology may be enhanced by integrating hybrid encryption methods to create a more secure electronic voting system.

References

1. Harrison, T. M., Pardo, T. A., & Cook, M. (2012). Creating open government ecosystems: A research and development agenda. *Future Internet, 4*(4), 900–928.
2. Wang, K.-H., Mondal, S. K., Chan, K., & Xie, X. (2017). A review of contemporary e-voting: Requirements, technology, systems and usability. *Data Science and Pattern Recognition, 1*(1), 31–47.
3. Gritzalis, D. A. (2002). Principles and requirements for a secure e-voting system. *Computers & Security, 21*(6), 539–556.
4. Anane, R., Freeland, R., Theodoropoulos, G. (2007). E-voting requirements and implementation. In *The 9th IEEE CEC/EEE 2007* (pp. 382–392). IEEE.
5. Moura, T., Gomes, A. (2017). Blockchain voting and its effects on election transparency and voter confidence. In *Proceedings of the 18th Annual International Conference on Digital Government Research*, ser. dg.o'17 (pp. 574–575). ACM. [Online]. Available: https://doi.org/10.1145/3085228.3085263
6. Ayed, A. B. (2017). A conceptual secure blockchain-based electronic voting system. *International Journal of Network Security & Its Applications, 9*(3).
7. Hardwick, F. S., Gioulis, A., Akram, R. N., & Markantonakis, K. (2018, July). E-voting with blockchain: An e-voting protocol with decentralisation and voter privacy. 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)* (pp. 1561–1567). IEEE.
8. Wang, K.-H., Chan, K., Xie, X., & Mondal, S. K. (2017). A review of contemporary e-voting requirements, technology, systems and usability. *Data Science and Pattern Recognition, 1*(1), 31–47.
9. Appalaraju, V., Rajesh, V., Saikumar, K., Sabitha, P., & Kiran, K. R. (2021, December). Design and development of intelligent voice personal assistant using python. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 1650–1654). IEEE.
10. Naidu, T. P., Gopal, K. A., Ahmed, S. R., Revathi, R., Ahammad, S. H., Rajesh, V., Inthiyaz, S., & Saikumar, K. (2021, December). A hybridized model for the prediction of heart disease using ML algorithms. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 256–261). IEEE.

11. Teju, V., Sowmya, K. V., Yuvanika, C., Saikumar, K., & Krishna, T. B. D. S. (2021, December). Detection of diabetes melittus, kidney disease with ML. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 217–222). IEEE.
12. Mannepalli, K., Raju, K. B., Sirisha, J., Saikumar, K., & Reddy, K. S. (2021, December). LOW complex OFDM channel design using underwater-acoustic-communication using machine learning techniques. In *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 1505–1513). IEEE.
13. Kumar, K. S., Vatambeti, R., Narender, M., & Saikumar, K. (2021, December). A real time fog computing applications their privacy issues and solutions. In *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 740–747). IEEE.
14. Ajay, T., Reddy, K. N., Reddy, D. A., Kumar, P. S., & Saikumar, K. (2021, December). Analysis on SAR signal processing for high-performance flexible system design using signal processing. In *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 30–34). IEEE.
15. Raju, K. B., Lakineni, P. K., Indrani, K. S., Latha, G. M. S., & Saikumar, K. (2021, October). Optimized building of machine learning technique for thyroid monitoring and analysis. In *2021 2nd International Conference on Smart Electronics and Communication (ICOSEC)* (pp. 1–6). IEEE.
16. Kailasam, S., Achanta, S. D. M., Rao, P. R. K., Vatambeti, R., & Kayam, S. (2021). An IoT-based agriculture maintenance using pervasive computing with machine learning technique. *International Journal of Intelligent Computing and Cybernetics.*
17. Koppula, N., Sarada, K., Patel, I., Aamani, R., & Saikumar, K. (2021). Identification and recognition of speaker voice using a neural network-based algorithm: Deep learning. In *Handbook of Research on Innovations and Applications of AI, IoT, and Cognitive Technologies* (pp. 278–289). IGI Global.
18. Rao, K. S., Reddy, B. V., Sarada, K., & Saikumar, K. (2021). A sequential data mining technique for identification of fault zone using FACTS-based transmission. In *Handbook of Research on Innovations and Applications of AI, IoT, and Cognitive Technologies* (pp. 408–419). IGI Global.
19. Saikumar, K., Rajesh, V., & Babu, B. S. (2022). Heart disease detection based on feature fusion technique with augmented classification using deep learning technology. *Traitement du Signal, 39*(1), 31–42. https://doi.org/10.18280/ts.390104
20. Shravani, C., Krishna, G. R., Bollam, H. L., Vatambeti, R., & Saikumar, K. (2022, January). A novel approach for implementing conventional LBIST by high execution microprocessors. In *2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT)* (pp. 804–809). IEEE.

A Novel Approach to Avoid Road Traffic Accidents and Develop Safety Rules for Traffic Using Crash Prediction Model Technique

Sk Hasane Ahammad, M. Sukesh, Mekala Narender, Sajjad Ali Ettyem, Kadhum Al-Majdi, and K. Saikumar

Abstract The expansion of nations and communities has resulted in a variety of externalities, such as an increase in traffic accidents. Many attempts have been undertaken to minimize the injuries and fatalities and their intensity. Traffic safety modeling is a most significant technique to motivate harmless mobility because it is capable of the creation of Crash Prediction Models (CPMs) as well as the investigation of the fundamentals that contribute to the incidence of crashes. Statistical modeling has been utilized in this process in the past, regardless of the fact that they are aware of the limits of this sort of strategy which allows you to experiment with other options, such as using machine learning approaches. Machine learning approaches applied

The original version of this chapter has been revised: The city name of the fourth author was incorrectly published with Muscat instead of Dhi Qar. The correction to this chapter is available at https://doi.org/10.1007/978-981-19-9512-5_62

S. H. Ahammad
Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Guntur, India

M. Sukesh (✉)
Department of Computer Science and Engineering, Vaagdevi College of Engineering, Warangal, Telangana, India
e-mail: manyam_s@vaagdevi.edu.in

M. Narender
Department of Computer Science and Engineering, Jayamukhi Institute of Technological Sciences, Narsampet, Warangal, India
e-mail: narenderyadav1103@gmail.com

S. A. Ettyem
National University of Science and Technology, Dhi Qar, Iraq
e-mail: sajad.a.ataim@nust.edu.iq

K. Al-Majdi
Ashur University College, Baghdad, Iraq
e-mail: dr.kadhum@au.edu.iq

K. Saikumar
School of Engineering, Department of AI-ML, Malla Reddy University, Hyderabad, Telangana 500043, India
e-mail: saikumarkayam4@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_34

to collision datasets can assist researchers in better knowing the features of motorist behavior, highway surroundings, and meteorological circumstances that are linked to varying mortality risk levels. If we build a reliable predictive model capable of automatically classifying the degree of injury in diverse traffic accidents, we may be able to discover patterns involved in severe wrecks. These patterns of behavior and road accidents can be used to design traffic safety rules.

Keywords Patterns · Modeling · Safety · Machine learning · Traffic · Crash prediction models

1 Introduction

Traffic deaths have shown to be one of the major causes of serious damage, and their prevalence has been rising over time. It gives emergency workers' crucial information for determining the intensity of catastrophes, determining the possible impact of the event, and implementing efficient accident management methods [1]. Reliable techniques for determining safety levels linked with current road sites or prospective designs are critical to lowering the number of accidents that occur. Another technique for evaluating safety is based on the use of safety inspection procedures, although they only apply to already existing roads. Predictive models using accident frequency as a dependent variable have been developed as a result of this observation [2]. Serious injury is concentrated on and taken into consideration just for sake of consistency in the accident forecast, despite the fact that money loss and property damage are equally common in more fatal crashes [3, 4]. This led to the employment of a Poisson or a negative binomial error structure for simulating the incidence of road accidents. Traffic-related events kill more than 1.35 million population per year, according to the WHO's most current 2018 research [5]. They motivate us to investigate and develop systems targeted at improving infrastructure safety, reducing traffic accidents, and pinpointing which elements contribute to an accident [6]. Predictive accuracy for the majority class is greater, while predictive capacity for the minority class is lower when classifiers are trained on datasets that contain infrequent occurrences [7]. RUMC-based Random Tree (RUMC-RT), RUMC-based k-NN and RF (RUMC-k-NN), and RUMC-based LR and RF (RUMC-LRRF) may be trained using either an unbalanced training set or balancing training and testing sets that are RUMC-based. Crash severity is influenced by variables such as age, gender, safety measures, and risk-taking behavior of drivers [8]. New techniques and statistical models have been used extensively in the study of injury severity outcomes and fatality rates [9]. A lack of safety precautions and restraint system utilization has been proven to be a predictor of RTI severity and fatality in multivariate logistic regression models (e.g., seat belt and helmet use). Road light levels, location, time of the accident, and automobile age are all environmental variables that have been shown to influence the degree of injuries sustained by drivers [10].

2 Related Work

As a black-box tool used for forecasting continuous or distinct output, MLAs may find the most important features (i.e., the most significant characteristics that impact the resulting outcomes of the model) and thus allow us to determine how a certain element is connected to the phenomena examined [11, 12]. Machine learning regression (MLR) techniques to traffic analysis have been developed in several researches during the previous decade. Such algorithms take into account a wide range of network characteristics, including highway, user, vehicle, and environmental characteristics. k-NN, SVM, and DT-based models, like categorization and Regression Tree, M5-Tree, RF, Very Random Trees, and Gradient Tree Boosting, all are intended to forecast the frequency of crashes along specific lengths of road or junctions [13, 14].

Several MLAs were recommended by the authors to accomplish this goal, including decision tree, k-NN [15, 16], LR, and RF. There are a number of MLAs often used for the same purposes as SVMs [17], including NN and NB classifiers [18, 19]. For the majority of categories which are overburdened, standard ML classifiers fail to identify minorities [20]. When it comes to forecasting the minorities, these classifiers fall far short. We can get around these problems by using resampling techniques [21]. When categorical input components are present, the approach is known as SMOTE-NC and is first described in [22]. While oversampling is used to ensure that the datasets are balanced, undersampling is used to ensure that only a small number of observations from the majority of class are used. Saikumar et al. [23, 24] describe the RUMC approach, which incorporates a randomized undersampling of the class label to get a statistically equal database.

3 Methodology

Predicting whether or not data in an input dataset will fall into one of the model's predefined categorization classes is a typical situation in ML procedures. By forecasting a dependent variable from completely undiscovered input representing new cases, the trained model accomplishes a classification task. Because time series is utilized to train the model, it is classified as supervised learning. This classification approach can forecast categories in two scenarios: one, when third-party judgments are predicted, and two, when third-party decisions are predicted. The second situation is when categorization is based on statistical facts. The Road accidents have been identified in a prior manner which was shown in below Fig. 1.

The primary goal of this research is to forecast the intensity of traffic accidents. The idea of categorization is employed for this purpose. Classifying models are trained on historical data from this application area, and the likelihood of rows belonging to one class or status over another is computed when all characteristics are given.

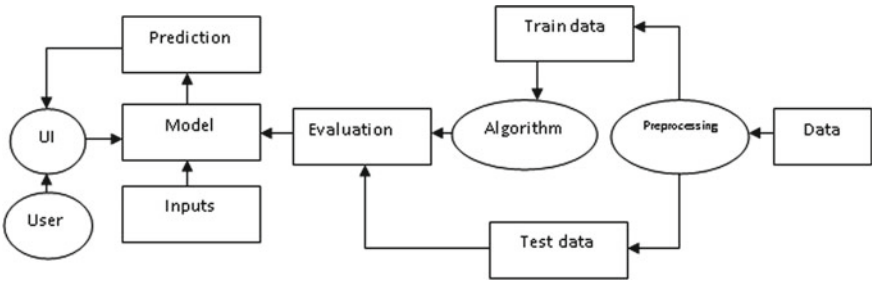


Fig. 1 Proposed model's architecture

4 Classification Algorithms

Input data [25] from X are mapped to outputs from Y using classification methods, where Y is $\{1, \ldots C\}$, and C is the set of classes. Binary classification is used when the number of output classes is 2, $C = 2$. The classification is known as multiclass categorization if the value of C is more than two. SVM, NB, DT, and other classification techniques are available for classification problem. Many available algorithms have been solving traffic accident issues but operating conditions are critical so an advanced traffic accident detection system should be compulsory.

4.1 Random Forests

Random Forests are a machine learning ensemble model that has its roots in DT. Consequently, these decision tree algorithms may oversimplify the set of data, but when combined, they produce a far better model. A RF is formed by assembling a set of DT that has been created and based on them by conducting random sampling of the characteristics. Random Forests are created using a process known as bootstrap aggregation or bagged data.

$$N_{rs} = \text{int}\left[\log_2\left(N_p + 1\right)\right] \tag{1}$$

Here, N_p is number of input factors. In this study, $N_p = 7$ and resulting $N_{rs} = 5$.

4.2 Naive Bayes (NB)

Classification techniques based on Bayes theorems such as spamming email screening and technical article categorization are based on NB techniques, which

are supervised training procedures. To put it another way, Naive Bayes assumes that the characteristics are all Traffic Safety Forecast.

4.3 K-Nearest Neighborhood (k-NN)

The k-NN classifiers can also be used to organize objects of many types, and its flexibility and resilience are two of its most significant characteristics. The k-NN algorithm is a discriminative supervised machine learning method. The k-NN classifier uses a strategy that involves establishing a majority vote among the K Road Safety Predictions.

$$d_{ij} = \sqrt[2]{\sum_{k=1}^{m} \left(x_{ik} - x_{jk}\right)^2}, \tag{2}$$

where m is the number of independent variables (i.e., the dimensionality of the elements) and the k-th independent variable x_{ik} and x_{jk} are the results for observational data I and j, correspondingly.

4.4 Logistic Regression (LR)

This is the most basic and widely used model for addressing classification issues. Unlike linear regression, a sigmoid function is used to cope with outliers in a logistic regression model. By changing weights inversely proportionate to class frequency, the class weights' parameter adjusts weights for unbalanced classes. Even with a "balanced" class weight, the model has not been doing well since the dataset was considerably imbalanced.

$$P(z) = \frac{1}{1 + \mathrm{e}^{-z}}. \tag{3}$$

To calculate the chance of an event (crash severity) occurring, we use $P(z)$, which ranges from zero to one. The dependent variable of the linear multivariate regression is defined in Eq. (4) below.

$$z = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_m x_m, \tag{4}$$

where b_0 is a constant term;

m is the number of independent variables;

$xi(i = 1, 2, 3, ..., n)$ represents the value of the i-th input factor;

$bi(i = 1, 2, 3, ..., n)$ is the regression coefficient assigned to the i-th input factor.

Using Eq. (5) and the probabilities $P(z)$, the LR classification gives the following prediction about z:

$$\hat{z} = \begin{cases} \text{Class } 0 \text{ if} P(z) < 00.5 \\ \text{Class } 1 \text{ if } P(z) \geq 00.5 \end{cases} \tag{5}$$

In addition, the LR regression coefficients may be regarded as a measure of the independent variables' relative significance.

4.5 Gradient Boosting Machine (GBM)

Another sort of ensemble approach is gradient boosting, which is particularly common in decision tree algorithms. Using machine learning algorithms to reduce mean squared error in Road Safety Prediction, GBM succeeds effectively. On undersampled data, this method performed well in terms of accuracy and reasons to question; however, when applied to the entire dataset, the algorithm is unable to forecast even one uncommon category.

4.6 Performance Metrics

MLAs may be assessed and compared based on a wide range of performance measures, as previously stated. The overall accuracy of the classifier and the precision, TPR, FPR, TNR, and F1-score is defined by Eqs. (9)–(14).

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}, \tag{6}$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}, \tag{7}$$

$$\text{TPR} = \frac{\text{FP}}{\text{TN} + \text{FP}}, \tag{8}$$

$$\text{TNR} = \frac{\text{TN}}{\text{TN} + \text{FP}}, \tag{9}$$

$$F1 = \frac{\text{TP}}{\text{TP} + \frac{\text{FN}+\text{FP}}{2}}. \tag{10}$$

Here, the number of True Positive and True Negative occurrences is referred to as TP and TN, respectively, while TN is the number of True Negative (TN) instances. False Positives (FPs) are cases of class 0 being incorrectly classed as class 1; FP is

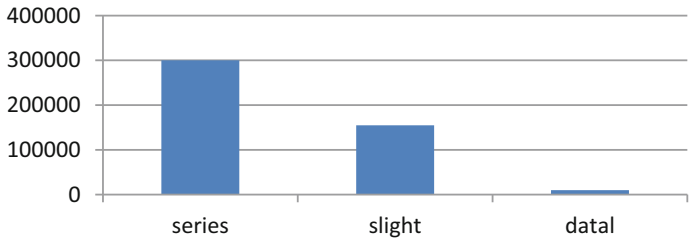


Fig. 2 Bar graph representation for total accident count

the number of such occurrences. This is the number of FN or instances of class 1 that were mistakenly assigned to class 0; this is the number of False Negatives. Class 1 represents the $F + I$ class, while class 0 represents the PDO class, as should be noted. The classifier's total accuracy is meant to indicate the classifier's overall performance. A positive prediction's precision indicates how accurate it is. Classifiers' TPR (recall) is the percentage of positive cases accurately identified. Similarly, the TNR represents the percentage of false negatives accurately identified by the classifier. The false alarm rate (FPR) is the proportion of false alerts among all negative events.

5 Dataset Preparation

For this research, we used a dataset from the UK on road traffic accidents. Weather patterns, road class, traffic speed, junction information, road surface circumstances, illumination situations, and other variables are included in the dataset's 1,920,000 records and 34 categories. The data relating to minor severity are 84.84%, serious intensity is 13.86%, and deadly severity is 1.30% in our database.

We divided the dataset depending on the severity of the accident and chose information for something like the training and testing datasets in equal ratios for data validation. As a consequence, training and evaluating ML models on clean and consistent data are critical to improving their performance. The property "Accident Severity" was the project's objective feature. The three permissible values for this feature are minor, serious, and fatal as shown in Fig. 2.

6 Results and Discussion

After and then, the data were divided into train and test data in an 80:20 ratio. To anticipate the conclusion, we used most of the data's classifiers. We utilized the default Naive Bayes method without modifying any hyperparameters, although we did some tuning when utilizing Random Forest to improve the performance. The Random Forest classifier produced the best results of all the classifiers. The measures

of performance are used to describe the outcomes achieved by the programs explained in Figs. 3 and 4.

Among all the classifiers tested, Random Forest beat XGBoost, *k*-NN, and GNB by a large edge and support vector classification by an exceedingly little percentage as shown in Figs. 5. Although the gradient boosting machine takes longer to run than Random Forest Classification, it has a higher AUC and F1-score than any of the other techniques tested for this set of data.

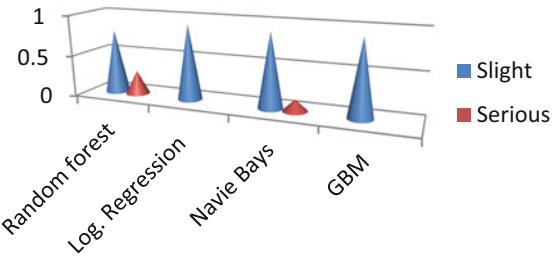


Fig. 3 Algorithm analysis of full data

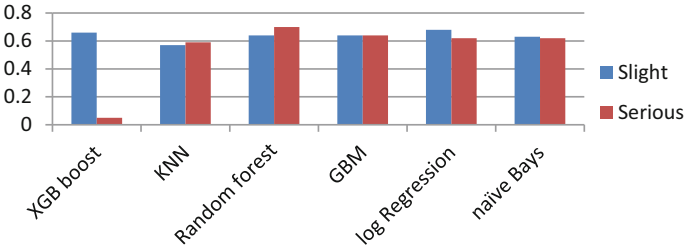


Fig. 4 Algorithm analysis of under sample data

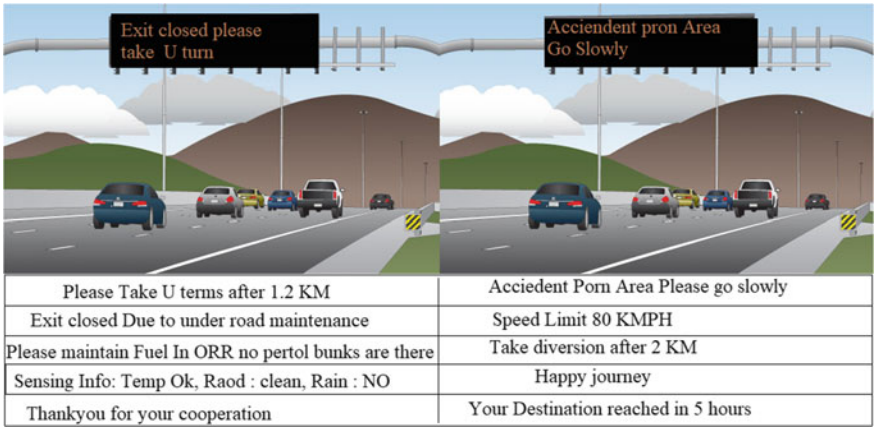


Fig. 5 Accident severity status for serious and slight

Because of its high prediction accuracy of 63% and scalability, Random Forest is an effective classification learning approach for medium and large datasets like this test bed. Gradient boosting machine is a great option since it performs similarly to Random Forest, with 62% prediction accuracy and faster execution duration.

Additional data on the Standard Occupational Classification (SOC) may be obtained and combined through this dataset to give an additional complete picture of how the road accident severity procedure works as shown in Fig. 5.

7 Conclusion

Traffic congestion accidents are a major concern, and predicting their size using trustworthy methods is now required. In conclusion, the majority of algorithms favor the most widely known effective preprocessing and unbalanced data approaches. Accident severity can be graded based on current weather, light, traffic signal, road surface, speed limit, and other factors. However, no one factor impacts the magnitude of an accident. This can be extended by taking into account the region's coordinates, and the problem will be transformed into a regression problem. We can therefore forecast the likelihood of that behavior in a particular area. If the danger is greater, quick action should be done. Other ML approaches for evaluating road traffic accidents intensity should be researched, and their effectiveness should be tested using publicly accessible transportation datasets.

References

1. Sohn, S. Y., & Shin, H. (2001). Pattern recognition for road traffic accident severity in Korea. *Ergonomics, 44*(1), 107–117.
2. Global Status Report on Road Safety (2015). http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/
3. Abdel-Aty, M., & Abdelwahab, H. (2004). Analysis and prediction of traffic fatalities resulting from angle collisions including the effect of vehicles' configuration and compatibility. *Accident Analysis and Prevention, 36*(3), 457–469.
4. Chang, L. Y., & Wang, H. W. (2006). Analysis of traffic injury severity: An application of non-parametric classification tree techniques. *Accident Analysis & Prevention, 38*(5), 1019–1027.
5. Select How To Explain Gradient Boosting. https://explained.ai/gradientboosting/index.html
6. Mohamed, E. A. (2014). Predicting causes of traffic road accidents using multi-class support vector machines. *Journal of Communication and Computer, 11*(5), 441–447.
7. Ossenbruggen, P. J., Pendharkar, J., & Ivan, J. (2001). Roadway safety in rural and small urbanized areas. *Accident Analysis and Prevention, 33*(4), 485–498.
8. Alsolami, B., Mehmood, R., & Albeshri, A. (2020). Hybrid statistical and machine learning methods for road traffic prediction: A review and tutorial. *Smart Infrastructure and Applications*, 115–133.
9. Teju, V., Sowmya, K. V., Yuvanika, C., Saikumar, K., & Krishna, T. B. D. S. (2021, December). Detection of Diabetes Melittus, Kidney Disease with ML. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 217–222). IEEE.

10. Mannepalli, K., Raju, K. B., Sirisha, J., Saikumar, K., & Reddy, K. S. (2021, December). LOW complex OFDM channel design using underwater-acoustic-communication using machine learning techniques. In *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 1505–1513). IEEE.
11. Kumar, K. S., Vatambeti, R., Narender, M., & Saikumar, K. (2021, December). A real time fog computing applications their privacy issues and solutions. In *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 740–747). IEEE.
12. Ajay, T., Reddy, K. N., Reddy, D. A., Kumar, P. S., & Saikumar, K. (2021, December). Analysis on SAR signal processing for high-performance flexible system design using signal processing. In *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 30–34). IEEE.
13. Raju, K. B., Lakineni, P. K., Indrani, K. S., Latha, G. M. S., & Saikumar, K. (2021, October). Optimized building of machine learning technique for thyroid monitoring and analysis. In *2021 2nd International Conference on Smart Electronics and Communication (ICOSEC)* (pp. 1–6). IEEE.
14. Kailasam, S., Achanta, S. D. M., Rao, P. R. K., Vatambeti, R., & Kayam, S. (2021). An IoT-based agriculture maintenance using pervasive computing with machine learning technique. *International Journal of Intelligent Computing and Cybernetics.*
15. Koppula, N., Sarada, K., Patel, I., Aamani, R., & Saikumar, K. (2021). Identification and recognition of speaker voice using a neural network-based algorithm: Deep learning. In *Handbook of Research on Innovations and Applications of AI, IoT, and Cognitive Technologies* (pp. 278–289). IGI Global.
16. Rao, K. S., Reddy, B. V., Sarada, K., & Saikumar, K. (2021). A sequential data mining technique for identification of fault zone using FACTS-based transmission. In *Handbook of Research on Innovations and Applications of AI, IoT, and Cognitive Technologies* (pp. 408–419). IGI Global.
17. Raju, K., Pilli, S. K., Kumar, G. S. S., Saikumar, K., & Jagan, B. O. L. (2019). Implementation of natural random forest machine learning methods on multi spectral image compression. *Journal of Critical Reviews, 6*(5), 265–273.
18. Garigipati, R. K., Raghu, K., & Saikumar, K. (2022). Detection and identification of employee attrition using a machine learning algorithm. In *Handbook of Research on Technologies and Systems for E-Collaboration During Global Crises* (pp. 120–131). IGI Global.
19. Mythreya, S., Murthy, A. S. D., Saikumar, K., & Rajesh, V. (2022). Prediction and prevention of malicious URL using ML and LR techniques for network security: Machine learning. In *Handbook of Research on Technologies and Systems for E-Collaboration During Global Crises* (pp. 302–315). IGI Global.
20. Saikumar, K., Rajesh, V., & Babu, B. S. (2022). Heart disease detection based on feature fusion technique with augmented classification using deep learning technology. *Traitement du Signal, 39*(1), 31–42. https://doi.org/10.18280/ts.390104
21. Appalaraju, V., Rajesh, V., Saikumar, K., Sabitha, P., & Kiran, K. R. (2021, December). Design and development of intelligent voice personal assistant using python. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 1650–1654). IEEE.
22. Jothsna, V., Patel, I., Raghu, K., Jahnavi, P., Reddy, K. N., & Saikumar, K. (2021, March). A fuzzy expert system for the drowsiness detection from blink characteristics. In *2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)* (Vol. 1, pp. 1976–1981). IEEE.
23. Saikumar, K., Rajesh, V., & Babu, B. S. (2022). Heart disease detection based on feature fusion technique with augmented classification using deep learning technology. *Traitement du Signal, 39*(1).

24. Anandkumar, R., Dinesh, K., Obaid, A. J., Malik, P., Sharma, R., Dumka, A., Singh, R., & Khatak, S. (2022). Securing e-Health application of cloud computing using hyperchaotic image encryption framework. *Computers & Electrical Engineering, 100*, 107860. ISSN 0045-7906. https://doi.org/10.1016/j.compeleceng.2022.107860
25. https://scikitlearn.org/stable/modules/generated/sklearn.feature_selection.chi2.html#sklearn.feature_selection.chi2

Intrusion Detection in the IoT-Fog Adopting the GRU and CNN: A Deep Learning-Based Approach

Zahraa Majeed Al-Khuzaie, Salah A. K. Albermany, and Mohammed Ahmed AbdlNibe

Abstract The main objective of this research is to utilize the technologies of cloud computing in the applications of the IoT. The IoT network is divided into three layers: the cloud computing layer, the edge layer, and the fog layer. More than twenty-five million devices are connected to the fog layer leading to an increase in data traffic in the network in general. As a result, there will be an increase in the number of attacks. Therefore, protecting the data of the IoT and detecting attacks are indispensable. Since new types of attacks frequently emerge, intrusion detecting systems (IDSs) have to be developed to counteract the new types of attacks. However, built upon the principles of deep learning and machine learning, most of the current IDSs are based on predicting the probability of an attack. The most commonly used IDSs are the KNN and the SVN. Such IDSs suffer from low accuracy rates in attacks detection, time consumption, and a large number of false alarms. Thus, this paper suggests a new model of deep learning that is built upon combining two algorithms: the convolution neural network (CNN) and the gated recurrent unit network (GRU). Additionally, two types of datasets are utilized: the NSL-KDD and UNSW-NB15. These datasets are categorized in accordance with multiclass classification. The suggested model provides a better detection rate in comparison with the other models. It achieves a detection rate that is 1.5 more accurate than the other IDSs. Also, it exhibits fewer false alarms, and it provides less time for detection rate. The achieved results of the suggested model are due to utilizing the technologies of deep learning and machine learning.

Keywords Intrusion detection · Deep learning · Machine learning · IoT · Network traffic · CNN · GRU

Z. M. Al-Khuzaie (✉) · S. A. K. Albermany
Computer Science Department, University of Kufa, Najaf, Iraq
e-mail: zahraam.alkhuzai@student.uokufa.edu.iq

S. A. K. Albermany
e-mail: Salah.albermany@uokufa.edu.iq

M. A. AbdlNibe
Department of Electronics and Communication Engineering, Faculty of Engineering, University of Kufa, Kufa, Iraq
e-mail: Mohammeda.khaleel@uokufa.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_35

1 Introduction

The continuous development of information and communication technology has a critical impact on various aspects of human life. One of the fields that exhibits such development is the Internet of Things (IoT), which requires indispensable development in machine learning, data science, and Internet services. Such development offers an unprecedented increase in the applications and services mediated by the IoT. Simultaneously, a rapid increase in cyber-attacks has been documented. Nevertheless, researchers employed deep learning (DL)-based algorithms combined with ML algorithms in their investigations due to the increasing number of attacks during the period between 2005 and 2015 [1–3]. The DL technology aids in identifying data more accurately for the purpose of ensuring users' information security and privacy. DL, also, offers a new method for solving the problem at hand without having to decrypt data traffic; however, the behavior of data traffic can be assessed to detect malicious elements [4]. In accordance, this paper suggests various systems for identifying encrypted data traffic by adopting technologies of DL with a significant level in classification accuracy. This paper contributes to the existing body of research by using one hybrid network structure. This structure is CNN + GRU, which be compared to different hybrid structures introduced by other researchers. Data features will be identified and summarized to detect malicious traffic whether it is encrypted or unencrypted. The chosen DL system will be tested over two datasets. These datasets are NSL-KDD and UNSW-NB15 [5–7]. Also, the multiclass method is employed to classify these two datasets.

2 Previous Work

Approaches based on DL are pervasive in the field of intrusion detection. DL offers an enhancement for intrusion detection by developing the structures of GPU. The GPU is essential in the performance of DL technologies. The previous studies aimed at identifying and detecting cyber-attacks or at least reducing the severity of such attacks. All previous work is dealt with identifying the type of attacks. They are also dealt with the features of the attacks as well as the accuracy of intrusion detection. Across all the previous research, the following DL algorithms were utilized. They are convolutional neural networks (CNNs), deep belief networks (DBNs), autoencoding (AE), and recurrent neural networks (RNN) with fundamental differences in operational considerations in addition to differences in choosing the parameters [8]. Moreover, across all the previous research, the following ML algorithms were utilized. These algorithms are support vector machine (SVM) [9], random forest [10], adaptive boosting [11], and K-means clustering [12]. It should be indicated here that all the previous work lacked a specified methodology in selecting the features of datasets. And it is important to point out that selecting the features of datasets is

known as feature derivation. In fact, attackers take advantage of the lack of a specified methodology in selecting the features of datasets in carrying out their attacks [13, 14]. Mostly, the typical ML offers models of feature derivation for training, learning, and testing. These models depend on the value of feature vectors that have been extracted. As a result, a feature vector-based model will be constructed. The feature vectors use the characteristics of DL and ML.

3 The Architecture of the Suggested Model

As clarified in Fig. 1, the suggested model contains two input datasets: the UNSW-NB15 and KDD-NSL. Each one of them has been divided into two datasets: training dataset and testing dataset. Later, these datasets have been gathered into what is called combined datasets. This step was followed by processing these datasets so that they could be organized and prepared for the training and testing. Processing the datasets required three stages: data cleaning, one-hot encoding, and Z-score normalization. Below is a brief explanation for each one. Data cleaning includes the correction of some flaws in the features of the nominal values by unifying the written form of some values such as replacing the values "worms", "WORMS", and "Worms" with the value "Worms" after the deletion of spaces before and after the values if there are any. Also, data cleaning includes processing the values of errors and the missing values in the nominal features by replacing them with values that suit the distribution of the column values of features. For example, the values of errors and the missing values are replaced with the value of "median" or the value of "mean" for values of features columns. One-hot encoding—this type of encoding is applied to the categorical features or the limited nominal features. According to this type of encoding, the feature column is replaced with the number of columns that matches the number of categories within the original feature column. The values of the new columns are ones and zeros. The one value, in each new column, corresponds to the locations of categories in the original feature column, while the zero value fills in the other locations. Z-score normalization: In this type of normalization, the distribution of values in the feature column is changed into a normal distribution as per the scale $z \sim N(0, 1)$ with a mean of 0 and a standard deviation of 1. After the completion of these three stages, modeling of the suggested system will be conducted. The modeling stage comprises several layers. The first layer is the K-fold cross-validation; it is based on the confusion matrix. The confusion matrix randomly selects a sample from the dataset. The sample is portioned into two subsamples: The first subsample is of the size 10% which is specified for testing; the second subsample is of 90% size which is specified for training. Later, the role of these two subsamples is exchanged so that the 10% sized subsample will be specified for training and the 90% sized subsample will be specified for testing. This process will be repeated 10 times. It is worth noting that the process is repeated according to the value of K. That is, when K equals 2, then the process is repeated 20 times. If K equals 4, then the process will be repeated 40 times. And the process is repeated so forth till it covers 100% of the

subsamples. After this, the modeling process is carried out through 1D CNN layer algorithm as illustrated in Fig. 1. Afterward, the modeling process continues through the max-pooling 1D layer; it is the process of dividing large datasets into smaller subsamples so that they could be easily treated. Later, the modeling process will be followed by a checking stage which is conducted in the batch normalization layer. Subsequently, the modeling process goes through an additional new layer which is called the GRU layer as illustrated in Fig. 2. This layer aids in yielding more accurate results in comparison with the previous models in addition to making the detection model perform faster. Next, the modeling process will go through the stages of the max-pooling layer, the batch normalization layer, and the GRU layer. This recurrent stage is known as the reshape layer. The final layer is known as the dropout layer. According to the results of the dropout layer, it would be possible to obtain the accuracy of the detection, the type of attacks (recall), the number of the detected attacks, the detection rate, and the false-positive rate.

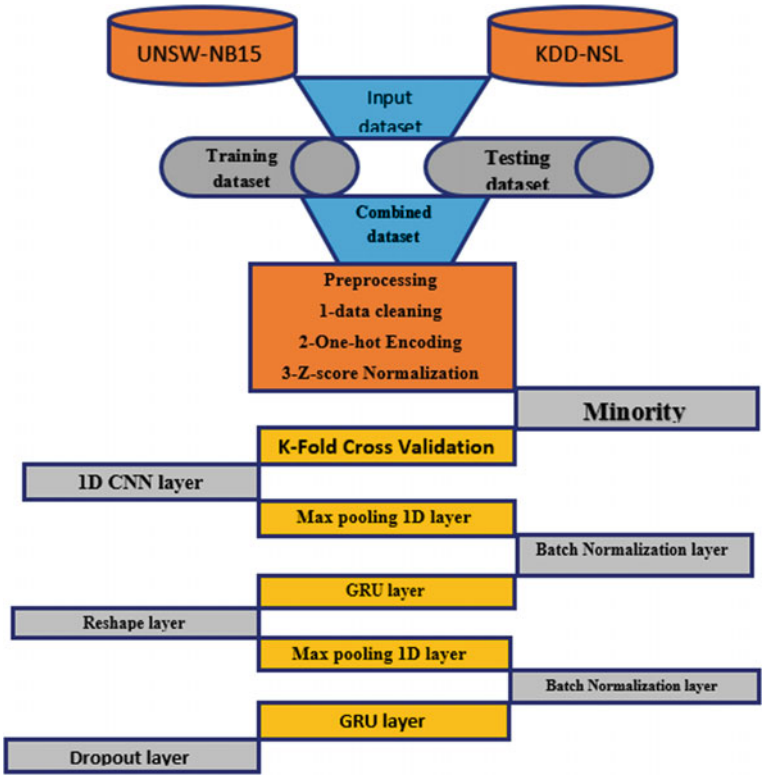


Fig. 1 Architecture of the suggested model

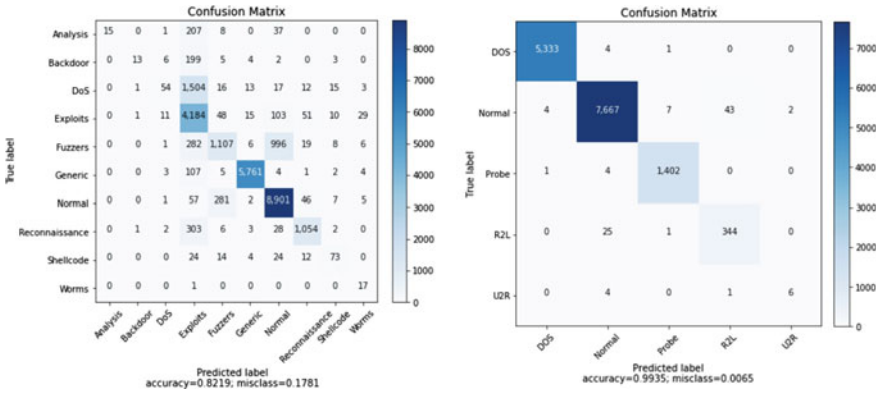


Fig. 2 Confusion matrix for UNSW-NB15and NL-KDD

4 Data Preprocessing

The preprocessing of NSL-KDD and UNSW-NB 15 is carried out by the features of normalization and one-hot encoding. The NSL-KDD contains basic registries including all the categories of attacks, while UNSW-NB 15 contains unenhanced registries that include separate attacks such as the Reconnaissance, Shell code, and Worms. And to solve this issue, the oversampling technique is adopted. Equally important, stratified K-fold cross-validation is utilized to divide layers within the NSL-KDD and UNSW-NB 15 datasets by using the technique known as the K-field. Stratified K-fold cross-validation could also be used to train data by altering the K-field so it could have different values such as K2, K4, K6, K8, and K10. Afterward, random oversampling is conducted for the recurrent data within the NSL-KDD and UNSW-NB 15 by using the code random over sampler class of oversampling Python. This results in reducing the number of data used, and it enhances the accuracy of detection for this category of data. Thus, the amount of data in the UNSW-NB 15 will be 173,000 out of 257,673, while the amount of data in the NSL-KDD will be reduced to 148,517 out of 2254.

5 Evaluations and Discussions

The following evaluation metrics are used: accuracy (ACC), detection rate (DR), false-positive rate (FPR), F1-score, and ROC-AUC curve. The accuracy (ACC) metric represents the accuracy of the attack detection, that is, if the attack is normal or anomalous. The detection rate (DR) represents the levels or the layers that are represented by the K-field, where each layer has its own detection value. The sum of these values represents the DR. However, the false-positive rate (FPR), F1-score, and ROC-AUC curve will be expressed in Eqs. (1)–(3) and [15–17].

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{FP} + \text{TN} + \text{FN}} \tag{1}$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \tag{2}$$

$$\text{F1-score} = \frac{2 * \text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}} \tag{3}$$

In the equations above, TP stands for the number of attacks that are classified correctly. The TN represents the number of normal traffic that is classified correctly. FN stands for the number of attacks that are misclassified as normal traffic, while the FP represents the number of normal traffic that is misclassified as an attack. Also, the ROC-AUC curve assesses the capability of the suggested model in distinguishing among the categories of the datasets in the case of threshold variation. Lastly, the AUC stands for the whole area under the ROC curve. AUC value varies from 0 to 1. Basically, if the value of AUC is high, then the model will better classify the various categories resulting in a more accurate manner of classification [18, 19].

6 Models Results and Discussion

The multiclass classification was used to classify the sets of the NSL-KDD and UNSW-NB 15 in accordance with Table 1.

At the K-field 2, the sets of the UNSW-NB 15 are classified so that they can be trained. Accordingly, the results show that ACC reached 81.27, while the DR reached 92.43, and the FPR reached 5.88. However, at the K-field 10, the results indicate that the ACC reached 82.19, the DR achieved 92.94, and the FPR achieved 5.27. To put it clearly, the average detection for all of the levels of the K-field is 81.938 for the ACC, 92.618 for the DR, and 6.08for the FPR. Conversely, at the K-field 10, the sets of the NSL-KDD provided better results than the results obtained when using the UNSW-NB 15. Therefore, the ACC reached the value of 99.282, the DR achieved

Table 1 Multiclass classification results

k	NSL-KDD			USNW-NB15		
	ACC%	DR%	FFR%	ACC%	DR%	FFR%
2	98.75	98.71	0.57	81.27	92.43	5.88
4	99.8	98.04	0.49	82.01	92.48	6.91
6	99.20	99.09	0.31	82.09	92.36	7.3
8	99.31	99.11	0.40	82.13	92.88	5.04
10	99.35	99.21	0.44	82.19	92.94	5.27
Average	99.282	98.832	0.442	81.938	92.618	6.08

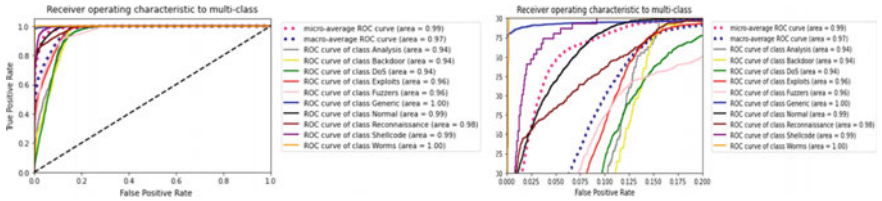


Fig. 3 ROC-AUC curve for UNSW-NB15

98.832, and the FPR achieved 0.442. As for the F1-score evaluation metric for both of the NSL-KDD and UNSW-NB15 datasets, Fig. 2 provides an overview of the obtained results.

It is evident that the F1-score reaches a more accurate value when using the NSL-KDD. The results show that the F1-score accuracy is 99.3 and the misclassification is 0.005. Nonetheless, when using the UNSW-NB 15 dataset, the F1-score achieved 82.19 accuracy and 0.02% misclassification as illustrated in Fig. 3. The AUC curve underneath ROC ranges from 1.00 to 0.99 for the attacks when using the UNSW-NB 15. The average of accuracy detection of ROC-AUC curve is the class Fuzzers which reached the value of 0.97%. Therefore, the micro-average of ROC curve was 0.97% as shown in Fig. 3. In contrast, when using the NSL-KDD, the micro-average of ROC curve was 0.1% for all types of attacks. This value represents the ideal status of detecting attacks in all over the world (Fig. 4).

7 Comparison: Suggested Model Versus Previous Models

In this section, the suggested model will be compared to previous models. The comparison will be conducted once while using the UNSW-NB 15 dataset and then while using the NSL-KDD dataset. First: when merging two algorithms (CNN-GRU) to previous models (CNN, LSTM, GRU, RNN, CNN-LSTM) and (CNN + GRU) when utilizing the UNSW-NB 15 dataset.

As Table 2 shows, the suggested model provides a better detection rate, false-positive rate, and accuracy values in comparison with the mentioned models. It is worth noting that the suggested model exhibits a detection that is roughly similar to the detection rates achieved by previous models as illustrated in Fig. 5. Secondly, the disease of the two algorithms together (CNN-GRU) to previous models (CNN, LSTM, GRU, RNN, CNN-LSTM) and (CNN + GRU) when utilizing the NSL-KDD dataset. It is shown that the suggested model is significantly better than all the previous models except the BAT-MC model in regard to the FPR metric, where the suggested model achieved a higher FPR. However, the suggested model is more suitable for intrusion detection in comparison with other models as given in Table 3. It is worth noting that the suggested model enhanced the detection rate by 1.5 value

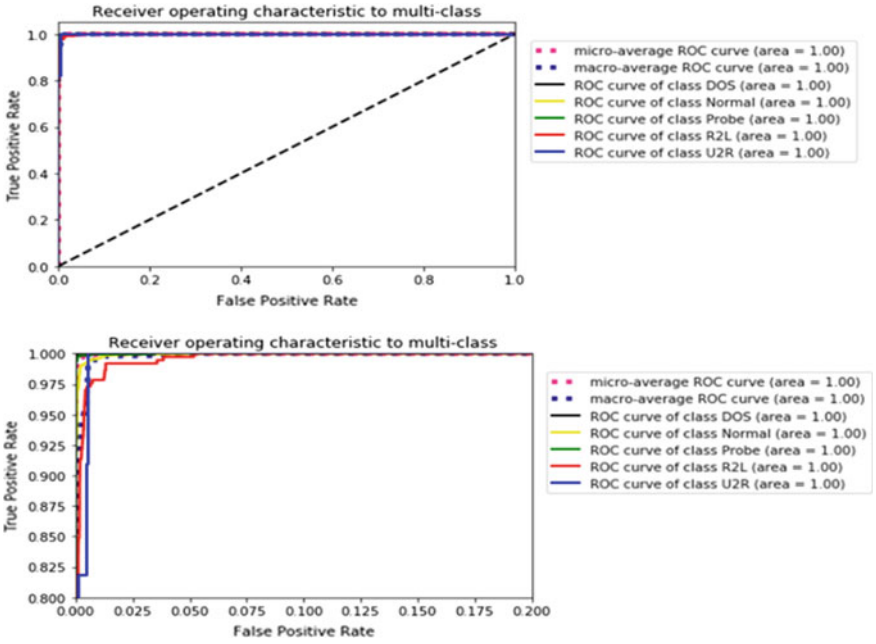


Fig. 4 ROC-AUC curve for NL-KDD

upon the rates achieved by previous models as illustrated in Fig. 6. This makes the suggested model excel all the previous models.

Table 2 UNSW-NB15 multiclass comparison experiment results

Model	ACC%	Precision	Recall	F1-score
CNN	91.2	87.5	96.1	91.5
LSTM	88.9	84.5	94.8	89.5
GRU	77.9	75.3	83.2	79
RNN	71.9	65.8	91.3	76.5
CNN + LSTM	87.6	85.5	90.6	88
CNN + GRU	82.19	81.8	80.9	82.19

Table 3 NSL-KDD multiclass comparison experiment results

Model	ACC%	Precision	Recall	F1-score
CNN	79.3	95.5	61.4	74.8
LSTM	75.8	95.4	54.2	69.2
GRU	79.1	95.4	61.2	74.5
RNN	76.1	88	60.5	71.7

8 Conclusion

In this paper, a new model for intrusion detection was introduced. The model is identified as deep learning CNN-GRU. Two datasets were used to control the size of data traffic by the new model. The batch size was 32. All types of data (balanced and not balanced data) were trained by adopting the SMOTE oversampling method. Results show that the new model is the more practical solution for intrusion detection when using the USNW-NB 15 dataset, where the accuracy detection rate achieved approximately similar to the accuracy achieved by other models. Nonetheless, it is imperative to point out the new model achieved better "precision", "recall", and "F1-score" which stand for the detection rate and the false-positive rate as illustrated in Fig. 5. Conversely, when utilizing the NSL-KDD dataset, the new model achieved successful accuracy detection rate by 1.5 values upon the accuracy rates achieved by previous models as illustrated in Fig. 6. Additionally, the new model achieved better "precision", "recall", and "F1-score" when utilizing the NSL-KDD. It is also obvious that the new model requires to be enhanced when using the NSL-KDD in regard to reduce the value of FPR.

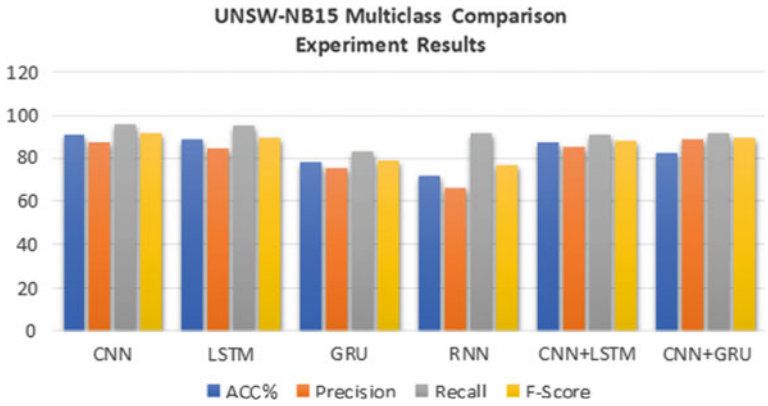


Fig. 5 UNSW-NB15 multiclass comparison experiment results

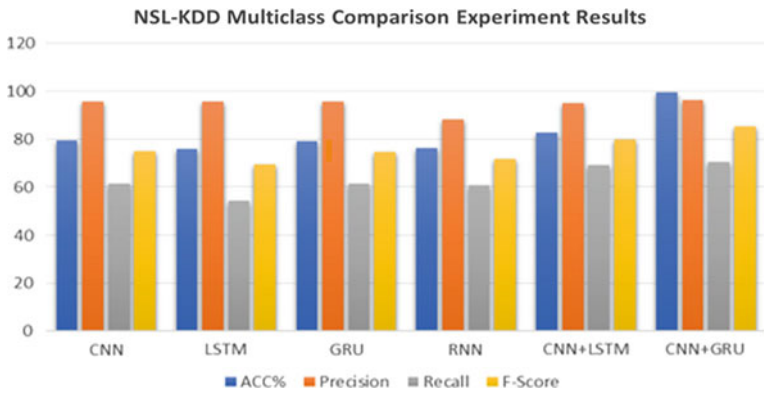


Fig. 6 NSL-KDD multiclass comparison experiment results

References

1. Tomer, V., & Sharma, S. (2022). Detecting IoT attacks using an ensemble machine learning model. *Future Internet, 14*(4), 102.
2. Gupta, R., Tanwar, S., Tyagi, S., & Kumar, N. (2020). Machine learning models for secure data analytics: A taxonomy and threat model. *Computer Communications, 153*, 406–440.
3. Rathore, S., & Park, J. H. (2018). Semi-supervised learning based distributed attack detection framework for IoT. *Applied Soft Computing, 72*, 79–89.
4. Choudhary, S., & Kesswani, N. (2020). Analysis of KDD-Cup'99, NSL-KDD and UNSW-NB15 datasets using deep learning in IoT. *Procedia Computer Science, 167*, 1561–1573.
5. Wang, Y., Fang, Z., Wang, M., Peng, L., & Hong, H. (2020). Comparative study of landslide susceptibility mapping with different recurrent neural networks. *Computers & Geosciences, 138*, 104445.
6. Yin, Y. et al. (2022). IGRF-RFE: A hybrid feature selection method for MLP-based network intrusion detection on UNSW-NB15 dataset. arXiv Prepr. arXiv2203.16365
7. Divekar, A., Parekh, M., Savla, V., Mishra, R., & Shirole, M. (2018). Benchmarking datasets for anomaly-based network intrusion detection: KDD CUP 99 alternatives. In *2018 IEEE 3rd international conference on computing, communication and security (ICCCS)* (pp. 1–8).
8. Kim, J., & Kim, H. (2016). Classification performance using gated recurrent unit recurrent neural network on energy disaggregation. In *2016 International conference on machine learning and cybernetics (ICMLC)* (vol. 1, pp. 105–110).
9. Agga, A., Abbou, A., Labbadi, M., El Houm, Y., & Ali, I. H. O. (2022). CNN-LSTM: An efficient hybrid deep learning architecture for predicting short-term photovoltaic power production. *Electric Power Systems Research, 208*, 107908.
10. Krček, M. et al. (2022). Deep learning on side-channel analysis. In *Security and artificial intelligence* (pp. 48–71). Springer.
11. Fan, C., Wang, J., Gang, W., & Li, S. (2019). Assessment of deep recurrent neural network-based strategies for short-term building energy predictions. *Applied Energy, 236*, 700–710.
12. Jain, T., & Gupta, C. (2022). Multi-agent intrusion detection system using sparse PSO K-mean clustering and deep learning. In *Proceedings of 2nd international conference on artificial intelligence: Advances and applications* (pp. 91–102).
13. Kshirsagar, D., & Kumar, S. (2022). Towards an intrusion detection system for detecting web attacks based on an ensemble of filter feature selection techniques. *Cyber-Physical System*, pp. 1–16.

14. Janarthanan, T., & Zargari, S. (2017). Feature selection in UNSW-NB15 and KDDCUP'99 datasets. In *2017 IEEE 26th international symposium on industrial electronics (ISIE)* (pp. 1881–1886).
15. Kulkarni, A., Chong, D., & Batarseh, F. A. (2020). Foundations of data imbalance and solutions for a data democracy. In *Data democracy* (pp. 83–106). Elsevier.
16. Malki, Z., Atlam, E., Dagnew, G., Alzighaibi, A. R., Ghada, E., & Gad, I. (2020). Bidirectional residual LSTM-based human activity recognition. *Computer and Information Science, 13*(3), 40.
17. Khan, Z. A., Adil, M., Javaid, N., Saqib, M. N., Shafiq, M., & Choi, J.-G. (2020). Electricity theft detection using supervised learning techniques on smart meter data. *Sustainability, 12*(19), 8023.
18. Shapiro, N. I., et al. (2009). A prospective, multicenter derivation of a biomarker panel to assess risk of organ dysfunction, shock, and death in emergency department patients with suspected sepsis. *Critical Care Medicine, 37*(1), 96–104.
19. Clark, R. D., & Webster-Clark, D. J. (2008). Managing bias in ROC curves. *Journal of Computer-Aided Molecular Design, 22*(3), 141–146.

Design, Optimization and Characterization of Optical Imaging Systems for Complex Temperature Environment

T. S. Srinivasan, Vivek Maik, and Samiappan Dhanalakshmi

Abstract The optical system's image quality depends on the following parameters, such as temperature, pressure, number of optical components, in-house mounting and shielding of the lens, etc. The optical imaging system is carefully designed and fabricated to the specific environment to ensure good image quality. Normally, the lens element extends or contrasts due to extreme temperature or pressure. The refractive index (dn/dT) and the focal length (F) are also modified because of the various environmental loads on the lens device. This leads to the original picture being defocused. Here, it is planned to design an optical imaging system to stabilize the image quality between the temperatures $-40°$ and $+120°$. To achieve this, it is used CODE V program in conjunction with the Glass Expert tool. The problem, in this case, is to find the most appropriate optical glass substance for the temperature condition. According to the objectives of this study, it is planned to construct an optical system and analyze its behavior concerning the suitable glass material under various temperature conditions.

Keywords Athermalization · Thermal compensation · Glass Expert tool · Passive athermalization · Environmental modeling

1 Introduction

Optical systems for imaging are generally influenced by thermal defocus and chromatic aberration due to changes in hostile environmental conditions (temperature and pressure). The property of the optical element behavior such as refractive index,

T. S. Srinivasan · S. Dhanalakshmi (✉)
Department of Electronics and Communication Engineering, College of Engineering and Technology, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Kanchipuram, Chennai, TN, India
e-mail: dhanalas@srmist.edu.in

V. Maik
Department of Electrical Engineering, Indian Institute of Technology Madras, Chennai, TN, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_36

air spacing, thickness and radius of curvature is also affected by an unstable environment [1–3]. Generally, it has two different techniques which are mostly used to stabilize the optical system free from temperature. One is active athermalization and the other one is passive athermalization. In active athermalization, it is based on the focal length shift, either lens or image plane relocated with the help of motor-driven mechanical arrangement. This makes complex mechanical infrastructure and increases the volume and weight of the system. To avoid this problem, passive athermalization is used in recent optical systems. It uses dissimilar bimetallic materials with opposite thermal expansion coefficient and that pair of materials attached with special metal mounting. It does not have any complicated mechanical motor-driven parts. And also, complete tolerance analysis is incorporated into an optical system to sustain the various environmental aspects. The optical designer needs to have specific attention to this problem, that thermal compensation is a sensitive area for optical imaging. To achieve this thermal compensation, the optical lens element and mounting/shielding material were carefully chosen for the various wavebands [4, 5]. The optomechanical engineer designing a system with thermal compensation is said to be Athermalized.

In this article, the optical imaging system is modeled for a complex temperature environment and characterizes the behavior of the system for thermal modeling. Here, for optimization purposes, it is taken a triplet lens with the following specification (entrance pupil diameter—25 mm, *F*-Number—4, off-axis angle—0, 3.5, 5). Before going for thermal load, it is well optimized with ambient temperature (22°). The behavior of the system is analyzed with the help of the modulation transfer function and spot diagram. The objective of this design is to optimize the behavior of the optical imaging system between −40° and +120°. To achieve this, here CODE V software is used along with Environmental modeling (ENVPIK macro).

2 Optimization Techniques

Optimization is one of the major parts in thermal compensation. For any system, the optimization techniques will helpful to produce some feasible solution. There are some optimization techniques which are available in the CODE V software. There are Automatic design, global optimization, Aspheric Expert and Glass Expert. The flow diagram Fig. 1 shows the thermal optimization procedures. Here, it is taken a triplet lens for optimization for the required temperature. Then, it is added with the specification. For the given constraint, the performance is evaluated with modulation transfer function and spot diagram. If the results are not meeting with the requirement, then it is passed to the Automatic design tool for changing the material or lens element thickness and spacer to generate the best output. Then, it is fed to the Aspheric Expert, that will change the lens from spherical to Aspheric surface. The main purpose of the Aspheric Expert tool is to make the rays to converge at single point which will helpful to reduce the aberration. This process will continue until get into the optimal design system. To do the design for further optimization, it is

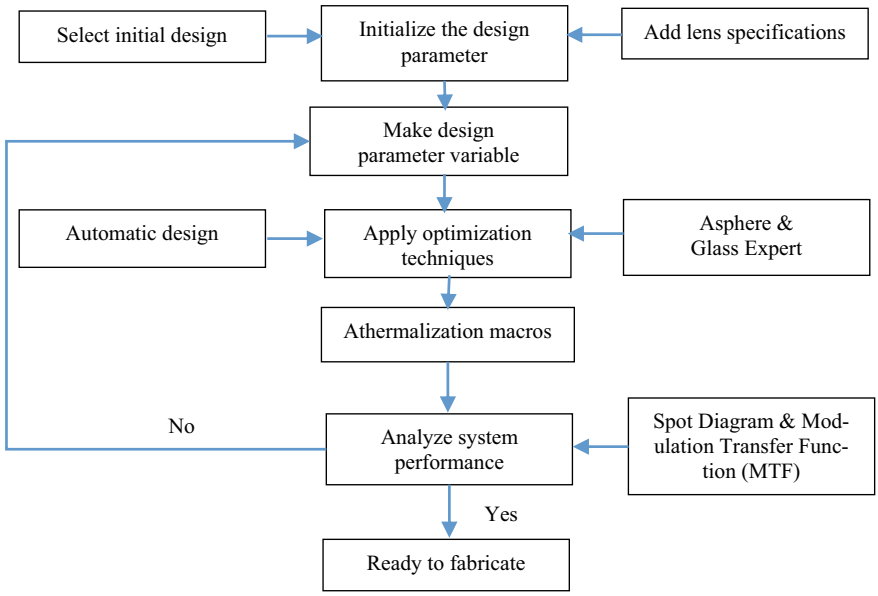


Fig. 1 Optimization model for athermalization macros

investigated with Glass Expert for suitable glass selection for our thermal modeling. In this design, Environmental modeling macro is applied to this system; then, the design is optimized with the help of Glass Expert tool. Once it optimized with Glass Expert, the optical system is ready to fabricate.

3 Methodology

In this design, advanced macro programming (ENVPIK) is used for thermal modeling along with the CODE V software tool. First, it is taken with a well-optimized triplet lens and it is supplied with thermal modeling for −40°–120°. Due to this thermal load, the MTF and spot size were modified. The methodology of thermal modeling is shown in Fig. 2.

Fig. 2 Methodology of thermal modeling

3.1 Athermalized Design Procedure

The process of athermal design is as follows [6–8]:

(1) Design a triplet lens and optimize the MTF and spot diagram for the ambient temperature.
(2) Apply an ENVPIK macro and add a dummy surface for each lens either front or rear end.
(3) ENVPIK generates three configurations for thermal modeling (+22 °C, −40 °C, +120 °C).
(4) Call the Glass Expert tool for the model and it starts substituting the appropriate glass.
(5) By using pull_seats.seq, macro deletes the dummy surfaces that are added before and after the lens.
(6) Now, check the image quality, and if it is meeting the requirement, then remove the dummy surface by using pull_seats.seq command. If it is not to the specification, do the process (3)–(6) again until it meets the requirement.

4 Existing System

The existing design parameters are shown in Table 1. This imaging has seven surfaces, in that three are spheres and four are aspheres. And also, the specification of our system is EPD—25 mm, F-Number—4, off-axis angle—0, 3.5, 5 and wavelength—dFc band. The dFc band consists of visible frequency. In order to use the above parameter and specification, we obtained the 2D lens system as shown in Fig. 3. To this existing imaging system, we applied our methodology for thermal modeling between −40° and 120°. Thereafter, we used analysis tool to investigate our system for athermalization. As MTF shows the how object data transfer from object plane to image plane. The existing system the off-axis angle for 5°, the MTF produces 0.43 for ambient temperature 22 °C. For the temperature −40 °C, MTF value is 0.33. And then, for +120 °C, it gives 0.25. Similarly, the spot size for the various temperatures is as follows: RMS spot size for the off-axis angle 5°, 5.9 μm at 22 °C, 11 μm at -40 °C and 16 μm at + 120 °C as shown in Figs. 4 and 5.

5 Proposed Optimized System

To optimize the optical system for the complex temperature, here is used ENVPIK along with a Glass Expert tool. ENVPIK is useful for thermal modeling and the Glass Expert will be useful to substitute the suitable glass for our design specification. Glass Expert tool substitutes suitable glasses from the glass catalog and checks the performance of the design [9–12]. It repeats the process until it meets the requirement.

Table 1 Existing imaging system design parameter

Surface number	Type of surface	*Y* radius	Thickness	Glass name	*Y* semi-aperture
1	Asphere	93.8300	12.1792	NLAK12_Schott	14.8545
2	Asphere	−112.4081	29.9180		13.5379
3	Sphere	−96.7740	2.4266	SF57HTULTRA_Schott	7.2267
4	Asphere	39.3079	0.6043		7.0754
5 (Stop)	Sphere	Infinity	25.9624		7.0755
6	Sphere	70.8327	4.5880	NLAK33B_Schott	9.9277
7	Asphere	−70.5605	65.7331		10.0463

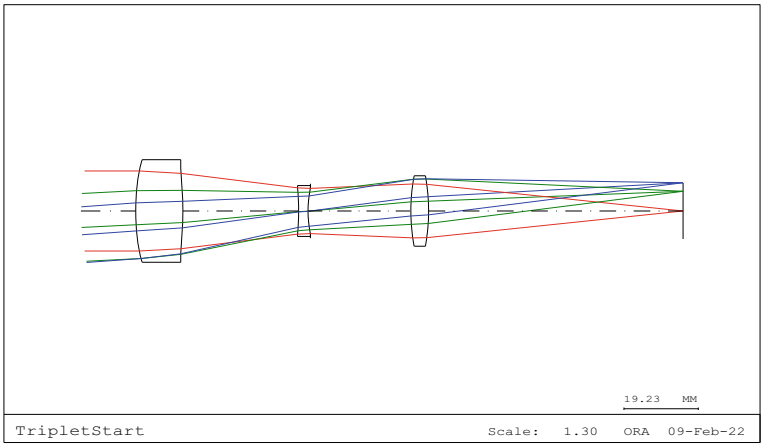


Fig. 3 Two-dimensional imaging system for existing design parameter

Figures 7 and 8 show the optimized spot diagram and MTF. Some other options are available to deal with procedure with pressure. Usually, in underwater, the temperature will reduce and pressure gets increased. Due to this high-sensitive pressure, the glass gets heavy stressed. This leads the material property will change and thereby the image quality degraded [13, 14]

From Fig. 8, it is observed that the spot size is gradually optimized for different temperatures. When compared to ambient temperature, the ray converging point is modified. Table 2 shows the comparative results of RMS spot size. Spot size at -40 °C is observed at 8 μm, but for 22 °C, it is 5 μm. Similarly, the spot size at 120 °C is observed at 4.9 μm, but for 22 °C, it is 5 μm. The other off-axis angle concerning spot size is tabulated. Figure 6 shows the optical system after thermal modeling. Compared to the initial system, in the final design of the optical system, it is noticed that the optical element's thickness and curvature are modified. And also, the entire size of the optical system is reduced from 19.23 to 13.89 mm. Similarly, the comparative spot size of before and after optimization is given in Table 2.

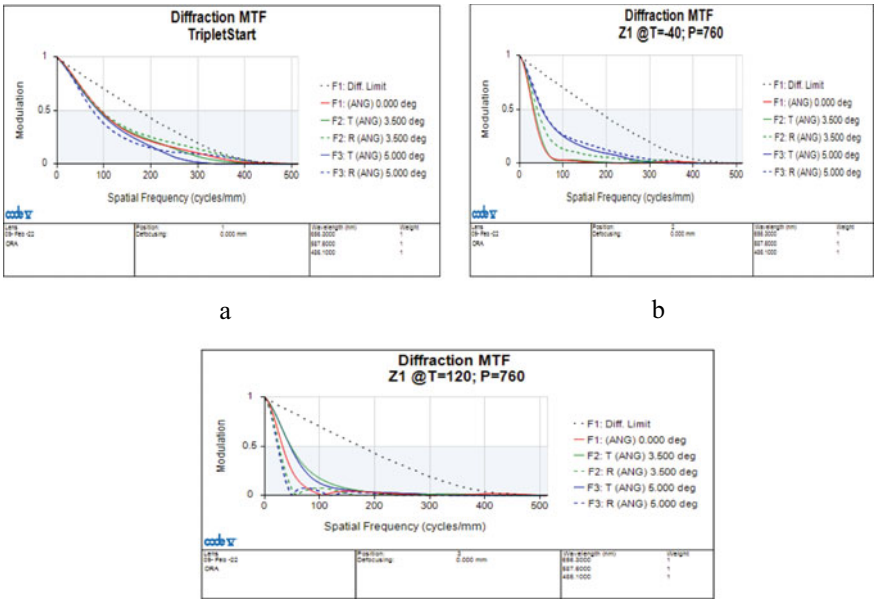


Fig. 4 MTF for existing system **a** 22° **b** −40° **c** +120°

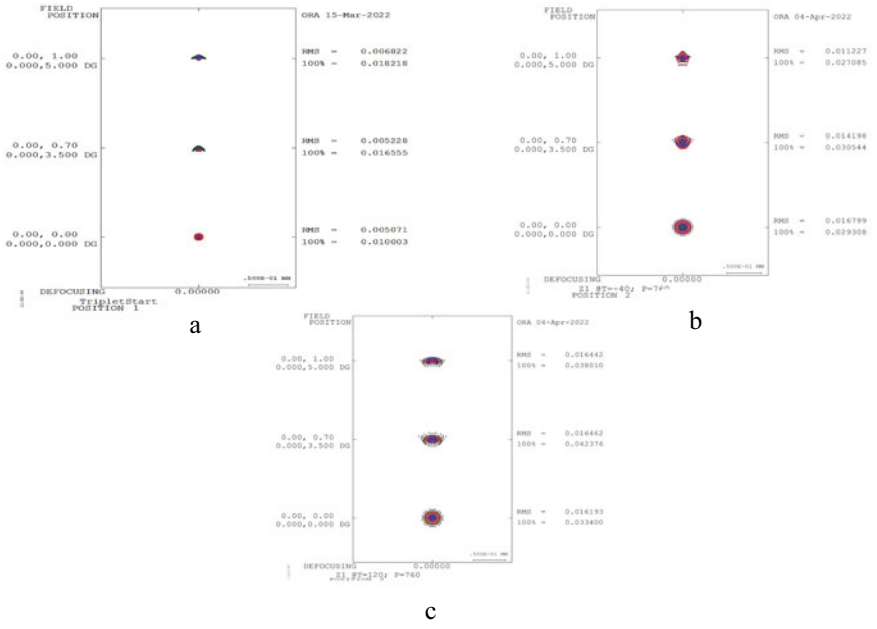
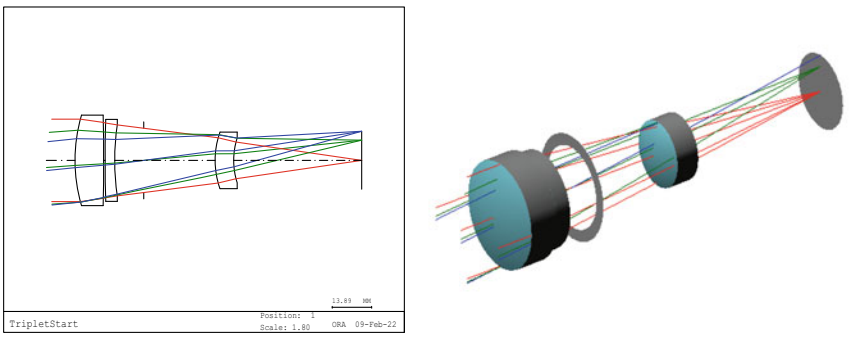


Fig. 5 Spot diagram of existing system **a** 22° **b** −40° **c** +120°

Table 2 Athermalization comparative results of the existing and proposed imaging systems

Imaging systems		Existing system			Proposed system		
Off-axis angle Deg C		0	3.5	5	0	3.5	5
Analysis tools	Temp Deg C						
MTF (100 cycles/mm)	22	0.46	0.45	0.43	0.55	0.55	0.46
	−40	0.14	0.14	0.33	0.39	0.55	0.39
	120	0.01	0.33	0.25	0.55	0.55	0.45
Spot diagram	RMS 22	0.005804	0.005846	0.005945	0.005071	0.005228	0.00682
	RMS −40	0.016799	0.014198	0.011227	0.008005	0.005269	0.00625
	RMS 120	0.016193	0.016462	0.016442	0.004940	0.005888	0.00745
	100% 22	0.12976	0.022229	0.017906	0.10003	0.016555	0.01821
	100% −40	0.029308	0.030544	0.027085	0.017392	0.012348	0.01283
	100% 120	0.033400	0.042376	0.038010	0.008471	0.018679	0.02018



a b

Fig. 6 Proposed optimized system **a** 2D imaging system **b** 3D imaging system

6 Conclusion

In this design, it is taken a triplet lens for thermal stabilization in the range of − 40°– +120°. Before taking for thermal analysis, the lens system needs to be well optimized. Here, we investigated the optical imaging system behavior for −40°– + 120 °C. After applying temperature to this system, it is notified that the modulation transfer function and spot diagram are distorted. By using the glass substitution method, optical element is replaced or repositioned and optimistic MTF is achieved with a reasonable spot size.

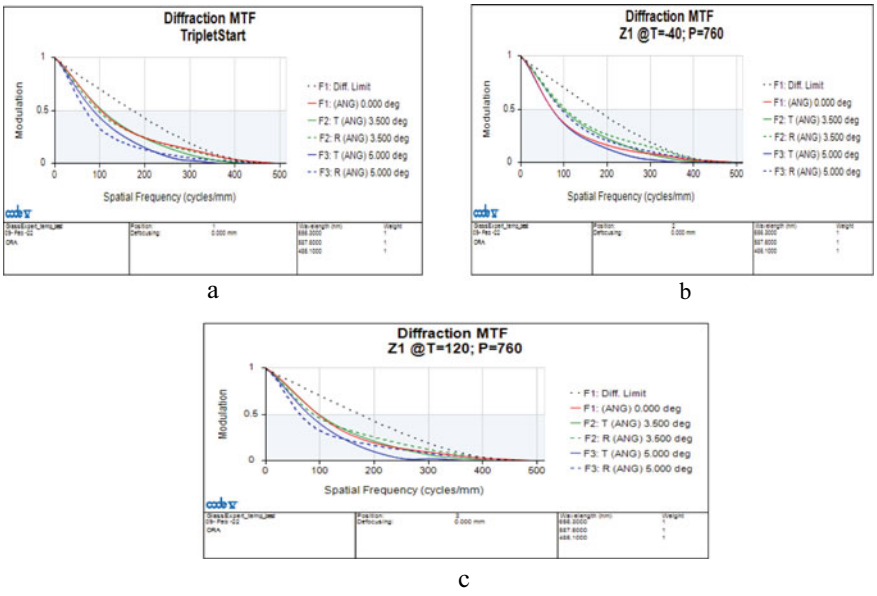


Fig. 7 MTF for proposed optimized system **a** 22° **b** −40° **c** + 120°

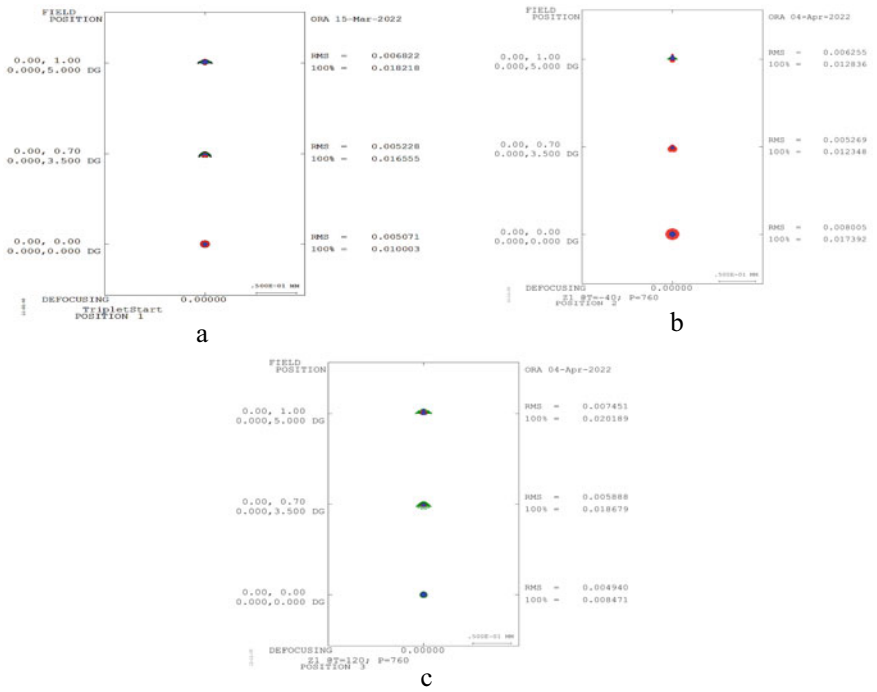


Fig. 8 Spot diagram of proposed optimized system **a** 22° **b** −40° **c** + 120°

Acknowledgements This work is supported by Start-Up Research Grant (SRG) File No SRG/2019/001553 Funding from the Science Engineering and Research Board (SERB) of the Department of Science and Technology (DST).

References

1. Rogers, J. R. (2019). An optically athermalized lens covering a 200-degree temperature range In *International Conference on Space Optics—ICSO 2018* (Vol. 11180, pp. 3019–3037). SPIE.
2. Rogers, J. R. (2014). Passive athermalization: required accuracy of the thermo-optical coefficients. In *International Optical Design Conference 2014* (Vol. 9293, pp. 352–360). SPIE.
3. Zhu, Y., Cheng, J., & Liu, Y. (2021). Multiple lenses athermalization and achromatization by the quantitative replacement method of combined glasses on athermal visible glass map. *Optics Express, 29*(21), 34707–34722.
4. Yu, X., Ni, M., Rui, D., Qu, Y., & Zhang, W. (2016). Computational method for simulation of thermal load distribution in a lithographic lens. *Applied Optics, 55*(15), 4186–4191.
5. Vijay Kumar Gowda, B. N., Gauni, S., & Maik, V. (2021). Diffraction based image synthesis. *Journal of Physics: Conference Series, 1964.*
6. Shi, J., Liu, J., Chen, T., Wang, J., & Yu, F. (2020). Calculation method for athermalized optical systems and athermal design based on CODE V. In *2020 12th International conference on intelligent human-machine systems and cybernetics (IHMSC)* (Vol. 2, pp. 87–91). IEEE.
7. Liu, T., Wang, C., Yu, Y., Liu, Z., & He, F. (2021). Passive athermal optical design method considering thermal-induced surface deformation. In *Photonics* (Vol. 8, No. 9, p. 396). MDPI.
8. Lim, T. Y., & Park, S. C. (2016). Achromatic and athermal lens design by redistributing the element powers on an athermal glass map. *Optics Express, 24*(16), 18049–18058.
9. Lim, T. Y., Kim, Y. S., & Park, S. C. (2015). Graphical selection of optical materials using an expanded athermal glass map and considering the housing material for an athermal and achromatic design. *Journal of the Optical Society of Korea, 19*(5), 531–536.
10. Xie, N., Cui, Q., Sun, L., & Wang, J. (2019). Optical athermalization in the visible waveband using the $1+\sum$ method. *Applied Optics, 58*(3), 635–641.
11. Ramsey, J. L., & Unger, B. L. (2017). Design of multiband optics using updated athermal/achromatic glass map. In *Advanced optics for defense applications: UV through LWIR II* (Vol. 10181, pp. 2–8). SPIE.
12. Gowda, V. K., Maik, V., Karibassappa, K., & Paik, J. (2016). Removal of underwater turbidity using an optical imaging platform. In *2016 International conference on electronics, information, and communications (ICEIC)* (pp. 1–5). IEEE.
13. Vijay Kumar Gowda, B. N., Gauni, S., & Maik, V. (2021). Underwater image enhancement by using color correction and contrast techniques. In *2021 Sixth international conference on image information processing (ICIIP)* (Vol. 6, pp. 467–471). IEEE
14. Mathias, A., & Samiappan, D. (2019). Underwater image restoration based on diffraction bounded optimization algorithm with dark channel prior. *Optik, 192*, 162925.

Decentralized Smart Irrigation with Remote Data Visualization

Sanjeev Kumar and Vivek Sharma

Abstract Every sector is evolving faster than ever in this fast-growing world. Smart technologies connected with different things are using the internet to collect and analyze data better to understand the manufacturing line, vehicles, etc. Same technologies can be used in the same way in the agriculture sector. The proposed system has multiple nodes, also known as things, connected to the Internet. These nodes are independent individual units, usually ESP8266, which can collect data using temperature, humidity, and moisture sensors for soil. This data can be stored and visualized in the cloud easily. This data can further be used along with weather reports to manage the irrigation system. Each node can independently control the irrigation of its area or sector. Data is stored on Google Firebase Real-Time Database. All the data can be visualized, and the farmer or cultivator can control irrigation through web clients. Thus, this system can manage irrigation and plantation on vast land with just one centralized portal with a click. It will improve the overall efficiency of the farming sector for farming and plantation in a greenhouse with a lesser workforce.

Keywords Microcontrollers · Wireless fidelity · Irrigation system · Remote communication · User interface

1 Introduction

With around 65% of India directly involved in the agriculture sector, it is the backbone of the country's economy and growth. However, even when the country has entered a new era in the twenty-first century, people in India follow most of the old and conventional farming methods. Even today, farmers are directly dependent on rain irrigation in some parts of the Country.

The main reason farmers do not know about the health of their plants, and the land's soil is the lack of knowledge and data about the land they are using and the

S. Kumar (✉) · V. Sharma
Department of Computer Science and Engineering, Technocrats Institute of Technology, Bhopal, India
e-mail: kumarsanjeev1950@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_37

plants they are growing in this technologically evolving world. Because of this issue, farmers cannot optimize the number of fertilizers, pesticides, water, etc., to provide the plants with optimum quality without wasting resources.

This optimal use is essential to reduce the wastage of resources. In turn, this will be easy on the farmers' pockets, and it will be better for the ecology too. Less water use means farmers do not need to spend much money to power their irrigation system. Thus, farmers will also buy fewer pesticides and fertilizers. Thus, deploying a pocket-friendly yet efficient and easy-to-operate system to automate the farming sector with properly structured database management becomes crucial.

2 Literature Review

2.1 Futuristic Approach to Agriculture

The author showcased a futuristic approach in the smart farming sector to perceive environmental data about soil moisture, fertility, weather, temperature, rainfall, etc., using numerous sensors. In addition, the authors discussed crop and water management, pest control, precision agriculture, food production, and its safety.

They mentioned various application areas of such innovative systems, including Crop Water Management, Precision Agriculture, Integrated Pest Management or Control (IPM/C), Food Production Automation, Green House Automation, and Other Projects Implemented to Date [1].

Wireless sensor nodes can be interconnected and connected to a gateway node. This gateway node is connected to the Internet, which shall transfer data from the sensor nodes to the database and server. The server then relays the data to the user at a remote location through a front-end user interface (U.I.) [2].

2.2 Moisture and Water Level Sensors with Arduino

Ritika et al., in their paper titled "A Research Paper on Smart Agriculture Using IoT," explained the system in which temperature and soil of moisture, level of water, etc., on the farm. The sensor nodes here are controlled by the Arduino Uno microcontroller, which works with Atmel's ATMega328P-PU [3].

The most crucial factor in farming is the water source. It is also necessary for agriculture and key to our sustainable quality of life. The water crisis is knocking at the doorstep of humankind. Therefore, keeping track of the water sources is very important nowadays [4, 5].

2.3 Sensor Nodes with IoT Network

In the paper titled "An IoT Based Smart Irrigation System" in May 2017, Priyadharsnee and Rathi discussed connecting sensor nodes with IoT systems to support the farms for automated irrigation facilities. Decision-making is done through a microcontroller [6].

The system was divided into three main modules. Parameter sensing module is responsible for sensing the parameters like temperature, soil moisture, and electrical conductivity, which are taken from sensors placed in soil used for cultivation. Analysis and decision-making has the threshold for all the parameters determined and programmed beforehand. This needs to be done before we start collecting the analog and digital data from the sensors [7]. User acknowledgement is essential for enabling farms or users to know about the complete state of their field and cultivation, especially for the farmers dependent on manual labor to cultivate the land [8].

2.4 Lightweight MQTT Protocol and Worldwide Connectivity

In 2019, Naman and Medhavi published paper titled "Home Automation with NoSQL and Node-RED through Message Queuing Telemetry Transport." They replaced the Hyper-Text Transfer Protocol (HTTP) with Message Queuing Telemetry Transport (MQTT) protocol. MQTT protocol has smaller digital footprint and smaller size of packet with less header which results in higher speed to transmission of data. This also enabled the system to work on lesser bandwidth and inconsistent connection especially in rural areas [9].

This system had a worldwide connectivity over any wired or wireless Internet, even on the mobile devices through a client. The system had a cloud database so it had a global connectivity and the home hub were individually connected with a broker on the local server. The local server has a connectivity with the cloud database.

3 Shortcomings of the Existing Systems

Local Reach and Connectivity. Several previous systems used to work on the local on-premise basis only. As a result, they do not have connectivity to the global system, which only restricts the farmers to local observability.

Bandwidth Limitations and Heavy Internet Protocols. Primarily, all the previous systems were using Hyper-Text Transfer Protocol (HTTP) for data transmission, which requires a larger bandwidth due to its larger packet size. So, the HTTP system may show latencies and even failure in some cases due to lower bandwidth in remote areas, especially in India, where fast Internet is still an issue.

Dependence on Centralized On-Premise Unit and Problem with Scaling. The previous systems worked as a single unit. However, scaling the system for a large-scale agro-industry is a very tedious task to handle with such a system. In addition, more sensing nodes will require additional infrastructure to handle many nodes. Therefore, a system with independent nodes must connect with the database directly without any on-premise central unit.

4 The Architecture of the Proposed System

The system is divided into entities—sensor node and Internet backbone. Users can control the irrigation system from the dashboard after analysis of soil and ambient data. Refer to Fig. 1.

4.1 The Architecture of the System

It consists of an ESP8266 microcontroller powered by a 5 V. A capacitive soil moisture sensor is attached to the A0 pin of the ESP8266 as the sensor gives analog outputs only. To perceive the ambient temperature and humidity, a DHT11 sensor is attached to the General Purpose Input–Output (GPIO) pin 0. Also, a waterproof soil temperature sensor is used to record soil temperature using the DS18B20 Water Proof Temperature Probe, as shown in Fig. 2.

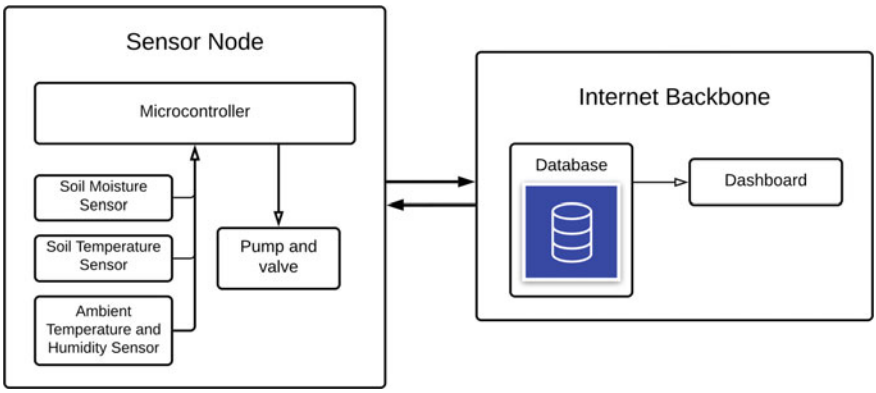


Fig. 1 Architecture of the system

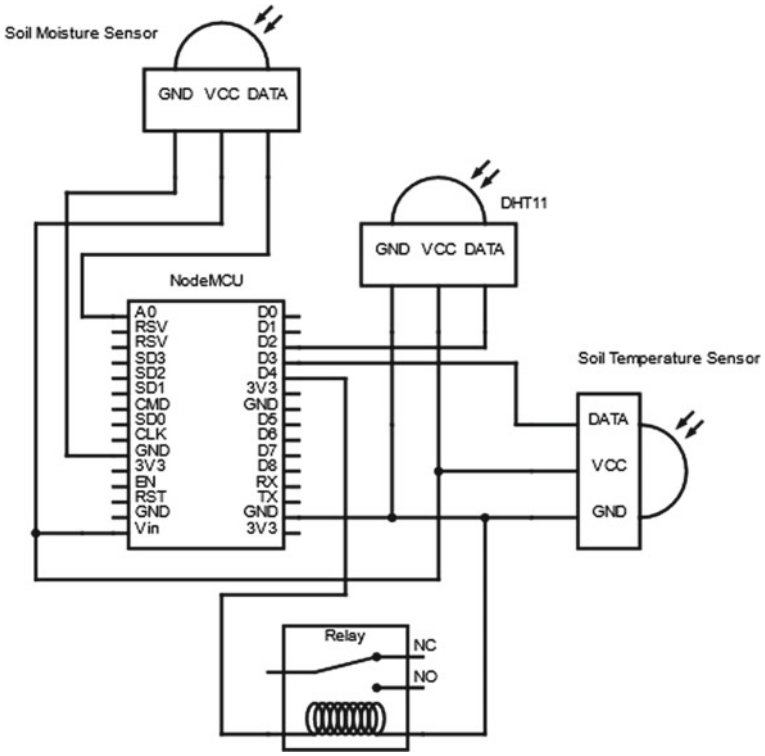


Fig. 2 Schematic of the sensor nodes

4.2 Cloud Server

As shown in Fig. 2, the data sent from the sensor nodes to the server is handled directly. The server handles the reception of all the REST-API requests. It is connected to the database on one side and the dashboard on the other. The database has tables for each feed having a unique feed ID and stored data according to those feed Ids.

The server responds to the APIs and handles them per the type of request. If there is a data request, the server takes the feed ID and searches the table to match the corresponding feed ID. It then copies the latest data from the table and creates a JSON response. This is then sent back to the sensor node. If the API request is in the update mode, the server reads the feed ID and creates a new row in the table of the corresponding feed ID. Also, the dashboard component subscribed to the feed ID is updated by the broker on the server. If the user changes some data on the dashboard using the component, it gets updated by the broker using the MQTT protocol in the database table of the corresponding feed ID.

5 Working of the System

5.1 Establishing a Wireless Connection

As ESP8266 can be set in two modes, the sensor node is set in STA mode to connect as a client to the Wi-Fi. The sensor node connects with the AP using SSID and password fed during the program upload. When the sensor node can connect to the hotspot network (access point) with the correct password, the system only goes for further steps. This way, the correct and authentic sensor nodes programmed with the correct SSID and password get connected.

5.2 Perception of Data from the Environment and Processing by the Microcontroller

As shown in Fig. 3, the program flow starts when each sensor takes the data from the microcontroller. The soil moisture, temperature, and DHT11 sensor send their data to the microcontroller. Unlike all other sensors sending a digital value, the soil moisture sensor sends analog signals to the ESP8266. This data is stored temporarily before sending it to the feeds. Each feed on the cloud server has a specific feed ID to identify each feed from the other uniquely. Thus, a feed pointer must be initialized with a unique feed ID which could point to the feed on the IoT database based in the cloud.

5.3 Time-Sensitive Transmission of Data

This system needs to be secure and time-sensitive because all the data shall be shown to the remote user or the farmers in real time.

First transfer mode is authorized by using an API key to uniquely identify the actual device. REST-APIs are very lightweight and easily understandable by humans and machines. The REST-API for reading data from the database takes parameters, including the secret API key and feed ID of the feed you need to fetch data from. The API sends a JSON response to this request made to the server.

The second way to send and receive data is by using the MQTT. It is a protocol for light data transmission on very low bandwidth with a small digital footprint. Each feed on the database has a feed ID to which it has subscribed. When the sensor node publishes some data to the specific feed ID, the feed subscribed to the feed ID reads that data and stores the value, as shown in Fig. 4.

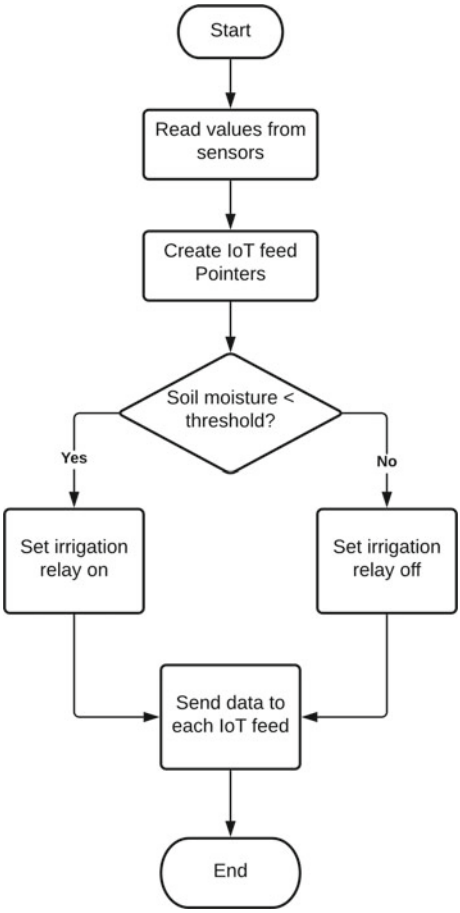


Fig. 3 Data perception and sending to the cloud IO feeds

6 Conclusion

The system could perceive the data about the farm's surroundings and the soil's health, like temperature and moisture, within 10 s and efficiently relay it to the cloud server via the Internet (Fig. 5).

Despite being running on the battery, this device consumes significantly less battery as the ESP8266 microcontroller is very power efficient. Thus, these systems are very suitable for deployment in rural areas. The dashboard of the IoT cloud is very intuitive and accessible. The components keep updating themselves as soon as new data is updated into the database tables.

WSN can be improved with intra-node communication between the different sensor nodes. The system depends on Wi-Fi access points for data transmission. This can be improved by using a communication technique suitable for rural areas

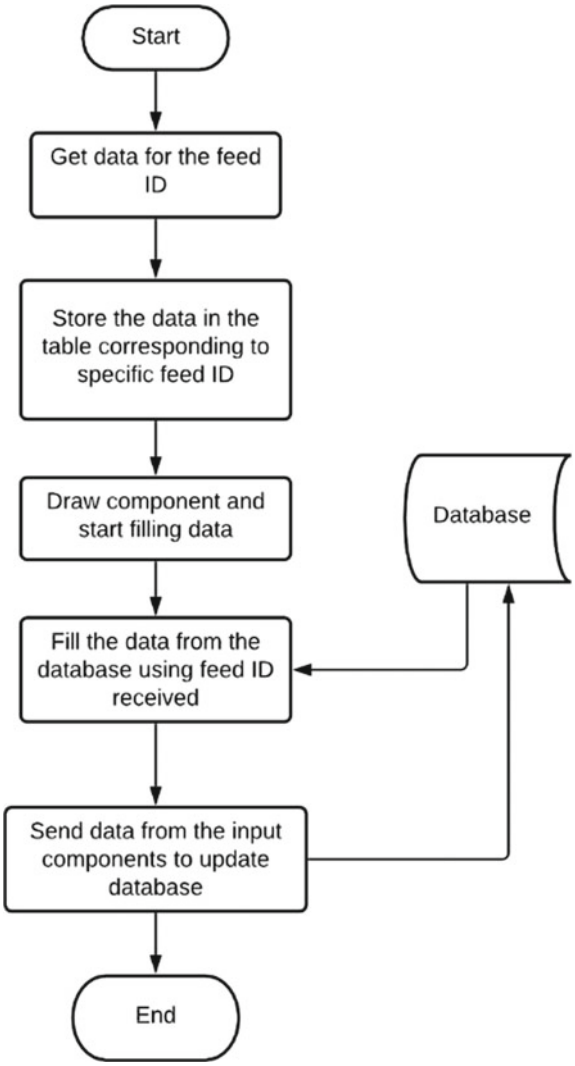


Fig. 4 Handling data from sensor nodes and updating dashboard

where the Internet is not available easily. GSM can be used for data communication via cellular reception to send SMS acknowledgement to the farmers.

Fig. 5 IoT dashboard with all the parameters within the limits

References

1. Welbourne, E., Battle, L., Cole, G., Gould, K., Rector, K., Raymer, S., Balazinska, M., Borriello, G. (2009). Building the internet of things using RFID: The RFID ecosystem experience. *IEEE Internet Computing, 20*(20), 48–55.
2. Atzori, L., & Antonio Lera, G. M. (2010). The internet of things: A survey. *Computer Networks, 54*(15), 2787–2805.
3. Srivastava, R., Sharma, V., Jaiswal, V., & Raj, S. (2020). A research paper on smart agriculture using IoT. *International Research Journal of Engineering and Technology, 7*(7).
4. Talpur, M. S. H., Shaikh, M. H., & Talpur, H. S. (2012). Relevance of internet of things in animal stocks chain management in Pakistan's perspectives. *International Journal of Information and Education Technology, 2*(1), 29–32.
5. Carvin, D., Owezarski, P., & Berthou, P. (2012). Managing the upcoming ubiquitous computing. International Federation for Information Processing.
6. Ragavi, V., Jayasudha Subburaj, P., & Soundaryaveni, C. (2019). Smart agriculture to increase farmers profitability using internet of things. *Indian Journal of Science and Technology, 12*(8), 1–6.
7. Ayaz, M., Ammad-Uddin, M., Sharif, Z., Mansour, A., & Aggoune, E. H. M. (2019). Internet-of-things (IoT)-based smart agriculture: Toward making the fields talk. Special section on new technologies for smart farming 4.0: research challenges and opportunities, Vol. 7.
8. Channe, H., Kothari, S., & Kadam, D. (2015). Multidisciplinary model for smart agriculture using internet-of-things (IoT), sensors, cloud computing, mobile computing big-data analysis. *International Journal Computer Technology Applications.*
9. Naman, C., & Medhavi, M. (2019). Home automation with NoSQL and Node-RED through message queuing telemetry transport. In *5th International conference on intelligent computing and applications* (pp 427–434).
10. Nayyar, A., & Puri, V. (2016). Smart agriculture: IoT based smart sensors agriculture. In *The international conference on communication and computing systems.*
11. Sujoita Purohit, S. P. (2021). Digitization in Indian agriculture: Evolution from simple to smart farming. *Indian Journal of Economics and Development, 9*, 1–6.

12. Saiz-Rubio, V. & Rovira-Más, F. (2020). From smart farming towards agriculture 5.0: A review on crop data management. Agronomy MDPI.
13. Arun, C., & Sudha, K. L. (2012). Agricultural management using wireless sensor networks— a survey. In *2nd International Conference on Environment Science and Biotechnology IPCBEE* (Vol. 48).

Comparative Study of Optical Character Recognition Using Different Techniques on Scanned Handwritten Images

Anshika Singh and Sharvan Kumar Garg

Abstract Optical Character Recognition (OCR) is always a prominent area of research and has gained attention in academia and industries, and more advancements are being performed to improve accuracy and quality of text and images. OCR is a technique that converts the digital or optical image (which can be image of typed or printed document or scanned handwritten document or scene photo) into machine-encoded format. OCR takes an image containing text as input, scans the text character by character, analyzes it, and generates a text corresponding to the text in the image, thus reducing the storage size and making accessibility of data easy and faster. In this paper, we will be studying OCR using different techniques like Convolutional Neural Network, Recurrent Neural Network, pytesseract, Keras-OCR, EasyOCR and comparing their results on handwritten scanned images.

Keywords Optical character recognition · Convolutional neural network · Recurrent neural network · Pytesseract · Keras-OCR · EasyOCR

1 Introduction

Optical Character Recognition is a technique that automatically recognizes the characters existing in the digital images. Character Recognition is accomplished through feature extraction and classification steps. OCR is the most assuring technique in the area of pattern recognition and Artificial Intelligence (AI), used for conversion of handwritten words, letters, or characters into digital form that we can edit or search efficiently and store more optimally.

A. Singh (✉)
Department of Computer Science, Shaheed Rajguru College of Applied Sciences for Women, University of Delhi, Delhi, India
e-mail: anshika.research@gmail.com

S. K. Garg
Department of Computer Science and Engineering, Subharti Institute of Technology and Engineering, Swami Vivekan and Subharti University, Meerut, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_38

OCR is utilized in various industries in the dockets, such as in the supply chain, in the medical field to label medicines and other equipment, and to enter data for checks such as passports, invoices, receipts and bank documents, license plates, business cards. It is very efficient in banking, legal, health care, and supply chains, among many others [1]. Motor vehicle number plates are automatically recognized through optical recognition features; the system uses cameras connected to the internet to analyze the plates [2]. The merits of the application of OCR include searchability, editability, accessibility, storability, translatability, and backups. The system has proven to work efficiently for businesses modernizing to the digital era.

Each person had a different handwriting style like shape, size, tilting, etc. So, we can write a character in ways. So, we will be applying different techniques or algorithms that will automatically recognize the characters or text in an input image. OCR comprises the following steps: taking an input text in the form of some image, optical scanning of the image, preprocessing (skew detection and correction, noise removal, binarization, etc.), segmentation (character or word segmentation), feature extraction (structural, global transform features, etc.), classification (CNN, RNN, SVM, etc.), text recognition, and generating output [3]. They proposed an OCR system with a faster training neural network which was developed, and each recognition stage was assigned with a training period of a short time. The character passed through the network is selected, and a similarity check is conducted by contrasting the pixels of objects. Final result is selected from the output having the highest score; the rate of recognition technique in this model is higher than that in the conventional network approach. Study indicates that to date, there is not even a single algorithm language which achieves 100% accuracy; filtering the noise at the preprocessing part improves algorithm quality [4]. OCR is applied in Captcha programs which reduces hacking risks. The internet performs various economic tasks like booking, registrations, education, and payments, among many others. The system is used in online libraries and institutional repositories to collect, preserve, or air intellectual data [1]. OCR helps in reducing paperwork for translation in multiple languages consequently decreasing the amount of storage and easy accessibility [5]. OCR is applied to process insurance papers and health forms to claim the insurance and maintain patient records in the medical sector [6].

2 Different Techniques to Achieve Image Text Recognition

2.1 Convolutional Neural Networks (CNNs)

CNN is an algorithm of deep learning which is inspired by visual system and has its applications in the area of Natural Language processing (NLP). It accepts an image as input and allocates importance in the form of trainable parameters (weight and bias) to different objects/features in the image and distinguishes them from each other. CNN is analogous to human brain connectivity patterns of neurons. Each neuron

responds to a stimuli receptive field (a limited region of visual field). Entire visual area is covered by overlapping these fields.

An input image is represented as a matrix of pixel values having three channels in case of RGB scale, whereas a grayscale image has only one channel. CNN has different layers: Convolutional, ReLU, Pooling, Fully connected. In CNN, we compare the image piece by piece. These pieces are nothing but the features or filters. In the convolutional layer, we apply those filters on all possible positions on the image. Then, the features are aligned with the input image followed by multiplication of each pixel in the image and its corresponding pixel of feature, add them up. Then, divide the resultant by the total number of pixels in the feature, create the map, and set the filter values at that point. After this, move the filter to all possible positions and compare the feature values to find a match. Same procedure is followed for each filter and fed to ReLU layer. Rectified Linear Unit (ReLU) is a function that will activate node only when the input value is greater than a specific value of threshold, whereas if value of the input is less than or equal to 0, it will output 0. However, if the value of the input goes above a certain value of threshold, it becomes linear with dependent variable. All three layers having any negative values get eliminated in the ReLU layer. It is then fed to the Pooling layer which reduces the size of the image by applying the following steps: choose a window size and a step, move the window over the entire filtered image, and take a maximum value from each window. It is applied on all filters. We stack up these layers again to achieve more reduced matrix of pixels and finally fed to the Fully connected layer. Here, we take filters and reduced image and place them into a single list. We will find the elements in vector with high value. We sum up the values of those elements and compare them with those in the dataset. The value which is closer is the predicted character in the input image. This is how CNN works on input image.

CNN applies relevant filters to an image in order to capture spatial and temporal dependencies. It can be trained to better understand the complexity of an image. Hence, it is a good choice for applications of image classification, face recognition, speech recognition, scene labeling, text classification.

2.2 Recurrent Neural Networks (RNNs)

Unlike a feedforward neural network where inputs and outputs were independent, previous state output is fed into the current state in the Recurrent Neural network. RNN is suitable for sequential models or time-series data models and finds applications in the field of Natural Language processing, image captioning, machine translation, language translation, speech recognition, etc. For understanding sequential data, we take an example of Gmail; here, we write an email where we get edit suggestions like we type Thank and it will suggest you Thanks and Regards.

As its name says RNN is recurrent, the same task is performed for each element of a sequence with output dependent on prior computations. RNN applies the concept of "memory" (short-term memory) which holds the information of prior inputs for

finding the next output in sequence. RNNs can make use of information in long sequences, but ideally they can look back only a few steps [7].

RNN had a number of input nodes, hidden nodes (with feedback loop so that information can pass back multiple times to the same node, also called recurrent units), and output nodes. Recurrent units process information for a set of known number of timesteps (each processing of input through hidden nodes), applying the activation function to each hidden state and input for that timestep. Hidden nodes have three parameters in RNN: input's weight, hidden unit's weight, and a bias. RNN uses modified backpropagation, i.e., backpropagation in time (BPTT) which unfolds in time to train the weights. BPTT computes the gradient vector [8]. There are more variants of RNN: Gated Recurrent Units (GRUs), Long Short-Term Memory (LTSM), Bidirectional Recurrent Neural Networks (BRNNs) [9].

When we talk about CNN and RNN, we need a dataset to train the network, but there are some other tools like pytesseract, Keras-OCR, EasyOCR which have predefined libraries.

2.3 Pytesseract

Pytesseract is also known as Python-tesseract. It is a tool in Python for Optical Character Recognition (OCR). It recognizes text present inside the image. It is a wrapper class for Tesseract-OCR Engine provided by Google [10]. Pytesseract is used to detect binary images and extracting characters. In number plate recognition, it recognizes the text in color images and in gray images with accuracy 61% and 70%, respectively [11].

2.4 Keras-OCR

Keras-OCR provides end-to-end sequential training steps for building a new OCR models [12]. It is used to digitize modern libraries to code articles into various categories, analyze texts syntactically, text and speech annotation. It is used to process handwritten images and classify them to specific categories [13].

2.5 EasyOCR

EasyOCR consists of OCR library which can read short text. It can also read multiple languages simultaneously in case they are compatible together. EasyOCR makes use of font files and template matching algorithms together to recognize broken or connected characters or badly printed characters [14].

EasyOCR is applied in imaging invoices, which helps track financial records, preventing piling up lists of payments. The system scans checks and writings on it without the need to involve a human. The system simplifies data collection in agencies and organizations, making data handling and processing simple [15].

3 Proposed Work

Our motive is to apply all the above techniques to handwritten scanned images to recognize the text embedded and study their behavior. The text recognition from the image process includes various steps as shown in Fig. 1.

3.1 Preprocessing

The purpose of this process lies in obtaining better accuracy in text recognition to obtain a better text recognition rate. Input can be in the form of RCB or gray image with possibilities of non-uniform background or some watermarks. So, it starts with the image enhancement process, i.e., noise elimination, minimizing blurring, contrast improvement followed by skew detection and correction, then perform thresholding to eliminate any watermarks or noise to extract the information from

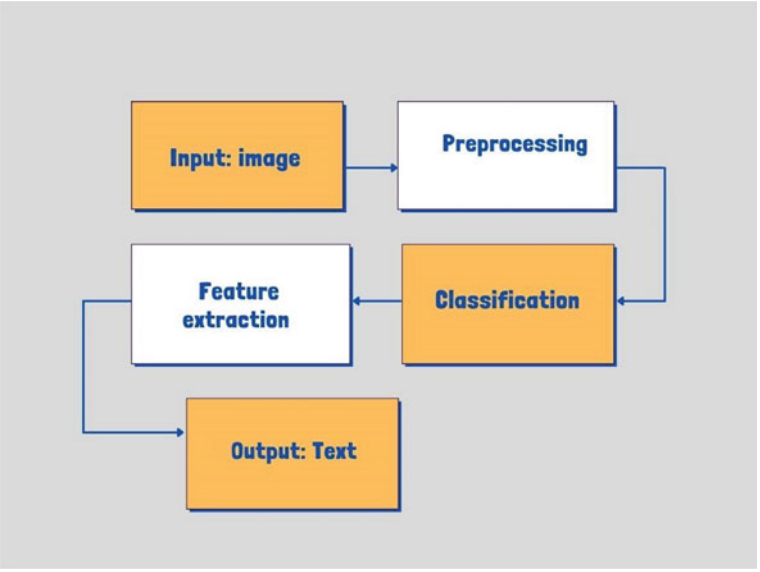


Fig. 1 Different steps in OCR

its background. Next step is segmentation for graphics isolation from text and separate individual characters, words, or sentences. After this, morphological operations to add pixels in case of eroded parts in characters present in preprocessed images. Processing of images is necessary for photography in feature classification. However, research should be done to improve digital imaging [16]. The use of these techniques normalizes images to a standard size, and this enhances image quality and recognition.

3.2 Feature Extraction

Extracting features is a vital step which eliminates redundancies from data. Accuracy of the classification can be improved by considering the most relevant features [17]. Features selected should be efficient enough to classify even among characters or symbols with close similarity. They must have different values for different classes and similar values for identical classes.

3.3 Classification and Text Recognition

Here, we implement CNN, RNN, pytesseract, Keras-OCR, EasyOCR on scanned image of handwritten text to recognize the embedded text in image and extract recognized text (Figs. 2, 3, 4, 5 and 6).

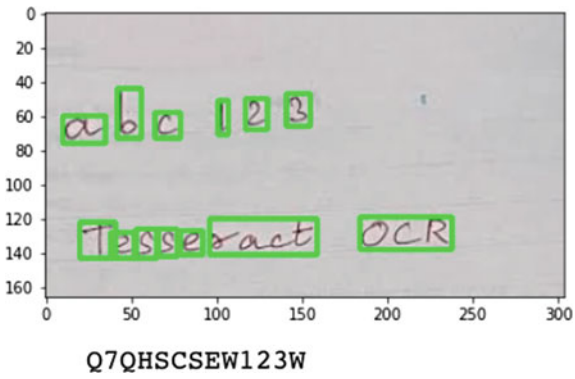


Fig. 2 OCR using CNN

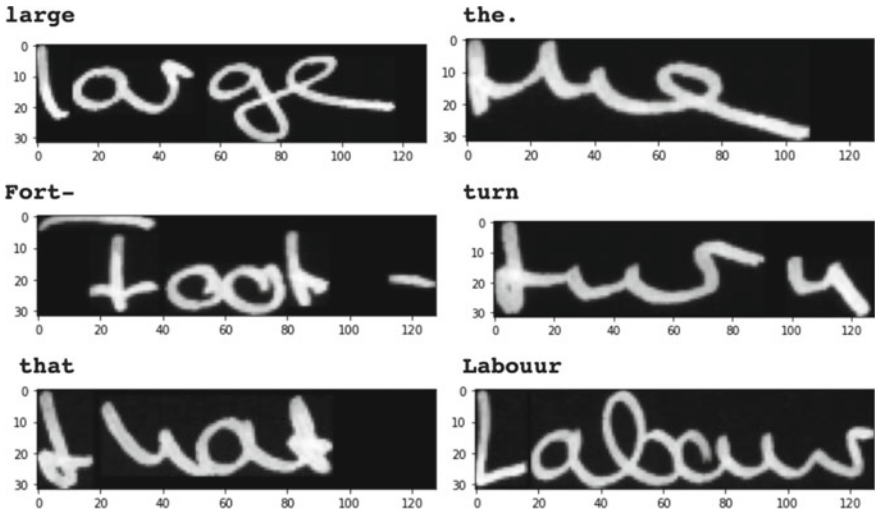


Fig. 3 OCR using RNN

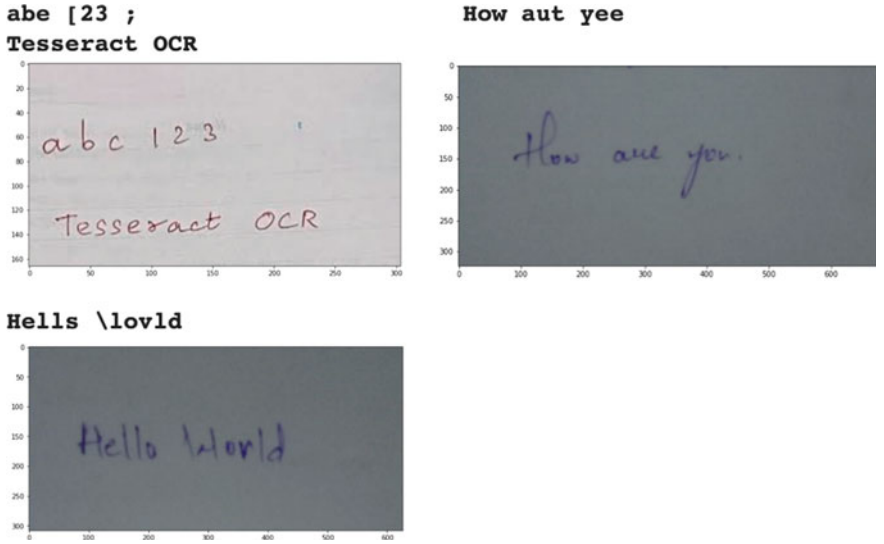


Fig. 4 OCR using pytesseract

4 Conclusion

We studied OCR using various techniques in this paper. OCR is divided into three major steps: preprocessing, feature extraction, and classification and text recognition. Here, in the classification step, we apply different techniques to classify the characters

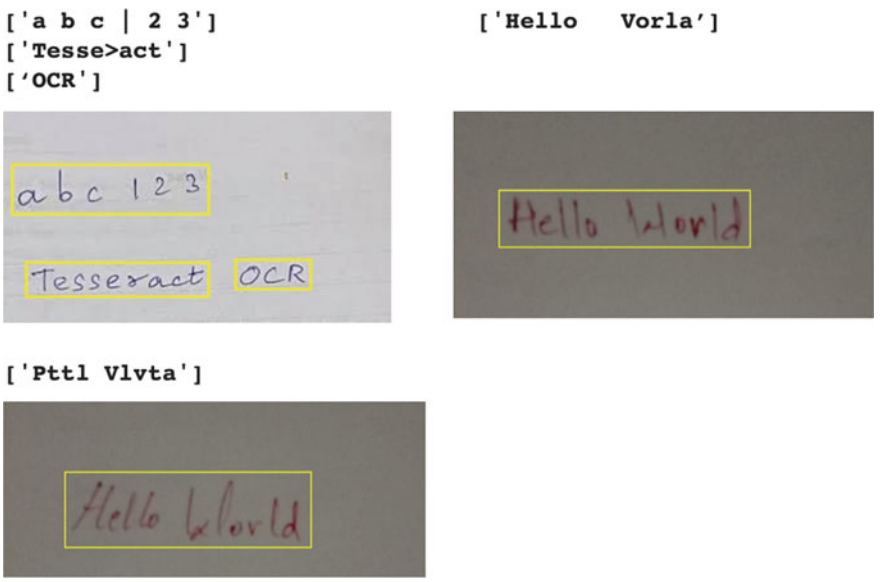


Fig. 5 OCR using EasyOCR

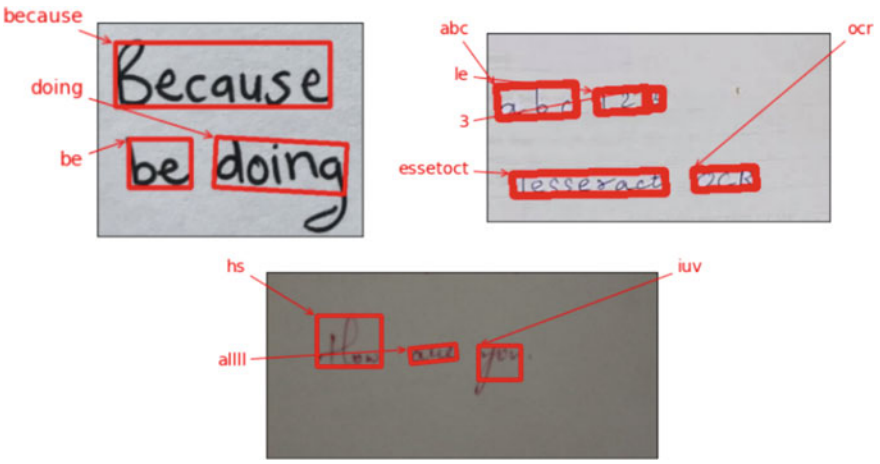


Fig. 6 OCR using Keras-OCR

or text embedded in an image. The merits of the application of OCR include searchability, editability, accessibility, storability, translatability, etc. OCR has several applications: number plate recognition to prevent vehicle theft, in Captcha programs to reduce hacking risks, data entry process of various business documents, for passport recognition and extraction of traveler information in airports, data entry for patient

treatment summary in hospitals, etc. CNN and RNN are more time-consuming techniques as compared to pytesseract, Keras-OCR, and EasyOCR. As the results show that CNN and EasyOCR give the least accuracy among others, Keras-OCR works better than pytesseract, EasyOCR, and CNN. RNN is the best suitable technique in case of text recognition as it works well in the deformed style of writing the characters. However, accuracy of CNN can be enhanced by using larger datasets. In case of usage of predefined libraries and datasets, pytesseract performs better than EasyOCR for handwritten images and images of high resolution. While EasyOCR perform well in case of images with organized text, RNN and Keras-OCR works better in case of unorganized and multi-font or style of text embedded in images.

References

1. Rao, N. V., Sastry, A. S. C. S., Chakravarthy, A. S. N., & Kalyanchakravarthi, P. (2016). Optical character recognition technique algorithms. *Journal of Theoretical and Applied Information Technology, 83*(2), 275–282.
2. Dalarmelina, N. D. V., Teixeira, M. A., & Meneguette, R. I. (2019). A real-time automatic plate recognition system based on optical character recognition and wireless sensor networks for ITS. *Sensors, 20*(1), 55.
3. Sabu, A. M., & Das, A. S. (2018). A survey on various optical character recognition techniques. *Conference on Emerging Devices and Smart Systems (ICEDSS), 2018*, 152–155.
4. Dasari, M. S. K., Mehta, S., & DD, M. D. S. (2020). Optical character recognition of devanagari script using machine learning-a survey. *Journal of Xi'an University of Architecture & Technology*, 593–599. ISSN (1006-7930).
5. Sumathi, C.P., Santhanam, T., & Devi, G. (2012). A survey on various approaches of text extraction in images. *International Journal of Computer Science and Engineering Survey, 3*(4).
6. Surana, S., Pathak, K., Gagnani, M., Shrivastava, V., M. T. R., & Madhuri, G. S. (2022). Text extraction and detection from images using machine learning techniques: a research review. In *2022 International Conference on Electronics and Renewable Systems (ICEARS)* (pp. 1201–1207).
7. WILDML—Stanford Canvas. https://canvas.stanford.edu/files/1090843/download?download_frd=1
8. Towards Data Science. https://towardsdatascience.com/rnn-recurrent-neural-networks-how-to-successfully-model-sequential-data-in-python-5a0b9e494f92
9. Machine Learning Mastery. https://machinelearningmastery.com/an-introduction-to-recurrent-neural-networks-and-the-math-that-powers-them/
10. Pytesseract 0.3.9. https://pypi.org/project/pytesseract/
11. Patel, C., Patel, A., & Patel, D. (2012). Optical character recognition by open source OCR tool tesseract: A case study. *International Journal of Computer Applications, 55*(10), 50–56.
12. Keras-ocr. https://keras-ocr.readthedocs.io/en/latest/
13. Gulli, A., & Pal, S. (2017). Deep learning with Keras. Packt Publishing Ltd.
14. Open eVision. https://documentation.euresys.com/Products/Open_eVision/Open_eVision_2_5/en-us/Content/03_Using_Open_eVision/D1_EasyOCR_-_Reading_Texts/EasyOCR_-_Reading_Texts.htm
15. Sai Rakesh Kamisetty, V. N., Sohan Chidvilas, B., Revathy, S., Jeyanthi, P., Anu, V. M., & Mary Gladence, L. (2022). Digitization of data from invoice using OCR. In *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)* (pp. 1–10).

16. Alkoffash, M. S., Bawaneh, M. J., Muaidi, H., Alqrainy, S., & Alzghool, M. (2014). A survey of digital image processing techniques in character recognition. *International Journal of Computer Science and Network Security (IJCSNS), 14*(3), 65.
17. Arif, M., Hassan, H., Nasien, D., & Haron, H. (2015). A Review on Feature Extraction and Feature Selection for Handwritten Character Recognition. International Journal of Advanced Computer Science and Applications. 6(2).

Deep Learning Models in EEG Signals: Comparative Analysis

Awwab Mohammad, Farheen Siddiqui, and M. Afshar Alam

Abstract The main issue in EEG-based brain mapping analysis is the feature extraction process of EEG signals. The features which are extracted from the EEG signals are then used for classification. A brain-related medical diagnosis can be done through a sufficient amount of unique features. Many sets of features are used for the classification of EEG signals like autoregression, Energy Spectrum Density, Energy Entropy, and Linear Complexity. Here, different subjects or tests can be identified by features of different discriminative powers. Presently, architectures and training paradigms have proven to be hard to get which show significant compelling results compared to conventional methods. Still, there are a lot of scopes to get new classification methods of EEG signals by using deep learning which might later become well known. This study explores various existing deep learning methods for classification and feature extraction depending on their performance and accuracy.

Keywords ANN · BCI · Electroencephalography (EEG) · Electrooculogram (EOG) · Fast compression residual convolutional neural networks (FCRes-CNNs) · K-Nearest Neighborhood (KNN) · Local gradient pattern (LGP) · Local graph structure (LGS) · Local neighbor descriptive pattern (LNDP) · Least square SVM (LS-SVM) · Multilayer perceptron (MLP) · Random forest (RF) · Sparse representation (SR) · Variational mode decomposition (VMD) · Wavelet transform (WT)

A. Mohammad (✉) · F. Siddiqui · M. Afshar Alam
Department of Computer Science and Engineering, Jamia Hamdard, New Delhi 110062, India
e-mail: awwabmohammad@yahoo.com

F. Siddiqui
e-mail: fsiddiqui@jamiahamdard.ac.in

M. Afshar Alam
e-mail: aalam@jamiahamdard.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_39

1 Introduction

Machines can be made to learn by themselves by studying their former experiences which help in reducing the amount of effort needed by utilizing machine learning. The most used approaches are supervised learning, unsupervised learning, and semi-supervised learning. An expert is required in the machine learning domain that can use the preconditioned feature extraction techniques. Moreover, the main difficulty is the selection of useful features for solving a problem from a difficult task. The task of gathering useful features from raw input data for feature selection can be avoided by the use of deep learning techniques for a particular problem. Using multiple processing layers that can adapt to different features of datasets and multiple levels of abstraction makes up a deep learning model. To learn many specific features, a network of multiple levels is needed. Different applications like image recognition, speech recognition, language translation, natural language understanding, signal processing, face recognition, etc., reap the benefits of obtaining reassuring results by using deep learning.

To gain any useful outputs for computers to read, we need to measure and process brain activities in a familiar BCI workflow. EEG is used to measure the electrical activities of various regions of the brain [1–3].

For detecting disorders in the brain, the most frequently and capable technique used is a combination of neuronal firing in the brain which is known as EEG signals [4]. The testing and working on EEG signals are excessively strenuous and tiresome; therefore, an automated computer-aided diagnostic technique is needed to be developed. We obtain poor performance when we classify patterns based on sampled waveforms. Therefore, to increase the performance of classification, we need to extract only the characteristic features of the data. We need to obtain all of the sources, properties, and features of the data to get a suitable classifier. The four most familiar sets of features are time-domain features, frequency-domain features, wavelet features, and cepstral features. The EEG data recorded can be grouped under time-domain analysis (voltage versus time) and frequency-domain analysis (power versus frequency). For EEG-based communication, both of these analysis forms can be used [5–8]. The changes that occur in the magnitude of voltage can be used as a command in the time domain. These changes in voltage are indicated as an evoked potential or evoked response. The changes that occur in the amplitude of the signal in a specific frequency band can also be used as commands in the frequency domain and are known as a rhythm. For narrowband signals like a sine wave in the frequency domain, we can use the Fast Fourier transform. For any real-time applications, this method proves to be the best in terms of speed as compared to other methods. The main disadvantage of this model is that it cannot be used for analyzing short EEG signals because of poor spectral estimation. Wavelet transforms in both time and frequency domains have a fluctuating window size, and these wavelet transforms become broader at low frequencies and narrower at higher frequencies. For the study of abrupt and brief signal changes, WT is the most appropriate method. This method requires a fitting parent wavelet. To achieve favorable frequency resolution in the

frequency domain, we use AR. It yields improved frequency resolution and curbs the damage of spectral issues. The AR spectral estimation model should be carefully chosen because if an incorrect model is used it will yield poor spectral estimation [9–11]. Therefore, a good classification algorithm should be designed for a classification model.

2 Related Work

In 2020, Turker et al. [1] developed a novel feature extraction network for classifying the EEG signal based on local graph structure. They have produced an ensemble framework of LGS with logically extended LGS, symmetric LGS, vertical LGS, vertical symmetric LGS, zigzag horizontal LGS, middle LGS, and zigzag vertical LGS. Further, the authors have created a new network for extracting features integrating the discrete wavelet transform with these LGS methods. In the proposed framework, they have utilized the 2D-DWT for performing the pooling and the feature extraction was accomplished using the LGSs. The feature reduction was made possible by employing both the neighborhood component analysis (NCA) and the relief. Their technique was achieved by enhancing the classification accuracy that was exhibited by the experimental outcomes with the Bonn dataset.

In 2018, Shanzhi et al. [12] developed a method to extricate the characteristics from the EEG data with reduced noise in the signal. In the "graph spectrum domain", the rhythm-based graph components were extracted with the aid of the graph filter. Further, with the assistance acquired from the singular spectrum analysis, the authors have extracted the desired rhythm from the graph filtered signal. The simulated EEG signals were verified using the Markov process amplitude.

In 2018, Leilei et al. [5] projected an EEG feature extraction approach to multivariate EEG signals by deploying recurrent autoencoders. They acquired the EEG features by encoding the EEG signals with Echo State Network, and further, the EEG signals were recovered by decoding them. Hence, the proposed model was referred to as an Echo State Network or FE-ESN. Further, the effectiveness in terms of both the clustering as well as classification of the proposed FE-ESN was evaluated.

In 2019, Rahman et al. [4] developed an innovative method for emotion recognition from the highly efficient BCI system via EEG signal. Here, the feature extraction was accomplished by hybridizing the concepts of both principal component analysis (PCA) and t-statistics. The signal dimensionality was reduced for implementing spatial PCA and based on the t-statistical inferences; the suitable features were selected among the classes. The evaluation of the proposed model was done with the SEED dataset (SJTU Emotion EEG Dataset), and the classified extracted features were done using the SVM, ANN, LDA, and KNN.

In 2019, Aymen et al. [13] developed two new spectral estimators for implementing BCI from the EEG signals for "sturdy against non-Gaussian, non-linear and non-stationary signals". The proposed two new spectral estimators made use of the L1-norm regularization as well as quantile regression in spectrum level estimate the

order to motor imagery (MI)-related EEG. The MI-related EEG dataset was gathered from the project done with BCI motor imagery. Their results show that the newly presented methods increase MI's ability to classify data.

In 2017, Roozbeh et al. [14] projected a robust feature extraction approach in BCI for obtaining features from the signals. In the proposed model, the discriminatory information was extracted by utilizing the PCA and the cross-covariance method. The optimum feature set was identified for characterizing the mental state signal distribution, and this was done by deploying the "correlation-based variable selection with the best first search". For verification, they used three different machine learning approaches to see how robust the suggested feature extraction was. They were MLP, LS-SVM, and LR.

In 2017, Abeg and Haider [15] introduced two efficient feature extraction methods LNDP and 1D-LGP to classify epileptic EEG signals. They utilized various classifiers for classifying the non-seizure signals as well as the epileptic seizure such as NN, SVM, DT, and ANN. To obtain the final accuracy, they used ten-fold cross-validation method.

In 2020, Huang et al. [16] presented a method for classifying based on sparse representation (SR) and fast compression residual CNNs. The "common spatial pattern approach" is used to acquire the EEG signal's properties. These attributes are used to build a redundant dictionary with a sparse representation thereafter. Lastly, the FCRes-CNN model was used to import the EEG-type samples. When compared to the sparse representation classification (SRC) technique, the experimental findings demonstrate that the classification method performs better.

In 2020, Saini et al. [17], for mental task identification and classification, suggest a lightweight 1D-CNN architecture. The robustness of the suggested architecture is assessed using artifact-free and artifact-contaminated EEG signals from publicly accessible datasets, namely "Keirn and Aunon (K) database, the EEGMAT (E) database, and the in-house (R) database". The suggested architecture provides the greatest subject-independent classification accuracy in database K, with 99.7% and 100% for multi-class classification and pair-wise mental tasks classification, respectively. Database E shows 99% and the recorded database R shows 98% classification accuracy.

In 2020, Garcia-Moreno et al. [18], to recognize EEG motor images for the left and right hands, introduced a classifier based on CNN and LSTM techniques. In the suggested model, they address the impact of utilizing raw data rather than data separated into frequency ranges. The validation accuracy in the right categorization was 96.5%, according to their findings.

In 2019, Zhang et al. [19] work on EEG time-series information by using an LSTM network with an attention mechanism in their paper, which leads to a unique method for classification of left/right-hand movement. For this purpose, the EEG signals are analyzed for a variety of temporal and frequency-domain properties, which are then utilized to train an LSTM network to complete the classification job. They use the EEG movement dataset to conduct extensive tests and show that their suggested technique outperforms many standard approaches in both intra-subject and cross-subject validation schemes. In addition, they suggested an approach to analyze the

data collected by the sensors and observe EEG topography to monitor the brain's active areas during the tests.

In 2020, Uyulan [20], to identify four separate MI tasks—left hand, right hand, tongue, and foot motions, researchers suggested a hybrid technique that blends the 1D-CNN with the LSTM. After PCA-based artifact reduction, the temporal representation of MI tasks is retrieved using a hybrid deep learning network. Current techniques of recognizing EEG and EOG combined motor imagery tasks do not perform as well as the one shown here does, according to ten-folded CV findings.

In 2021, Varshney et al. [21], using multi-channel EEG data, offer a computational technique for classifying mental arithmetic-based cognitive burden activities. The method calculates several entropy aspects from each channel of the EEG signal, including approximation entropy, sample entropy, permutation entropy, dispersion entropy, and slope entropy. These characteristics were incorporated into "LSTM, bidirectional LSTM, and gated recurrent unit (GRU)" RNN models for automated categorization of mental arithmetic-based cognitive burden tasks. The method was tested using a publicly accessible EEG database based on mental arithmetic tasks.

3 Techniques and Challenges of Different Classification Methods

An electroencephalogram signal is used to fix the disorder of the brain. It is the most frequently used method which is a collection of brain neuronal firing used to identify various mental tasks and in treating epilepsy too. The method of artificial EEG inquiry by a physician is the traditional method to identify different mental tasks. However, the observable study of EEG is immensely laborious and tedious. But still, different neurologists produce diverse and experimental results [4]. So, different diagnostic techniques which are computer automated should be proposed which can help the physicians in identifying and classifying different mental tasks and therefore play a decisive role in the prediction purposes. The table tabulates the classification accuracies and challenges of the existing works. In an LGS-based lightweight and cognitive feature extraction network [1], the classification accuracies are higher, and at the same time, the computational complexity is also higher. The adaptive graph spectral analysis approach could be possibly used to automatically detect seizures in the EEG signal. They should increase the difference between TPR (sensitivity) and FPR (1-specificity). The Echo State Network can work on both single- and multi-channeled EEG signals [5]. Apart from this, the feature extraction procedure results in substantial data loss. Further, the PCA and t-statistical approach provides consistent classification performance but is unfeasible to classify only three class problems. The Lasso quantile period gram is sturdy against non-Gaussian, nonlinear, and non-stationary signals. In this approach, we need to improve the classification performance for much more significant performance. PCA-aided cross-covariance scheme [14] yields the utmost accuracy as well as higher computational complexity.

Moreover, LNDP and 1D-LGP [15] have achieved better classification accuracy and high total computational time. The variational mode decomposition (VMD) and autoregression (AR) show excellent robustness, but take higher time for optimal selection of values (Table 1).

4 Conclusion and Future Scope

To get a reliable system so that we can extract features that depend on the type of data, goal, and application, we have to explore different machine learning models. A single dataset can provide us with various features. To train a dependable system, we need to do hundreds of experiments. Likewise, if we need to build up a good BCI system, we have to go through a huge number of EEG datasets. This creates a big problem when we have to work on vast amounts of data and especially for real-time applications. Therefore, in this paper, we studied different feature extraction models to find the best classification performance and accuracies in EEG signals. The work of Abeg Kumar Jaiswal and Haider Banka used various machine learning classifiers like NN, SVM, ANN, and DT, out of which ANN classifier achieved the best classification accuracies. The best classification accuracy achieved in a CNN network was found in the work of Manali Saini et al., who created a lightweight 1D convolutional neural network with accuracies of 99.7% and 100% for multi-class classification and pair-wise. Abhishek Varshney et al. used RNN models such as LSTM, BLSTM, and GRU-based RNN classifiers to get the best classification accuracies of 99.81%, 99.43%, and 99.81%. Caglar Uyulan proposed an LSTM and CNN-based hybrid method for classification with an excellent classification accuracy of 95.62%. In the future, we would propose a model for EEG-based emotion recognition, which will then be implemented in MATLAB. The performance of the proposed work will be evaluated in comparison to that of other traditional models about a variety of performance criteria including, but not limited to, accuracy, precision, specificity, and sensitivity.

5 Summary

- The main issue in EEG-based brain mapping analysis is the feature extraction process of EEG signals.
- Here, different subjects or tests can be identified by features of different discriminative powers.
- The task of gathering useful features from raw input data can be avoided by the use of deep learning techniques.
- But, we need to improve the classification performance for much more significant performance.
- In this paper, we studied different feature extraction models to find the best classification performance and accuracies in EEG signals.

Table 1 Comparative table of various deep learning models

S. no.	Author	Methodology	Features	Challenges
1	Tuncer et al. [1]	LGS-based lightweight and cognitive feature extraction network	• Higher success rate • They achieved 98.67% accuracy	• High computational complexity
2	Xu et al. [12]	Adaptive graph spectral analysis technique	• Able to avert the mixing of components with complex structures in EEG signals • It shows enhanced accuracy of 95%	• Higher time delay • When it comes to TPR (sensitivity), there is not much difference between it and FPR (1-specificity)
3	Sun et al. [5]	Echo State Network or FE-ESN	• This method can work on single- and multi-channeled EEG signals • Low computational complexity • They achieved 98.33% accuracy	• The extraction process causes a vast loss of critical data • Specific tasks can only be classified
4	Rahman et al. [4]	PCA and t-statistical approach	• Provides consistent classification performance • In terms of classification accuracy, the T-test is the most accurate method • They attained classification performance by using ANN and SVM classifiers of 86.57% and 85.85%, respectively	• Feature extraction time is higher • Requires drastic improvement in classification accuracy • Unfeasible to classify only three class problems
5	Meziani et al. [13]	Lasso quantile periodogram	• They achieved a classification performance of 80% using the KNN classifier and 75% using the RF classifier	• Need to improve the classification performance • Computation time needs to be optimized • A necessity for ideal parameters

(continued)

Table 1 (continued)

S. no.	Author	Methodology	Features	Challenges
6	Zarei et al. [14]	PCA-aided cross-covariance scheme	• Yields the utmost classification accuracy of 99.66% for both MLP and LS-SVM classifiers • Obtained the best overall results	• High computational complexity
7	Abeg and Haider [15]	LNDP and 1D-LGP	• 99.82% and 99.80% accuracy, respectively, utilizing an ANN classifier for LNDP and 1D-LGP	• High total computational time
8	Jing-Shan Huang et al. [16]	SR and FCRes-CNN	• The average accuracy of 98.82%	• Overfitting • Loss of original signal information when pooling layer used
9	Manali Saini et al. [17]	Lightweight 1D convolutional neural network architecture	• Database K: multi-class accuracy 99.7%, pair-wise accuracy 100% • Database E 99% • Database R 98%	• The use of just a few layers in a 1D CNN architecture in place of the many layers seen in a 2D or 3D architecture
10	F.M. Garcia-Moreno et al. [18]	Deep learning classifier based on CNN and LSTM techniques	• Classification accuracy of 96.5%	• The muse headband used in the experiment is difficult and awkward to wear in outdoor activities • Small sample size
11	Guangyi Zhang et al. [19]	LSTM network with attention mechanism for classification	• Classification accuracy for cross-subject scheme 83.2% • For intra-subject scheme 98.3%	• Their model would not be capable of early prediction or detection of hand movements because of the use of handcrafted features
12	Caglar Uyulan [20]	LSTM and CNN-based hybrid method for classification	• The hybrid model reached 95.62% classification accuracy	• Because of the k-fold CV, the train splits are predefined

(continued)

Table 1 (continued)

S. no.	Author	Methodology	Features	Challenges
13	Abhishek Varshney et al. [21]	Many different RNN models are used in classification, including the following: the LSTM, BLSTM, and GRU	• Each RNN classifier yielded classification accuracy scores of 99.81% (LSTM), 99.43% (BLSTM), and 99.81% (GRU-based RNN)	• Evaluating five entropy measures from each multi-channel EEG frame • Using three RNN variants and four classification strategies such as BMAC, GMAC, BFMAC, and DMAC

References

1. Turker, T., Sengul, D., Fatih, E., & Abdulhamit, S. (2020). A novel ensemble local graph structure-based feature extraction network for EEG signal analysis. *Biomedical Signal Processing and Control, 61*.
2. Dong, W., Peng, L., Xiaoli, L., Zhenhao, W., & Shimin, Y. (2020). The feature extraction of resting-state EEG signal from amnestic mild cognitive impairment with type 2 diabetes mellitus based on feature-fusion multispectral image method. *Neural Networks, 124*, 373–382.
3. Wenwen, C., Hong, W., Guanghui, Y., & Chong, L. (2020). An EEG based familiar and unfamiliar person identification and classification system using feature extraction and directed functional brain network. *Expert Systems with Applications, 158*.
4. Rahman, M. A., Hossain, M. F., Hossain, M., & Ahmmed, R. (2019). Employing PCA and t-statistical approach for feature extraction and classification of emotion from multichannel EEG signal. *Egyptian Informatics Journal*.
5. Leilei, S., Bo, J., Haoyu, Y., Jianing, T., Chuanren, L., & Hui, X. (2018). Unsupervised EEG feature extraction based on echo state network. *Information Sciences.*
6. Ricardo, R. -A., Jos, A. O. -L., Ivan, O. -P., & Susana, S. -U. (2020). Feature extraction from EEG spectrograms for epileptic seizure detection. *Pattern Recognition Letters, 133*, 202–209
7. Rahman, M. M., & Fattah, S. A. (2020). An efficient feature extraction scheme for classification of mental tasks based on inter-channel correlation in wavelet domain utilizing EEG signal. *Biomedical Signal Processing and Control, 61*.
8. Poomipat, B., Apiwat, L. -U., Krisnachai, C., & Jitkomut, S. (2020). A review of feature extraction and performance evaluation in epileptic seizure detection using EEG. *Biomedical Signal Processing and Control, 57*
9. Rajakumar, B. R. (2013). Impact of static and adaptive mutation techniques on genetic algorithm. *International Journal of Hybrid Intelligent Systems, 10*(1), 11–22.
10. Swamy, S. M., Rajakumar, B. R., & Valarmathi I. R. (2013, December). Design of hybrid wind and photovoltaic power system using opposition-based genetic algorithm with cauchy mutation. In *IET Chennai fourth international conference on sustainable energy and intelligent systems (SEISCON 2013)*, Chennai, India.
11. Rajakumar, B. R., Aloysius, G. (2012). A new adaptive mutation technique for genetic algorithm. In *Proceedings of IEEE international conference on computational intelligence and computing research (ICCIC)*, pp. 1–7, 18–20 Dec 2012, Coimbatore, India.
12. Shanzhi, X., Hai, H., Linhong, J., & Peng, W. (2018) An adaptive graph spectral analysis method for feature extraction of an EEG signal. *IEEE Sensors.*
13. Aymen, M., Karim, D., Tarek, M., & Abdelghani, C. (2019). A Lasso quantile periodogram based feature extraction for EEG-based motor imagery. *Journal of Neuroscience Methods, 328.*

14. Roozbeh, Z., Jing, H., Siuly, S., & Yanchun, Z. (2017). A PCA aided cross-covariance scheme for discriminative feature extraction from EEG signals. *Computer Methods and Programs in Biomedicine*.
15. Abeg, K. J., Haider B. (2017). Local pattern transformation based feature extraction techniques for classification of epileptic EEG signals. *Biomedical Signal Processing and Control, 34*, 81–952.
16. Huang, J.-S., Li, Y., Chen, B.-Q., Lin, C., & Yao, B. (2020). An intelligent EEG classification methodology based on sparse representation enhanced deep learning networks. *Frontiers in Neuroscience, 14*, 808.
17. Saini, M., Satija, U., & Upadhayay, M. D. (2020). Light-weight 1-D convolutional neural network architecture for mental task identification and classification based on single-channel EEG. pp. 1–11.
18. Francisco, M. G. -M., Maria, B, -E., Maria, J. R, -F., Jose, L. G. (2020). A CNN-LSTM deep learning classifier for motor imagery EEG detection using a low-invasive and low-cost BCI headband. In *16th International conference on intelligent environments (IE)* (pp. 84–91).
19. Zhang, G., Davoodnia, V., Sepas-Moghaddam, A., Zhang, Y., & Etemad, A. (2020). Classification of hand movements from EEG using a deep attention-based LSTM network. *IEEE Sensors Journal, 20*(6), 3113–3122.
20. Uyulan, C. (2021). Development of LSTM&CNN-based hybrid deep learning model to classify motor imagery tasks. *Communications in Mathematical Biology and Neuroscience*, pp. 1–26
21. Varshney, A., Ghosh, S. K., Padhy, S., Tripathy, R. K., & Acharya, U. R. (2021). Automated classification of mental arithmetic tasks using recurrent neural network and entropy features obtained from multi-channel EEG signals. *Electronics, 10*(9), 1079.

Analytical Analysis on LS, MMSE and Modified Entropy-Based LS Channel Estimation Techniques for 5G Massive MIMO Systems

Shaik Nilofer, Praveen Kumar Malik, P. Manju, and Sumit Agarwal

Abstract Universal frequency division multiplexing (UFMC) has obtained a lot of interest in 5G wireless communication. In UFMC systems, the function of channel transfer of radio channel appears unequal in both time and frequency domains. Therefore, estimating a channel dynamically is important for the detection of UFMC signals. There are many estimation methods for UFMC systems. This paper investigates pilot-aided channel estimation techniques for UFMC systems. It is known that least square (LS) and minimum mean square error (MMSE) algorithms are effective channel estimation (CE) methods to produce accurate estimation output. We proposed a novel modified entropy-based least square (MELS) channel estimation method which is based on mean value of the transmitted vector to improve the estimation accuracy of the UFMC system. This paper also explains the analytical analysis of the LS, MMSE and MELS channel estimation techniques. The performance analysis of this channel estimation methods is done by using simulation results. The simulation results are implemented using MATLAB software. The results show that at high values of SNR, the MELS algorithm outperforms the LS and MMSE for both bit error rate (BER) and mean square error (MSE).

Keywords 5G · Analytical analysis · Least square (LS) · Minimum mean square error (MMSE) · Modified entropy-based LS (MELS)

S. Nilofer (✉) · P. K. Malik
Lovely Professional University, Paghwara, Punjab, India
e-mail: nilofershaik@gmail.com

S. Nilofer · P. Manju
BVRIT HYDERABAD College of Engineering for Women, Hyderabad, India

S. Agarwal
Pennsylvania State University, State College, Pennsylvania 16802, US
e-mail: sua347@psu.edu

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_40

1 Introduction

The fifth generation of wireless technology is 5G. It will provide a high speed, low latency and high capacity than the LTE 4G networks. It is the fastest and most robust technology the world has ever seen. A discussion about the benefits of 5G [1] is really about delivering life-changing technologies through next-generation networks, and it has been built it with these capabilities in mind—to do everything people will want to do. 5G Ultra-Wide band's (UWB) high speed, low latency and massive capacity could enable delivering drone, traffic control in connected systems and other applications to reach their full potential. The possibilities are virtually limitless, ranging from emergency response to global payments to next-generation gaming and entertainment. 5G UWB, which is currently available in select areas, will allow massive technology than previous technologies to connect to mobile networks, enabling the Internet of Things (IOT) on a very high scale. The most of connected IoT devices worldwide was estimated to be around 13.8 billion in 2021 and increases to 30.9 billion by 2025. 2 5G UWB will help to meet the required network bandwidth demands. The present LTE systems use the OFDM wireless communication for the transmission of the information. An OFDM signal is made up of a series of modulated carriers that are closely spaced. When any type of modulation is implemented to a carrier, sidebands spread out on either side. A receiver must be eligible to obtain the entire signal in order to actually demodulate the data. As a result, when signals travel close together, they must be separated by a guard band and evenly spread, so the recipient can distinguish them using a filter. The basic procedure of OFDM is shown in Fig. 1.

Although the sidebands of every carrier overlap, they can be received without interference since they are orthogonal to one another. The linearity of the OFDM transmitter and receiver systems is one of their requirements. Intermodulation distortion will interfere between the carriers if there is any nonlinearity. This will initiate unwanted signals, causing interference and impairing transmission orthogonality. The key features of OFDM are that the information stream is carried by multiple carriers known as subcarriers. Subcarriers are orthogonal to one another, and each symbol has a guard interval added to it to reduce channel delay spread and ISI. The reliability of the OFDM system depends on the use of CP. To protect OFDM signals from ISI, the cyclic prefix serves as a buffer region or guard interval. Even with

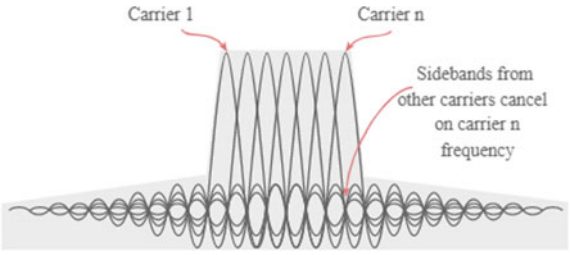


Fig. 1 Basic procedure of OFDM

much lower data rates transmitted by the multicarrier OFDM signal, this might be an issue in some situations. The CP serves two purposes. The CP acts as a guard interval, preventing ISI from the preceding symbol. It repeats the end of the symbol so that a frequency-selective multipath channel's linear convolution can be modelled as circular convolution, which can then be transformed to the frequency domain using a discrete Fourier transform. This method supports basic frequency-domain computation, such as CE and equalisation.

1.1 OFDM Advantages

Because of the numerous advantages it offers, OFDM is being used in numerous high data rate systems.

Immune to selective fading: Because OFDM splits the overall channel into numerous narrowband signals that have been impacted independently as flat fading sub-channels, it is much more resilient to frequency-selective fading than only one carrier systems.

Spectrum efficacy: A significant advantage of using similar overlapping subcarriers is that it tends to make efficient use of available spectrum.

Robust to ISI: Another advantage of OFDM is its resistance to intersymbol and inter-frame interference. This is due to low data rate on each sub-channel.

Robust to narrowband effects: With proper channel coding and interleaving, it is possible to restore symbols lost due to channel frequency selectivity and narrowband interference. Not all of the data have been lost.

Channel equalisation: OFDM has the advantage of making channel equalisation much simpler by using multiple sub-channels.

1.2 OFDM Disadvantages

While OFDM has indeed been broadly used, there are a few drawbacks to its use that must be acknowledged when evaluating its use.

High peak-to-average power ratio (PAPR): An OFDM signal has an amplitude variation similar to noise and a fairly large PAPR. This has an impact on RF amplifier efficiency because the amplifiers must be linear and accommodate large amplitude variations, which means that the amplifier cannot perform at a high efficiency level.

Sensitive to Doppler shift and drift: Another drawback of OFDM is that it is susceptible to Doppler shift and drift. Systems with a single carrier are less sensitive.

Because the CP retransmits previously transmitted data, it consumes system capacity and decreases overall data rate. As defined the OFDM system is sensitive to Doppler shifts, high out of band emission (OOBE) and high PAPR, the next-generation wireless communications are looking forward for different types of multi-carrier modulation (MCM) techniques. This paper provides information about the UFMC MCM technique which is best suitable for 5G systems.

To detect the data at the receiver end, the channel state information (CSI) [2] is required between each transmitter and the receiver. Therefore, CE is important in wireless communication system. Pilot-based CE is an important technique because of its simple implementation. To perform CE, the training symbols are inserted in data stream and receiver uses these symbols for detection. Pilot-based CE is one of the feasible methods in UFMC system. This training method is used widely for more steady performance because the entire system is divided into several number of independent subcarriers, which will have same bandwidth, and each subcarrier is to transmit its modulated signals. The modulated signals before transmission are filtered using Dolph–Chebyshev filter so that the intersymbol interference is reduced. This paper discusses analytical analysis of conventional LS and MMSE algorithms. This paper also discusses analytical analysis of proposed MELS CE algorithm. It also analyses all the CE methods using simulation results.

2 System Model

UFMC is an efficient, high data rate transmission technique for 5G mobile and wireless communication. UFMC presents the requirements of high bandwidth efficacy and enhanced implementation by the application of FFT and IFFT, reduction of intersymbol interference (ISI) by using Dolph–Chebyshev filter, robustness to multi-path fading and delay. The Dolph–Chebyshev filter reduces the insertion of cyclic prefix (CP) which is a main disadvantage of OFDM system which increases the length of the symbol.

A typical pilot-aided UFMC for 5G system is shown in Fig. 2. At the transmitter, the data symbols are grouped and mapped into multi-amplitude and multi-phase signals using QAM modulation. By using IFFT, the complex signals are modulated by N subcarriers.

Assuming N subcarriers with in UFMC system, all subcarriers are divided into A sub-bands, with each sub-band comprising a larger number of subcarriers successively. Each sub-band is comprised $K = N/A$ subcarriers. There are innumerable other techniques for splitting the subcarriers, such as random or average distribution. The S_a ($a = 1, 2, \ldots, A$) is the modulated OQAM symbols in the a^{th} sub-bands. It also includes Q_a subcarriers and is given as

$$\sum_{a=1}^{A} Q_a = N. \tag{1}$$

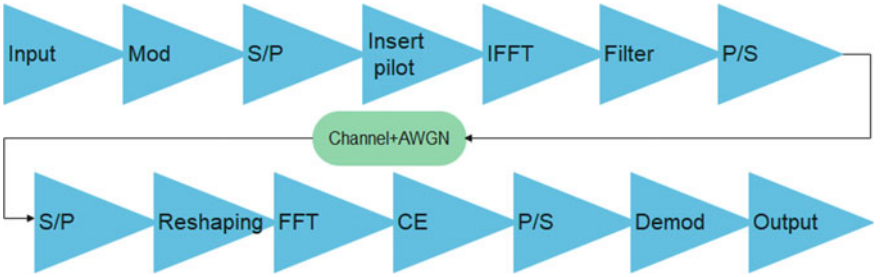


Fig. 2 Pilot-aided UFMC system

The modulated symbols in each sub-band are sent to an N-point FFT and then to the Dolphy–Chebyshev filter. In order to reject the effect of ISI in UFMC system, Dolph–Chebyshev filter is used. The function of Dolph–Chebyshev is constructed based on well-known polynomials of Chebyshev which is designed to solve the problem of designing a radio antenna which has optimal directional characteristics. The equation of Chebyshev polynomials is given as

$$T_p(y) = \begin{cases} \cos\left(p \cos^{-1} y\right) & \text{for } |y| \leq 1 \\ \cosh\left(p \cosh^{-1} y\right) & \text{for } |y| > 1 \end{cases}. \tag{2}$$

The recurrence relation of the defined polynomials is given as

$$\begin{aligned} &T_0(y) = 1, T_1(y) = y, \\ &T_p(y) = 2yT_{P-1}(Y) - T_{p-2}(y) \text{ for } p \geq 2. \end{aligned} \tag{3}$$

Figure 3 shows the window of Dolph–Chebyshev filter in time domain and frequency domain with the filter of 16 and side lobe attenuation of 40 dB.

These properties are derived from p-th order polynomial in y. $T_p(y)$ in the open interval of $(-1, +1)$ has p zeros and in the closed interval of $[-1, +1]$ has $p + 1$ extrema. $T_p(y)$ will oscillate between -1 and $+1$ for p in $[-1, +1]$. $T_p(y) > 1$ if y > 1 for large y, $T_p(y) \approx 2^{p-1} y^p$. The filtered messages out of each sub-band are added together to form X. As a consequence, the UFMC's transmitted signal is provided as

$$X = \sum_{a=1}^{A} \text{IFFT}(S_a) * f_a, \tag{4}$$

where f_a = filter coefficient for sub-band a. Using pilot-based CE technique with UFMC system improves the overall efficacy of the 5G wireless communication system.

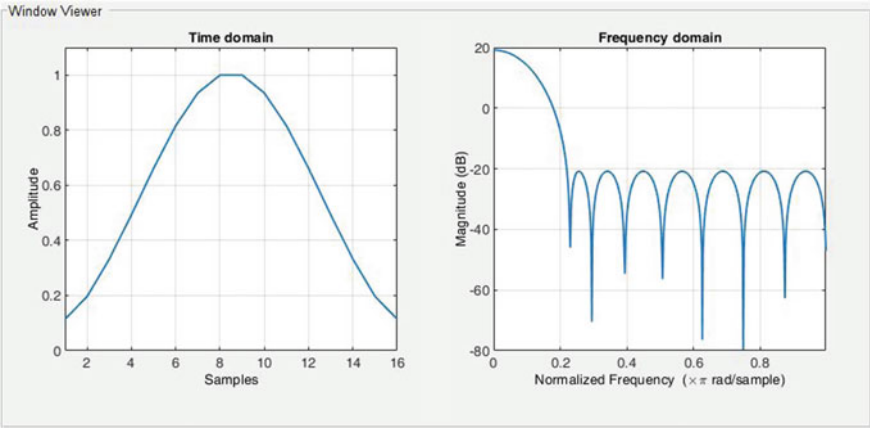


Fig. 3 Dolph–Chebyshev filter window in time and frequency domains

3 Mathematical Description of Pilot-Based CE

The CE is premised on pilots transferred at particular marks in the UFMC system's time and frequency grid. The channel attenuations are estimated by means of interpolations between these pilots where we assume that channel estimators can use all transmitted pilots in both of these instances. There is only one physical channel between both the transmitter and the receiver; therefore, channel attenuation frequency grid points are highly correlated, which can be used it for CE. Only pilots transmitted by that user can be used to estimate the attenuations for that user. Pilots are transmitted on certain positions in the time–frequency grid by using a two-dimensional generalisation of pilot symbol-assisted modulation of known symbols. The number of pilots to use is a trade-off between data rate and CE performance. Some of the conventional CE methods such as LS and MMSE analytical analysis is discussed along with the proposed CE technique.

3.1 Least Square CE

In mathematical statistics, the LS algorithm [3] is used to fit curves. When only considering the pilot signal in the UFMC system CE, the LS CE-transmitted signal can be expressed as

$$y(k) = h.x(k) + v(k), \tag{5}$$

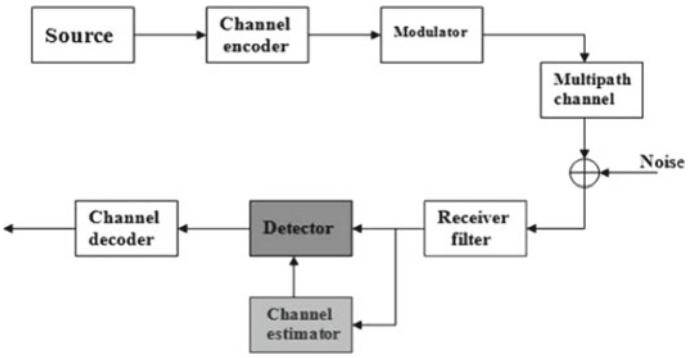


Fig. 4 LS channel estimation block diagram [3]

where $y(k)$—received symbol,
h—unknown channel coefficient,
$x(k)$—transmitted symbol,
$v(k)$—additive Gaussian noise.
The basic LS CE block diagram is given in Fig. 4.

The joint probability of the received signal with respect to the transmitted signal is given as

$$F_{Y(k)}(y(k)) == \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-1}{2\sigma^2}(y(k)-h.x(k))^2}, \tag{6}$$

where

$V(1), V(2), \ldots, V(N)$ are noise samples which are independent identically distributed (IID), $(y(1), y(2), \ldots, y(N))$ are independent and

$$\begin{aligned} &F_{Y(1)Y(2)\ldots Y(N)}(y(1), y(2), \ldots, y(N)) \\ &= F_{Y(1)}(y(1)).F_{Y(2)}(y(2)) \ldots F_{Y(N)}(y(N)), \end{aligned} \tag{7}$$

where $F_{Y(1)Y(2)\ldots Y(N)}(y(1), y(2), \ldots, y(N))$ are joint probability density function of observations and

$F_{Y(1)}(y(1)).F_{Y(2)}(y(2)) \ldots F_{Y(N)}(y(N))$ are product of individual PDF of $Y(1)Y(2) \ldots Y(N)$.

The function $F_{Y(1)}(y(1)).F_{Y(2)}(y(2)) \ldots F_{Y(N)}(y(N))$

$$\begin{aligned} &= \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-1}{2\sigma^2}(y(1)-h.x(1))^2} . \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-1}{2\sigma^2}(y(1)-h.x(1))^2 \ldots} \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-1}{2\sigma^2}(y(1)-h.x(1))^2} \\ &= \left(\frac{1}{2\pi\sigma^2}\right)^{\frac{N}{2}} e^{\frac{-1}{2\sigma^2}\sum_{k=1}^{N}(y(k)-h.x(k))^2} . \end{aligned} \tag{8}$$

Equation (8) is obtained as the function of the unknown parameter h, which is a likelihood function of $P(\overline{y},h)$, where h is a wireless channel coefficient. The observation vector is given as

$$\overline{y} = \begin{bmatrix} y(1) \\ \vdots \\ y(N) \end{bmatrix}. \tag{9}$$

The log likelihood of channel coefficient h is given as

$$\mathcal{L}\left(\overline{y};h\right) = \ln p(\overline{y};h), \tag{10}$$

where

$$\mathcal{L}\left(\overline{y};h\right) = \frac{-N}{2}\ln 2\pi\sigma^2 - \frac{1}{2\sigma^2}\sum_{K=1}^{N}(y(k) - h.x(k))^2. \tag{11}$$

To find maximum likelihood (ML) estimate, maximise $\mathcal{L}\left(\overline{y};h\right)$, then differentiate with respect to h and set equal to 0.

$$\frac{\mathrm{d}\mathcal{L}\left(\overline{y};h\right)}{\mathrm{d}h} = -\frac{1}{2\sigma^2}\sum_{K=1}^{N} 2(y(k) - h.x(k)).(-x(k)) = 0$$

$$\hat{h} = \frac{\sum_{k=1}^{N} x(k)y(k)}{\sum_{k=1}^{N} x^2(k)}. \tag{12}$$

After simplifying Eq. (12), the LS channel estimate is given as

$$\hat{h} = X^{-1}Y. \tag{13}$$

3.2 Minimum Mean Square Error CE

All of the pilots in this pilot-aided [4, 5] MMSE CE method are multiplexed with a wide range of data symbols in distinct subcarriers. The input symbols are linked directly to the output symbols. The computational complexity of the MMSE method is also low, whereas the computational complexity of the LS CE method is high. The key principle of the MMSE CE is to minimise the channel's MSE or BER. The MMSE block diagram is shown in Fig. 5.

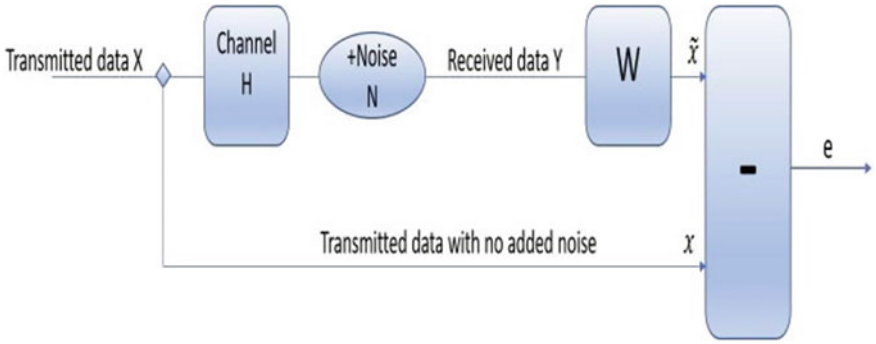


Fig. 5 MMSE channel estimation block diagram

The MMSE weight matrix is planned in such a manner that it produces a low MSE. The correlation between the approximated error and the signal which is received must fulfil the following condition in order to determine the weight matrix:

$$W.E\{e.Y^H\} = 0, \tag{14}$$

where $E\{.\}$ is the mathematical expression value and $(.)^H$ is the Hermitian transpose, which transposes the matrix that contains a combination of real and imaginary elements.

From the above equation,

$$E\{e.Y^H\} = 0, \tag{15}$$

$$E\{(WY - X).Y^H\} = 0, \tag{16}$$

$$E\{WYY^H - XY^H\} = 0, \tag{17}$$

$$E\{WYY^H\} - E\{XY^H\} = 0, \tag{18}$$

$$WE\{YY^H\} - E\{XY^H\} = 0. \tag{19}$$

By solving above equations, we get

$$W = E\{XY^H\}.E\{YY^H\}^{-1}, \tag{20}$$

where $E\{XY^H\} = R_{XY}$ is the cross-correlation of matrix X and Y, and $E\{YY^H\}$ is the autocorrelation of the matrix Y.

Assume that there is no correlation between transmitted data and noise, then

$$E\{X.n^H\} = 0 \,\&\, E\{n.X^H\} = 0. \tag{21}$$

To solve weight matrix W from equation,

$$R_{YY} = E\{YY^H\} \tag{22}$$

$$= H(P.I)H^H + \sigma^2.I, \tag{23}$$

where P is the power of the transmitted signal, σ is the Gaussian additive channel noise with variance and I is the identity matrix. H is the channel coefficient.

$$R_{XY} = E\{XY^H\} \tag{24}$$

$$= (P.\mathrm{I})H^H. \tag{25}$$

The weight matrix for MMSE estimators is derived from equations.

$$W = E\{XY^H\}E\{YY^H\}^{-1} \tag{26}$$

$$= H^H\left(HH^H + \frac{\sigma^2}{P}.I\right)^{-1}. \tag{27}$$

By using equation, the baseline algorithms can be written as

$$H_{\mathrm{MMSE}} = H^H\left(HH^H + \frac{\sigma^2}{P}.I\right)^{-1} H_{\mathrm{LS}}. \tag{28}$$

3.3 Modified Entropy-Based LS CE

The entropy-based method estimates antennas based on information transmitted to and from other antennas. As a result, for MIMO-UFMC, the LS CE algorithm with modified entropy is proposed. Figure 6 depicts the UFMC system model with the proposed channel estimation. The UFMC systems are able to be used for asynchronous transmission.

Let P represents the transmitter node and T represents the receiver node, both of which have N transmitter antennas and M receiver antennas. Because node P has N antennas, the received signal is given as

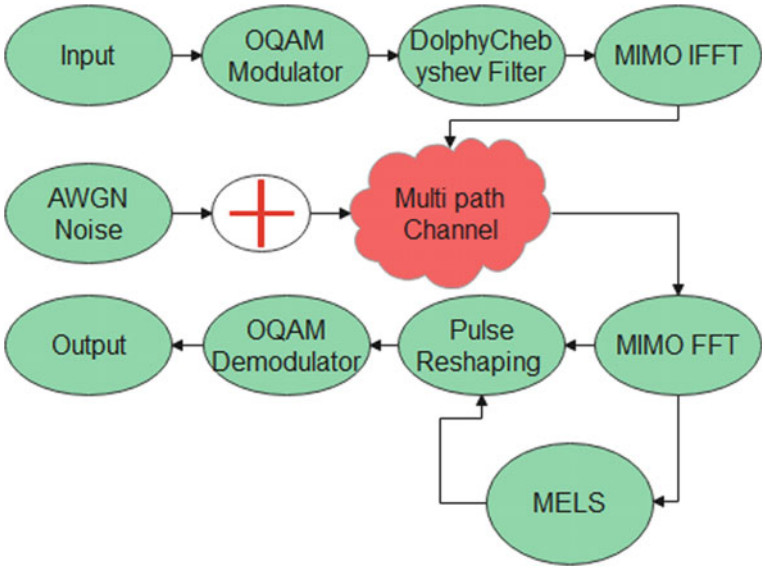


Fig. 6 MELS channel estimation for UFMC system

$$Y_p = S_p h_1 + S_t h_2 + F\widetilde{n_p}, \tag{29}$$

where S_p and S_t = pilot matrix that are known at the receiver end.

h_1, h_2 = channel matrices' estimate.

Therefore, the received signal equation is rewritten and is given as

$$Y_p = Sh + F\widetilde{n_p}. \tag{30}$$

In modified entropy, the sum of all obtained inputs must be determined by calculating first. The mean is later calculated based on the modulation order of the signal. The modified entropy is denoted by

$$S^{\theta} = \frac{X_1 + X_2 + \cdots + X_p}{M}, \tag{31}$$

where M = modulation order,

$X_1 + X_2 + \cdots + X_p$ = summation of the received inputs at the receiver.

Finally, the LS estimate after the modified entropy S^{θ} of the received signal is given as

$$\hat{h} = S^{\theta}\left(X^{-1}Y_p\right), \tag{32}$$

where S^{θ} = modified entropy of the S.

The BER and MSE are important considerations for any wireless communication system design. At the receiver end, the BER assessment of MIMO-UFMC in additive white Gaussian noise is obtained. In UFMC, each subcarrier is filtered using a Dolphy–Chebyshev filter [6], and each sub-band must perform the filter's inverse process. The noise variance of the UFMC system's a-th subcarrier in the ith sub-band is given as

$$\sigma_a^2 = \frac{\sigma_n^2}{|r_k^2|}, \tag{33}$$

where r_k = equivalent response of the filter related to kth subcarrier,

σ_n = Gaussian white noise variance of AWGN.

Finally, the BER of UFMC [7] with M-QAM under AWGN channel for the proposed CE is given as

$$P_e = \frac{1}{AI} \sum_{a=1}^{A} \sum_{i=1}^{I} \frac{2\left(\sqrt{M}-1\right)}{\sqrt{M}\log_2\sqrt{M}} Q * \sqrt{\frac{6E_b}{N_0}|r_k|^2}.\frac{\log_2\sqrt{M}}{M-1}, \tag{34}$$

where A = total number of subcarriers,

I = total number of sub-bands.

The sub-bands within the subcarriers of the entire band don't make UFMC an orthogonal waveform. The suggested CE with UFMC has a lower overall average BER.

The MSE of MELS CE for MIMO-UFMC is given as

$$P_{\text{MSE}} = \left\{S^{\theta} F \tilde{n}_p^2\right\}. \tag{35}$$

4 Simulation and Results

Table 1 lists the simulation parameters for the CSI performance evaluation.

BER and MSE are the two parameters used it to estimate system performance. The MSE is a metric that calculates the average square of the error. The MSE is calculated as the difference between the estimated and original channel CSIs. CSI is calculated for each pilot sub-channel. MSE is used to quantify the uncertainty in channel estimation. Another important parameter that characterises channel performance is BER. The number of bits altered to the transmission medium per second to use a digitally modulated signal is defined. When the probability of error is lowered while predicting a channel, the BER reduces, working to improve system performance.

Figure 7 shows that the proposed MELS technique for MIMO-UFMC systems does have a lower BER than conventional LS and MMSE [8, 9] techniques. When the BER is reduced, the system's performance improves. As a result, the proposed

Table 1 Channel estimation technique simulation parameters

S. no.	Simulation parameters	Numbers
1	Subcarriers	1024
2	Bits per subcarrier	8
3	Modulation	OQAM
4	Modulation order	256
5	Number of taps	3
6	SNR (dB)	15
7	Number of iterations	25
8	Filter length	16

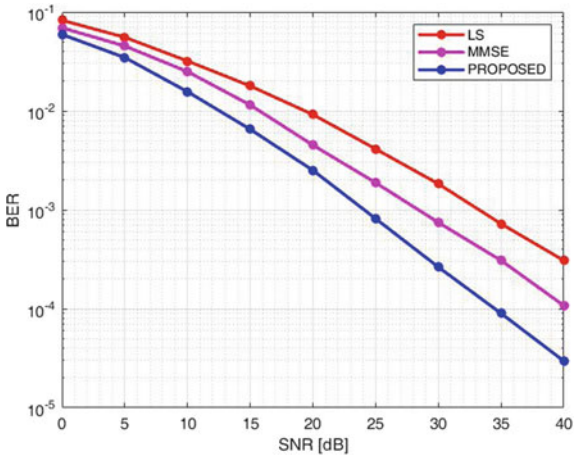


Fig. 7 BER versus, SNR for LS, MMSE and MELS

channel estimation method outperforms the existing similar channel estimation methods.

Figure 8 indicates that the proposed MELS technique reduces MSE for MIMO-UFMC systems when compared to conventional LS and MMSE techniques. MSE is a linear estimation method that is useful in statistical learning. Increasing the MSE values improves system performance. When compared to previous existing methods, the proposed channel estimation method, in conjunction with the UFMC technique, offers a low MSE value. The conventional CE methods described above are used in conjunction with the UFMC MCM technique.

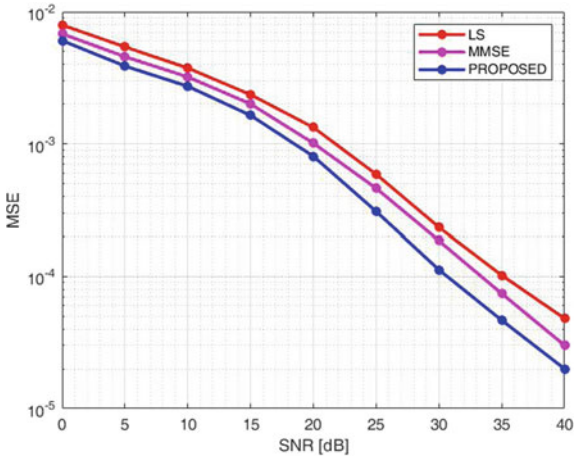


Fig. 8 MSE versus SNR for LS, MMSE and MELS

5 Conclusion and Future Scope

The purpose of this paper is to glance into pilot-aided channel estimation techniques for UFMC systems. The LS and MMSE algorithms are well-known for producing accurate CE output. To improve the estimation accuracy of the UFMC system, we proposed a novel modified entropy-based least square (MELS) channel estimation method based on the mean value of the transmitted vector. The analytical analysis of the LS, MMSE and MELS CE is stated in this paper. The simulation results analysed the performance of these channel estimation methods. MATLAB software is used to implement the simulation results. The results prove that the MELS algorithm outperforms the LS and MMSE at high SNR values. The proposed CE works well for MIMO-UFMC systems because it reduces the problem of using cyclic prefixes as in OFDM by employing the Dolphy–Chebyshev filter. The results demonstrate that the proposed CE technique outperforms the conventional LS and MMSE channel estimation techniques. The proposed channel estimation's reduction in BER and MSE shows an overall improvement MIMO-UFMC wireless system. The proposed can be extended for the other MCM techniques as well as the different parameters other than BER and MSE. In this paper, only 10×10 m MIMO antennas are used for transmission and reception; the same can be extended for more number of antennas.

References:

1. Shaik, N., & Malik, P. K. (2021). A comprehensive survey 5G wireless communication systems: Open issues, research challenges, channel estimation, multi carrier modulation and 5G applications. *Multimedia Tools Applications*. https://doi.org/10.1007/s11042-021-11128-z
2. Coleri, S., Ergen, M., Puri, A., & Bahai, A. (2002). Channel estimation techniques based on pilot arrangement in OFDM systems. *IEEE Transactions on Broadcasting, 48*(3), 223–229.

3. Shaik, N., & Malik P. K. (2022). 5G massive MIMO-OFDM system model: Existing channel estimation algorithms and its review. In P. K. Malik, J. Lu, B. T. P. Madhav, G. Kalkhambkar, & S. Amit (Eds.), *Smart Antennas. EAI/Springer Innovations in Communication and Computing*. Springer, Cham. https://doi.org/10.1007/978-3-030-76636-8_15
4. Zhao, Y., & Huang, A. (May 1998). A novel channel estimation method for OFDM mobile communication systems based on pilot signals and transform-domain processing. *IEEE VTC'98*, 46, 931–939.
5. Liu, M., Wang, H., Li, Y., & Li, P. (2019). Research on pilot-based channel estimation algorithms. In *2019 International conference on electronic engineering and informatics (EEI)* (pp. 454–457). https://doi.org/10.1109/EEI48997.2019.00104
6. Lynch, P. (1997). The Dolph–Chebyshev window: A simple optimal filter, *Monthly Weather Review*, *125*(4), 655–660. Retrieved May 24, 2022, from https://journals.ametsoc.org/view/journals/mwre/125/4/1520-0493_1997_125_0655_tdcwas_2.0.co_2.xml
7. Yongxue, W., Sunan, W., & Weiqiang, W. (2019). Performance analysis of the universal filtered multi-carrier (UFMC) waveform for 5G system. *Journal of Physics: Conference Series, 1169*, 012065. https://doi.org/10.1088/1742-6596/1169/1/012065
8. Kewen, L., & Ke, X. (2010) Research of MMSE and LS channel estimation in OFDM systems. In *The 2nd international conference on information science and engineering* (pp. 2308–2311). https://doi.org/10.1109/ICISE.2010.5688562
9. Khlifi, A., & Bouallegue, R. (2011). Performance analysis of LS and LMMSE channel estimation techniques for LTE downlink systems. *International Journal of Wireless & Mobile Networks 3*. https://doi.org/10.5121/ijwmn.2011.3511

A Study and Design of Flexible Planar Antenna with Different Substrates for Long-Range Applications

Sneha, Praveen Kumar Malik, and Joan Lu

Abstract In the past few years, there has been a huge rise in the need for flexible antennas, especially in the field of body area networks (BANs) or telemetry. The article proposed the performance analysis of different substrates used to design flexible antennas. For this analysis, the antenna is designed using the basic microstrip patch formula with the commonly used substrate FR-4 with a dielectric constant of 4.4. Then, the patch antenna is designed using different flexible materials, and their performance is studied and compared. For one comparison table, the dimension is compared for each substrate using the microstrip patch formula, keeping the LoRa frequency of 868 MHz as a reference. And, for the next comparison, the dimension is kept constant while the substrate is varied, and the results are compared and represented in graphs. From this article, the researcher will get help in selecting the flexible substrate for wearable antenna and the application depending on the size and performance of the transceiver system.

Keywords Body area network · Flexible material · Internet of Things · Long-range technology · Patch antenna · Telemetry

1 Introduction

This research article compares the flexible substrate and analyzes its performance in terms of gain, size reduction, and radiation characteristics. In the current scenario, the flexible antenna is in demand because of its advantages and applications mentioned in Fig. 1 [2], and both the academic and industrial worlds have a significant amount

Sneha (✉) · P. K. Malik · J. Lu
Lovely Professional University, Phagwara, Punjab, India
e-mail: snehabhardwaj13@gmail.com

J. Lu
e-mail: j.lu@hud.ac.uk

Department of Computer Science, University of Huddersfield, Huddersfield HD1 3DH, West Yorkshire, UK

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_41

of interest in the subject of flexible antennas [1]. Wearable technology is quickly advancing and has the potential to transform and improve many facets of life. A wide variety of applications, including biological sensors, WBANs, and IoT, can be supported by wearable technology. Antennas that use textile materials as conducting elements and substrates are referred to as textile antennas [3]. The potential for textile antennas to replace uncomfortable and clunky solutions offered by flexible batteries [4] and inflexible traditional batteries [5] as a power receiver for wearable and other portable systems is enormous. Constructing textile antennas involves employing conductive textile or fabric as the radiating element and other fabrics as the substrate. For instance, a polyester-based fabric with nickel, copper plating, and denim is used as a substrate for patch antennae [6]. A flexible wristband with a fabric antenna operating at 2.45 GHz with an input power sensitivity of 24.3 dBm has been described for a power harvesting application. Copper-coated woven polyester fiber has been used as conductive fabric, and polyester felt and woven polyester have been used as the substrate. Wireless power harvesting or transfer for wearable devices, on-body sensors, and protective gear for rescue operations are potential applications for textile antenna technology. A recent innovation is the inclusion of screen-printed antennas to the wearable receiving antennae for RFEH. On a flexible polycotton substrate, different layers of an antenna can be mapped using the screen-printing technique. Screen printing with conductive paint has been used to print an assortment of broadband rectennas with between 16 and 81 bow-tie antenna elements on a cotton t-shirt [6]. It has been demonstrated that employing silver paint makes connections between conductive fabric substrates and surface mount diodes trustworthy.

Flexible technology is a sought-after component for the future of electronics due to its benefits of lighter weight, low-cost manufacturing, ease of fabrication, and the

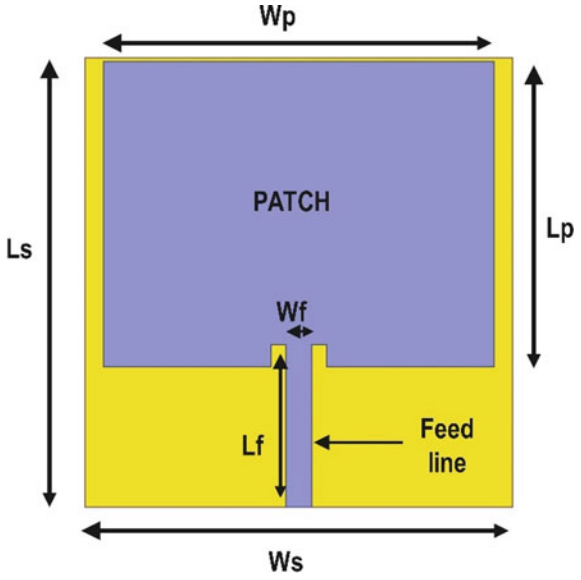


Fig. 1 Basic structure of microstrip patch antenna with a strip line feed

availability of frequently cheaper flexible substrates (such as foam, cotton, felt, and rubber) [7]. A roadmap for the viability of the aforementioned systems was also offered by the quick evolution of flexible and wearable wireless devices [8]. It is also well known that the qualities and traits of flexible antennas with strong bending support have a significant impact on the efficiency of flexible systems. Over the last ten years, numerous surveys have been published [9–11]. The design comparison of flexible antennas has not been fully surveyed in any of the articles. This inspired the author to provide a thorough study and analyze the different substrates with microstrip feed line patch antenna and compare their performance. The flexible antenna is designed using different flexible materials such as textile materials, fabrics, yarns, and threads that incorporate conductive fibers known as electronic textiles. They are referred to as "smart textiles" in the literature as can-do computing, local monitoring, and wireless communication in addition to being "wearable" [12]. An expanding interdisciplinary topic of study called "Electronic Textiles" brings together experts in microsystems, textiles, materials, and information technology. They employ several types of conductive fabrics, sensors, components of computation, data, and power distribution. The flexible material is also used in medicine, military, automation industry, for tracking purposes, and in the telemetry, field to communicate the sensor's data or to collect the information from a distance; for example, if the sensing device is integrated with LoRa technology, then the sensing range is around 10 km in the line-of-sight scenario. Similarly, the range of communication depends upon the operating frequency of the antenna, its radiation characteristics, and modulation technology used with the transceiver system.

The analysis starts with Sect. 2, in which the basic patch design has a microstrip feed line, and the dimension of the patch antenna is determined by the microstrip patch formula mentioned in [13]. Then, the design is optimized for the LoRa frequency band with substrate FR-4 of dielectric constant 4.3, and the performance parameter is analyzed. In the next step, the different substrates have been analyzed and the performance parameter is compared in Sect. 3. Section 4 deals with the conclusion of this article.

2 Antenna Design and Analysis

LoRa provides a wide range of wireless network services that can help to improve IoT Services. It is a low-power, wide-area technology that consumes very little power in data communication. It consumes much less power for the user device than the battery of IoT devices which can last for 10 years with a wide range of connectivity. For this communication purpose, monopole patch antenna designs are in trend with many structures and designs like hexagonal, pentagonal, square, rectangle and elliptical, and many more, because of their planarity and cost-effective nature [14–18].

The examination of the materials is the first step in the design process since they will have superior properties for creating flexible antennas, such as electrical conductivity, loss tangent, and relative permittivity. Among them, the relative permittivity

and loss tangent are crucial. They ought to have a lower number. Consequently, the substrate material should be chosen based on those factors. Following that, the ground plane, feeding structure, radiating component, and antenna shape should be established for design. A variety of software, including Computer Simulation Technology (CST), High-Frequency Structural Simulator (HFSS), Advanced Design System (ADS), etc., are then used to simulate the intended structure. For this article, the HFSS is used to simulate the design of the antenna.

Initially, the dimensions are defined using the analysis of the microstrip patch formula [9].

(i) The formula for width (W) of microstrip patch:

$$W = \frac{c}{2 * f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}, \tag{1}$$

where

ε_r substrate's dielectric constant,
c speed of light in free space.

(ii) The effective value of dielectric: $\frac{W}{h} > 1$

$$\varepsilon_{r_{\text{eff}}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} + \left(1 + \frac{12 * h}{W}\right)^{1/2} \tag{2}$$

(iii) The physical length of the patch:

$$L = \frac{c}{2 * f_r * \sqrt{\varepsilon_r}} \tag{3}$$

(iv) Effective length L_{eff} includes the fringing fields effects:

$$L_{\text{eff}} = L - 2\Delta L \tag{4}$$

(v) Patch length increases by:

$$\frac{\Delta L}{h} = 0.412\frac{\left(\varepsilon_{r_{\text{eff}}} + 1\right)\left(\frac{W}{h} + 0.244\right)}{\left(\varepsilon_{r_{\text{eff}}} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \tag{5}$$

Table 1 Dimension of patch for different substrates

Substrate	Dielectric constant (ε_r)	Loss tangent (tan δ)	Length (mm)	Width (mm)
Velcro	1.34	0.006	149	160
Felt	1.36	0.016	148	159
Denim	1.40	0.07	145	105
Cotton	1.54	0.058	139	153
Silk	1.75	0.012	130	147
Woven fabric	2.5	0.0015	109	130
Nylon	2.84	0.0117	102	124
Leather	2.95	0.16	100	122
Polyamide	3.5	0.0030	92.34	115
FR-4	4.4	0.25	82.37	105

For LoRa frequency, 868 MHz, the dimension has been determined using the above formula mentioned in Table 1. We can conclude from the table that a high dielectric substrate helps in size reduction, but the gain is very low with that material.

The basic microstrip patch structure is mentioned in Fig. 1. The structure has L_p and W_p which are the length and width of the patch and L_s and W_s are the length and width of substrate and ground. The feed line is also mentioned in the figure with length L_f and width W_f. The figure consists of a patch radiating structure, a ground structure in yellow color, and a microstrip feed line. The patch dimension is 82 mm $\times$ 103 mm. The antenna dimension is 120 mm $\times$ 113 mm $\times$ 0.25 mm. The ground dimension is 120 mm $\times$ 113 mm. The length of the feed line is 38 mm, and the width of the feed line is 6.5 mm. This structure is designed with an FR-4 substrate of dielectric constant 4.4, which is resonating at 868 MHz.

3 Results and Discussion

The designed antenna is simulated using HFSSv15 on a substrate of FR-4 and other flexible material with a thickness of 0.25 mm. A simulation of the proposed antenna was performed at frequencies between 500 MHz and 3 GHz. There are various parameters on which the substrate properties can be compared and analyzed, such as reflection coefficient, gain, efficiency, and radiation pattern of the antenna. Table 1 shows that substrate material for flexible antennas often exhibits low loss tangent values. FR-4, cotton, rubber, Styrofoam, felt, polystyrene, and denim material are among those that have the advantage of being inexpensive. However, FR-4 and rubber have higher relative permittivity and loss tangent values. So, the substrate material should be correctly selected based on its respective permittivity and loss tangent values.

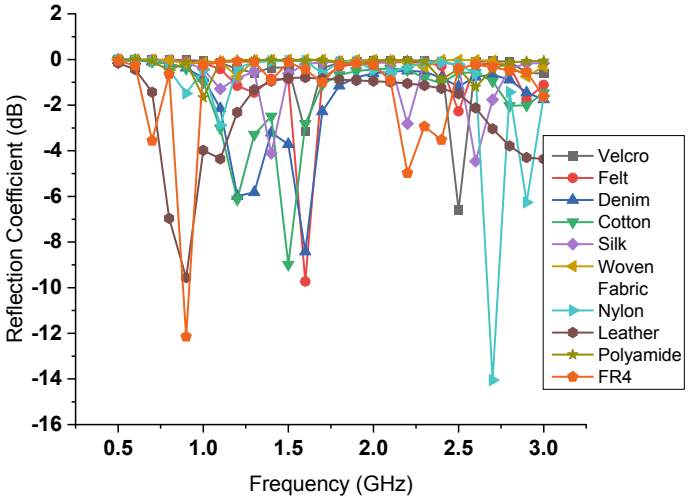


Fig. 2 Reflection coefficient comparison graph for the different flexible substrates

One crucial antenna characteristic, the reflection coefficient, determines the antenna's resonating spots, operating frequency, and minimum return loss, all of which determine the antenna's bandwidth. The reflection coefficient of the antenna is mentioned in Fig. 2. The graph has the reflection coefficient plot of an antenna with different substrates. Changes in frequency can be easily determined by just looking at the graph. The ability of an antenna to emit more or less in any direction as compared to a theoretical antenna is known as antenna gain. An antenna would radiate evenly in all directions if it could be constructed as a perfect sphere. Theoretically, such an antenna is known as an isotropic antenna. The gain of the antenna is mentioned in Fig. 3. The degree to which the radiation emitted is concentrated in one direction is measured by the directivity of an antenna or optical system. It is the ratio of an antenna's radiation intensity in one direction to its overall average radiation intensity.

4 Summary

This article offers a thorough analysis of numerous flexible antenna design difficulties. Some flexible substrates like leather provide good gain and directivity. For the cost-effective and ultra-wideband application, flexible FR-4 is used. Polyamide substrate is used for wearable devices such as Bluetooth, trackers, and many more. Teflon is used for space navigation sensor devices, and denim and cotton are mostly used for ISM applications. Flexible antennas are utilized in the application of using radio detection and ranging for communication, the Global Positioning System, telemedicine, and satellite connectivity. Recently developed design methods for antenna types, their characteristics, and how they affect different performances with

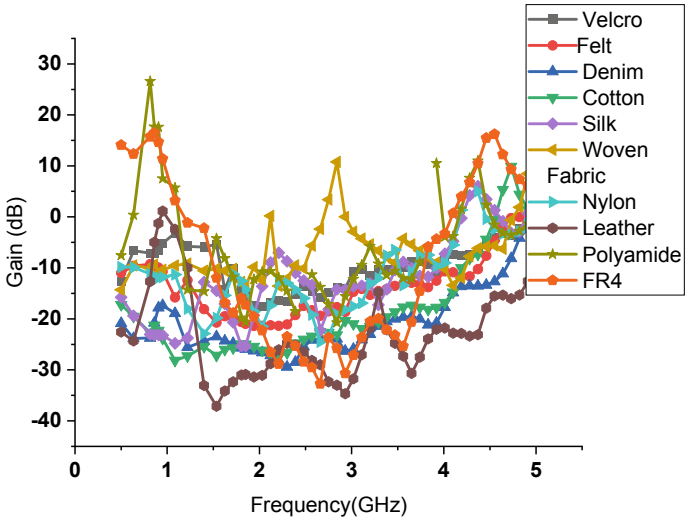


Fig. 3 Gain comparison graph for the different flexible substrates

bending were examined. They are these antennas. We are robust, optimistic, and have a bright future with the rapid development of wireless communication technologies. Therefore, the review has made it possible for the next researchers to create a flexible antenna that is ideal in every way.

References

1. Khaleel, H. R., Al-Rizzo, H. M., & Abbosh, A. I. (2013). Design, fabrication, and testing of flexible antennas. In *Advancement in micro strip antennas with recent applications*. ISBN 978-953-51-1019-4, ch.13.
2. Hu, J. (2010). Overview of flexible electronics from ITRI's viewpoint. In *2010 28th VLSI Test Symposium (VTS)* (pp. 84–84). https://doi.org/10.1109/VTS.2010.5469608
3. Corchia, L., Monti, G., & Tarricone, L. (2019). Wearable antennas: Nontextile versus fully textile solutions. *IEEE Antennas and Propagation Magazine, 61*(2), 71–83.
4. Yeo, J., Moon, S. G., & Jung, J. Y. J. (2008). Antennas for a battery-assisted RFID tag with thin and flexible film batteries. *Microwave and Optical Technology Letters, 50*(2), 494–498.
5. Starner, T. J. (1996). Human-powered wearable computing. *IBM Systems Journal*, *35*(3.4), 618–629.
6. Estrada, J. A., Kwiatkowski, E., Lopez-Yela, A., Borgonos-Garcia, M., Segovia-Vargas, D., Barton, T., & Popovic, Z. (2020). RF-harvesting tightly coupled rectenna array tee-shirt with greater than octave bandwidth. *IEEE Transactions on Microwave Theory and Techniques, 68*(9), 3908–3919.
7. Nathan, A., & Chalamala, B. R. (2005). Special issue on flexible electronics technology, Part 1: Systems and applications. *Proceedings of the IEEE*, *93*(7), 1235–1238. https://doi.org/10.1109/JPROC.2005.851525
8. Yongan, H., Chen, J., Yin, Z., & Xiong, Y. (2011). Roll-to-roll processing of flexible heterogeneous electronics with low interfacial residual stress. *IEEE Transactions on Components,*

Packaging and Manufacturing Technology, 1368–1377. https://doi.org/10.1109/TCPMT.2011.2157692
9. Huang, H. (2013). Flexible wireless antenna sensor: A review. *IEEE Sensors Journal, 13*(10), 3865–3872. https://doi.org/10.1109/JSEN.2013.2242464
10. Praveen Kumar, K., Sanjeeva Rao, K., Mallikarjuna Rao, V., Uma, K., Somasekhar, A., & Murali Mohan, C. (2013). The effect of dielectric permittivity on radiation characteristics of coaxially feed rectangular patch antenna: Design and analysis. *International Journal of Advanced Research in Computer and Communication Engineering*, *2*(2).
11. Zahran, S. R., Abdalla, M. A., & Gaafar, A. (2017). How bending affects a flexible UWB antenna. Microwaves and RF.
12. Kubicek, J., et al. (2022). Recent trends, construction, and applications of smart textiles and clothing for monitoring of health activity: A comprehensive multidisciplinary review. *IEEE Reviews in Biomedical Engineering, 15*, 36–60. https://doi.org/10.1109/RBME.2020.3043623
13. Balanis, C. A., & Theory, A. (2005). *Analysis and Design* (3rd ed.). Wiley.
14. Kumar, P., & Ghivela, G. C. (2019). Optimized N-sided polygon shaped microstrip patch antenna for UWB application. IEEE.
15. Syam Sundar, P., Kotamraju, S. K., Sri Kavya K. Ch., Madhav, B. T. P., Srikanth, Y., & Babu, N. (2020). Pentagon shaped microstrip antenna for wireless IoT applications. *Journal of Critical Reviews, 7*(14). ISSN 2394-5125.
16. Zhuo, L., Han, H., & Shen, X. (2020). A U-shaped wide-slot dual-band broadband NB-IoT antenna with a rectangular tuning stub. In *EEE 4th Information Technology, Networking, Electronic and Automation Control Conference (ITNEC 2020).*
17. Shin, G., Park, J., Park, T. R., & Yoon, C. -J. (2020). Sustaining the radiation properties of a 900-MHz-band planar LoRa antenna using a 2-by-2 thin EBG ground plane. *IEEE Access*, *8*, 145586–145592.
18. Elijah, A. A., & Mokayef, M. Miniature microstrip antenna for IoT application. *Materials Today: Proceedings.* https://doi.org/10.1016/j.matpr.2020.05.678

Sustainable Development, Renewable Energy and Environment

Pooja Malik, Praveen Kumar Malik, Rajesh Singh, and Anita Gehlot

Abstract Sustainable development is necessary to conserve natural resources, clean environment and protecting species in the world. Day by day, poverty is increasing and natural resources are reducing due to imbalance between our way of living life and environment. Peoples fulfill their own present needs without thinking of future generation needs. The goal of sustainable development is to protect the planet and all the people will enjoy peace and prosperity by 2030 without compromise future generation needs. Renewable energy sources play an important role for sustainable development. Renewable energy sources can help us to make our environment clean. Solar energy and wind energy are used for generation of electricity, agriculture and transport facility with least cost. This paper focuses on to preserve our environment and natural resources for sustainable development.

Keywords Sustainable development goals · Renewable energy · Natural resources · Environment

P. Malik (✉)
Department of Electronics and Communication, Lovely Professional University, Phagwara, Punjab 144411, India
e-mail: er.pujamalik550@gmail.com

P. K. Malik
School of Electronics and Electrical Engineering Department, Lovely Professional University, Phagwara, Punjab 144411, India
e-mail: praveeen.23314@lpu.co.in

R. Singh
Division of Research and Innovation, Uttaranchal University, Dehradun, Uttarakhand 248001, India

A. Gehlot
Department of Electronics and Communication Engineering, Uttaranchal University, Dehradun, Uttarakhand 248001, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_42

1 Introduction

Sustainable development is a development without destroying the environment and natural resources. Development of resources is necessary for maintaining quality of human life. Global ecological crisis such as ozone layer depletion, global warming, air pollution and degradation of land may lead to randomly exploitation of natural resources. Social, economic and environmental problems may arise due to overutilization of resources. Two important natural resources such as land and soil should be conserved. Land resources are used for different uses such as forest, net sown area, fallow land, waste land, permanent pasture and grazing land and land used for non-agricultural purposes such as industries, buildings and roads. Activity of humans such as overgrazing, mining and deforestation may lead to land degradation. Agricultural land in India has been increased about 5.94 Mha from year 1970–1971 to 2014–2015. Large number of the landholdings in India has less than a hectare. The lacks of natural resources and credit provide less productivity. It has been observed that the average size of farm is inversely proportional to the population [1]. Hence, for better productivity, natural resources should be provided to the landholders continuously in the time. Table 1 shows land used category in Mha for year 1970–1971 and 2014–2015. It indicates that net sown area and permanent pasture and grazing land are decreased to some extent due to increasing population, need of food and shelter. So, there is a need to preserve land for sustainability. Pie charts in Figs. 1 and 2 show land used category in percentage for year 1970–1971 and 2014–2015.

Another important natural resource is soil resources. Soil resources can be conserved by several methods such as crop rotation, windbreaks, contour farming and afforestation.

Forest resources are also very necessary to preserve for sustainable development. Many animal species are dependent on forest. Peoples living near forests are depended on the forest products for their lives. Government Forest Department takes care of land and resources of forest. Many industries are used forest resources for making bidis and paper.

Table 1 Land used category in India (Mha) [1]

Land used category	1970–1971	2014–2015
Net sown area	141	140
Forest	64	72
Barren and uncultivated waste land	28	17
Areas under non-agriculture use	16	27
Permanent pasture and grazing land	13	10
Areas under miscellaneous tree crops and grove	4	3
Culturable wasteland	18	13
Current fallow land	11	15
Fallow other than current fallow	9	11

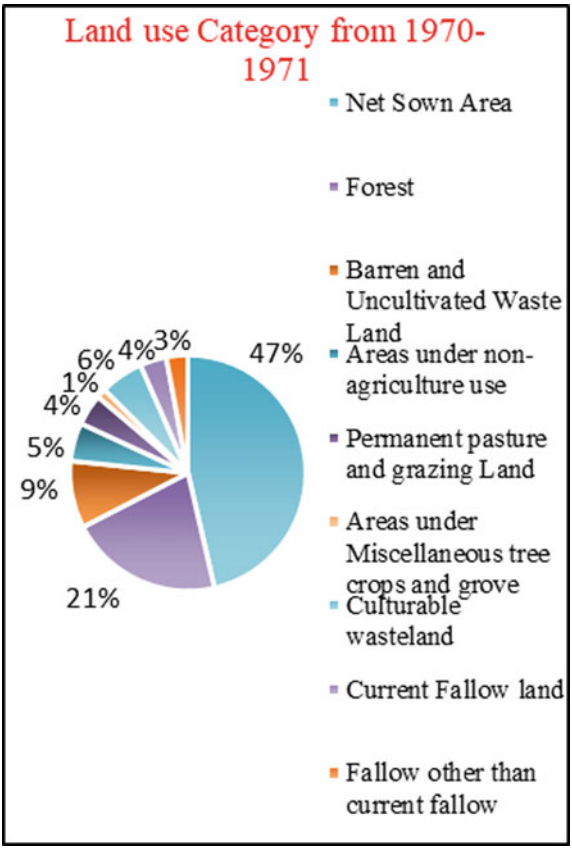


Fig. 1 Land-used category from 1970 to 1971

1.1 Achievements to Protect Forests

- The Government of India has instituted Amrita Devi Bishnoi Wildlife Protection Award in the memory of Amrita Devi Bishnoi. She protected a grove of Khejri trees by sacrifices her life in 1731 in Khejarli, Rajasthan.
- The Chipko movement began in 1970 for the protection of trees and forests. Figure 3 shows that this movement led by mainly women from rural villages of Himalayan regions.

Both the trees and the mothers teach that to live and also to be ready to die for the sake of others proves to be the real foundation of bliss.

The Chipko Movement, 1987 Laureate

- Ajit kumar Benerjee had worked as Divisional Forest Officer in West Bengal. He took initiative to protect Sal forests. There were 612 villager families who were

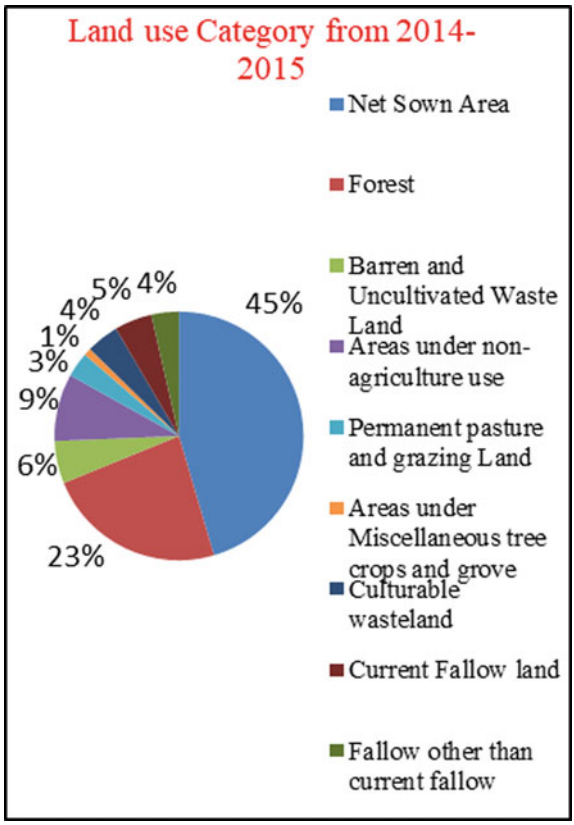


Fig. 2 Land used category from 2014 to 2015

Fig. 3 Women hug trees during Chipko Andolan

involved in managing 12.7 km^2 of degraded Sal forests. Profit of 25% of forests was shared with the villagers.

1.2 Renewable Energy Resources (RESs)

Wind and solar renewable energies are clean, pollution free, no carbon emission, replenished energy resources. Due to their advantages, different countries will use renewable energy for their power generation systems in the future. These energy resources reduce electricity bills and require low maintenance. By 2022, India has aim to produce 60 GW of electricity from wind power and 100 GW of electricity from solar power. The Government of India (MNRE) is providing the policy support for renewable resources growth. Renewable resources are highly beneficial for sustainable development.

Figure 4 shows that technical, political, economic, social and environmental sectors' growth is depended upon renewable energy RES sustainable development.

2 Related Work

By reading many papers, we have concluded some observations regarding sustainable development as shown in this section.

General Assembly of United Nations in 2015 adopted 17 sustainable development goals. These goals are interlinked with environmental, economic and social

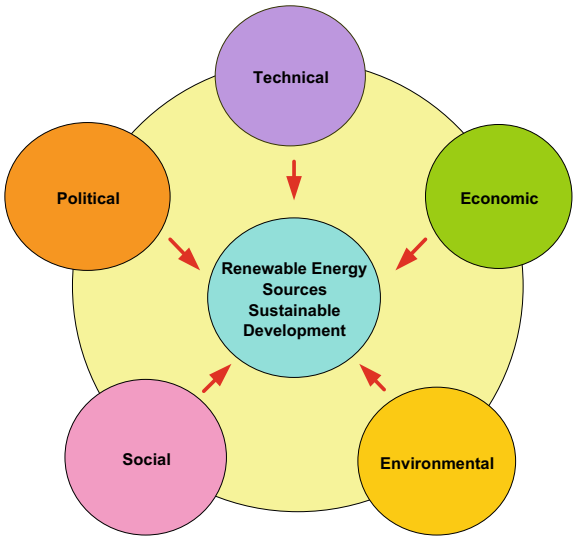


Fig. 4 Renewable energy sources' sustainable development evaluating factors [2]

system. Out of three systems, when only one is fulfilled and others are not good, then it is not considered as sustainable development [3]. India works for efficient and clean energy system such as afforestation, conservation of water, forest protection, disaster management, agriculture, renewable energy for electricity and transportation. The developed country had provided support of US$ 100 billion per year to the developing nations [4]. In private sector, we can achieve sustainability goals through corporate sustainability by clean production and economic growth. The multinational companies in Japan prioritize some sustainable development goals shown in Fig. 5 for making decision such as goals 4, 8, 9, 11, 12, 14, 17 [5]. Agenda of 17 sustainable development goals is discussed with current and future challenges faced for sustainable development. There is a need to reduce growth of population to minimize poverty level. Table 2 shows that population is a big challenge for India. As per UN estimation, if population of India is increasing 1.7 billion by 2050, then India may face high ecological crisis [6]. Fossil fuels release large amount of greenhouse gases which cause air pollution and degrade the environment. So, there is a need to develop policymaking decisions for utilization of large amount of renewable energy resources. A reliable hybrid approach data envelopment analysis (DEA) and fuzzy best–worst method (FBWM) was used for making energy policymaking method [2].

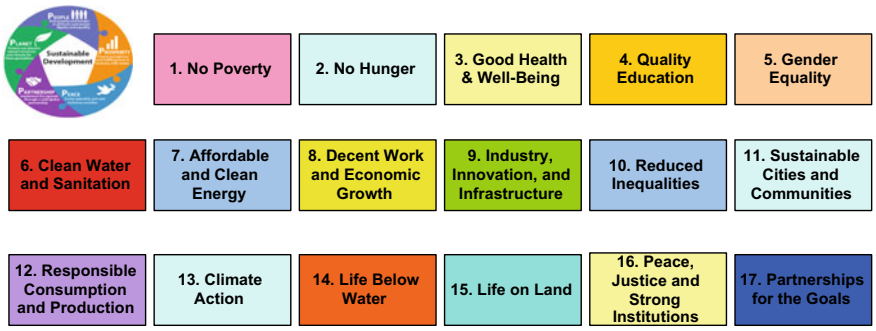


Fig. 5 United nation sustainable development 17 goals 2015 [9]

Table 2 Features of India [6]

Features	India
Area	3.287 million km^2
Population	1.324 billion
Gross national income (GNI) per capita	5.663
Ranking as per the 2017 UN Human Development Index	131

3 Sustainable Development Goals

Initially, Millennium Development Goals (MDGs) were adopted in 2000 to improve health and reduce poverty. MDGs focused on three components: security, development and peace. It helped to minimize inequity of gender, degradation of environment and poverty hunger. SDG came after MDGs on September 25, 2015. Seventeen sustainable development goals as shown in Fig. 5 and 169 targets were adopted by Union Nation for social, economic and environmental sustainable development [7]. Mostly, goals have cooperative relationship with no poverty (Goal 1) and good health and well-being (Goal 3). Affordable and clean energy (Goal 7) has powerful relationships with no poverty (Goal 1), zero hunger (Goal 2), good health and well-being (Goal 3), decent work and economic growth (Goal 8) and climate action (Goal 13), but a medium negative correlation with Goal 12 (responsible consumption and production). This indicates that there is a need to increase energy efficiency, use of renewable energy for sustainable development. There are some sustainable development goals which show no correlation with Goal 13 (climate action) and Goal 17 (partnerships for the goals) [8].

3.1 Challenges of Sustainable Development

- Increasing population and poverty.
- Increasing corruption.
- Absence of efficient Leadership, Governance and investments.
- Inequality in gender: men and women.
- Gap between rural and urban areas.
- Loss of biodiversity and forest.
- Land, water and soil degradation.
- Protection from deaths of under 5 years' children by health diseases such as tuberculosis, AIDS and malaria.

3.2 Strategies for Sustainable Development

The United Nation Development Program describes the following strategies to face challenges for sustainable development by 2030 agenda:

- Leaving no one behind.
- Building resilience.
- Better governance.
- Gender equity.
- Use of renewable energy.
- Global policy network.

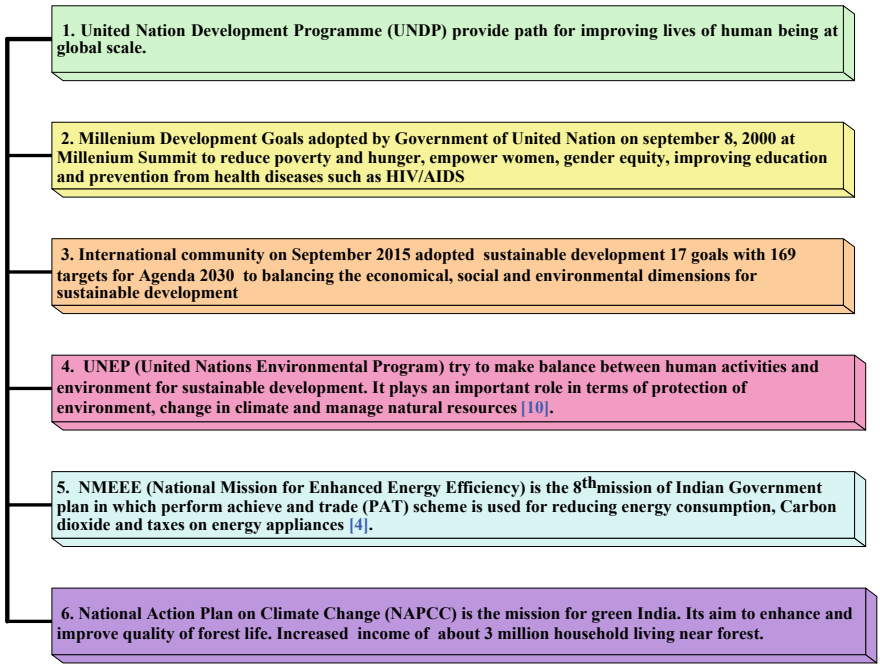


Fig. 6 Achievements for sustainable development

- Digitization and more innovative.
- Financial support for fight with natural crisis.

4 Achievements

Following are the achievements of Indian government and United Nations for sustainable development as shown in Fig. 6.

5 Conclusion

The results show that sustainable development is necessary for our safe and peaceful life on the planet. Sustainable development goals have to be achieved by 2030 to fulfill our needs by balancing between three components of sustainable development: environmental, social and economic. Sustainable development goals can be achieved by no poverty or hunger, usage of renewable energy resources, conserve natural resources, prevention from economic crisis, clean water, minimize the discrimination between boys and girls and prevent animal species by saving ecosystem. By

reducing greenhouse gases, prevention from deforestation and soil erosion can help to achieve sustainability in life. Corporate sustainability for private sectors and renewable energy sustainability for generation of power will provide reliable results for sustainable development.

References

1. Kareemulla, K., Krishnan, P., Ravichandran, S., Kumar, B. G., Sharma, S., & Bhatta, R. (2021). Spatiotemporal analysis of size and equity in ownership dynamics of agricultural landholdings in India Vis-à-Vis the world. *Sustainability, 13*(18), 10225.
2. Kolagar, M., Hosseini, S. M. H., Felegari, R., & Fattahi, P. (2020). Policy-making for renewable energy sources in search of sustainable development: A hybrid DEA-FBWM approach. *Environment Systems and Decisions, 40*(4), 485–509.
3. Barbier, E. B., & Burgess, J. C. (2017). The sustainable development goals and the systems approach to sustainability. *Economics*, *11*(1).
4. Sustainable development, 06, Climate Change, Economic Survey, Volume 1, 204–228 (2020–21).
5. Ike, M., Donovan, J. D., Topple, C., & Masli, E. K. (2019). The process of selecting and prioritising corporate sustainability issues: Insights for achieving the Sustainable Development Goals. *Journal of Cleaner Production, 236*, 117661.
6. Leal Filho, W., Tripathi, S. K., Andrade Guerra, J. B. S. O. D., Giné-Garriga, R., Orlovic Lovren, V., & Willats, J. (2019). Using the sustainable development goals towards a better understanding of sustainability challenges. *International Journal of Sustainable Development and World Ecology, 26*(2), 179–190.
7. Singh, Z. (2016). Sustainable development goals: Challenges and opportunities. *Indian Journal of Public Health, 60*(4), 247.
8. Fonseca, L. M., Domingues, J. P., & Dima, A. M. (2020). Mapping the sustainable development goals relationships. *Sustainability, 12*(8), 3359.
9. United Nations. Sustainable Development Goals: 17 Goals to Transform our World. Accessed May 26, 2017. Available at http://www.un.org/sustainabledevelopment/sustainable-development-goals/
10. Abashidze, A. K., Solntsev, A. M., Kiseleva, E. V., Koneva A. V., & Kruglov D. A. (2016). Achievement of sustainable development goals (2016–2030): International legal dimension. *Indian Journal of Science and Technology*, *9*(37).

An Insight to Textile Substrates for Wearable Antenna

Safina Shokeen, Harbinder Singh, and Anurag Sharma

Abstract This paper presents a systematic review of wearable antennas focusing on different textiles used in the fabrication process. Textile fabrics used as substrate in antennas give a wearer a high-end comfort level. To this, several articles related to Wearable Textile Antenna operated at 2.45 GHz ISM band were selected and analyzed. This review shows the variety of textiles such as jute, felt, silk, jeans, and many more that have been used in fabricating a flexible antenna. Furthermore, findings reveal the pros and cons of using the fabric based on different parameters associated while fabricating the antenna. In addition, fabrication techniques such as sewing, printing, and direct handwriting along with antenna structures are also discussed. Finally, the conclusion reflects some future work in the given field.

Keywords Wireless technology · Wearable textile antennas · Textile material · Fabrication

1 Introduction

Technology has advanced in recent years and has revolutionized human daily activities. The technological advancement in sensors, low-power circuits, and constant miniaturization of devices has realized new opportunities and empowered the growth of Wearable Antennas. Due to significant achievement in the last few years, Wearable Antennas has successfully served their purpose in different applications such as military, entertainment, sports, and majorly medical. The rate at which the population is increasing to many folds increases the demand for the latest technology. Wearable Devices are one such integral part of the upcoming promising technology.

S. Shokeen (✉) · H. Singh
Department of Electronics and Communication Engineering, Chandigarh University, Mohali, India
e-mail: safinashokeen@gmail.com

A. Sharma
Department of Electronics and Communication Engineering, Indraprastha University, Delhi, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_43

Wearable devices are those which can communicate with external devices through some wireless modules. These electronic devices incorporate components like sensors, batteries, and antennas. And since these antennas are majorly responsible for transmitting and receiving data, these devices are popularly known as Wearable Antennas [1]. Taking into consideration the medical application, wearable antenna plays a significant role in detecting and further monitoring the health conditions of patients situated even at remote locations [2]. Since these devices are integrated into the wearer's outfit or are being directly worn by individuals (precisely patients), the design and construction of antennas should be such that it barely affects the human body. Keeping in mind the constraints, wearable antennas are fabricated accordingly. In the last few years, different materials have been used during fabrication having different properties and serving numerous characteristics.

Hence, in this systematic review, we have studied different materials of textile [3] used in antenna fabrication that served their purpose in the sector of health care. These materials have been analyzed based on their properties (such as dielectric constant, loss tangent, and SAR), availability in the market, impact on the human body, and a few more.

2 Different Textiles as Substrates with Their Pros and Cons

While designing a wearable antenna, the first and foremost critical step is the selection of substrate keeping in mind the various constraints regarding the objectives already being set up. For the last few years as we all know that textile antennas majorly used in wearable applications, they are primarily known as wearable textile antennas. The textile material of the substrate is selected in such a way that the fabricated antenna is flexible enough to withstand physical deformation conditions. Also, based on fundamental parameters of antenna such as gain, radiation efficiency, SAR, and bandwidth, the textile material should be an ideal one in terms of dielectric constant, tangent loss, and a few more parameters [4]. Table 1 listed some of the frequently used textile materials as substrates due to their good performance as wearable antennas.

2.1 Approach to the Review

For our research, we have searched for articles from the Web of Science indexed SCI, SCIE, and ESCI. Using the keyword "Textile Antennas" in the search engine resulted in thousands of articles that involved all kinds of antennas whether wearable or non-wearable and also have applications in almost all sectors. Based on this, we further decided to include "Wearable Textile Antennas" in our search criteria. Though a majority of the articles we got were satisfying our goal, still we have to be more focused, and hence, we again searched with more sets of keywords such as "Textile Antenna for Medical" or "Wearable Textile Antenna in Medical". Precisely,

Table 1 Common textile materials as the substrate

Substrate material	Dielectric constant	Thickness (mm)	Tangent loss	Feature	Pros	Cons	References
Wash cotton	1.51	3	0.02	EBG-based antenna	SAR reduces and efficiency increases	Not mentioned	Ali et al. [5]
Jute	1.87	0.55	0.052	A different layer of jute is used during the simulation	Made from natural fiber, so it is environmental friendly	Due to the higher value of the tangent loss, gain reduces	Zeouga et al. [6]
Denim	23,405	0.7	0.0985	Antenna with a triangular slot	Return loss improved	Reduced antenna gain	Noor et al. [7]
Polyester	1.44	2.85	0.01	Patch antenna on a human phantom model	The flexible material and antenna show high front-to-back ration	Performance deteriorated under wet conditions	Hussain et al. [8]
Felt	1.22	2	Not mentioned	Antenna with beam-steering capabilities	Capability to radiate in four directions	Not mentioned	Jais et al. [9]

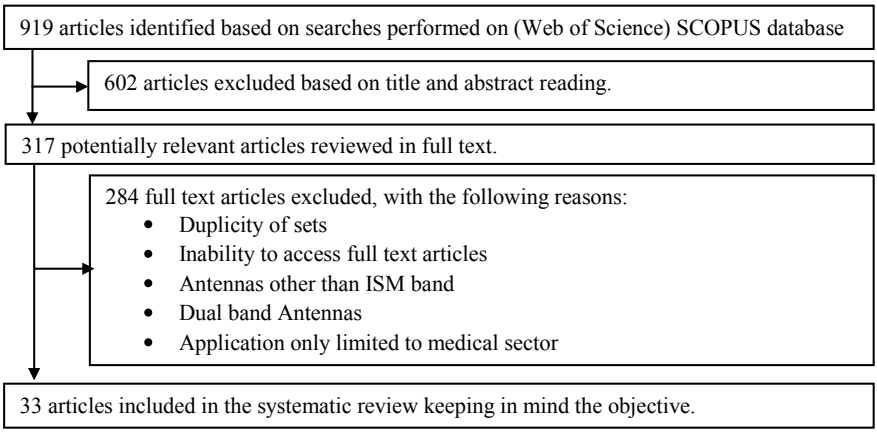


Fig. 1 Flow diagram of the systematic review

the search terms focused on "wearable antenna" or "Textile antenna" with Medical. We have kept the search window restricted from the year 2009 to 2019 considering most of the work has been carried out in the last decade.

Based on searches performed, we identified a total of 919 papers that further underwent different inclusion/exclusion criteria manually. The very first step excluded 602 papers after the title and abstract reading.

Then from the remaining 317 papers, 274 potentially relevant articles were excluded due to various reasons that include (a) duplicity of sets; (b) full-text articles not accessible; (c) antennas other than ISM band; (d) dual-band antennas; and (e) application only limited to the medical sector. The final resultant set includes 33 articles that were thoroughly reviewed keeping in mind the objective of "Textile based Wearable Antenna in ISM band for Medical Applications". Figure 1 shows a flow diagram of the search strategy for systematic review.

3 Discussion

This section represents the classification of articles on which they have been categorized. Table 2 shows the detailed classification of the articles which are further discussed in subsections.

3.1 Reference

The first classification relates to the total number of articles being thoroughly studied after going through the search strategy as already mentioned in Fig. 1. 33 full-text

Table 2 Classification of articles

References	Year	Substrate material	Antenna structure	Tool used	Fabrication technique/feeding technique	Key features
1	2015	Polyester textile	Circular quarter mode	CST	Substrate Integrated Waveguide	a. SIW technology results in good isolation between antenna and body. b. The antenna provides excellent free-space performance
2	2018	Polyester textile	Patch	HFSS	Inset feeding technique	a. The radiation pattern was perpendicular to the axis of the wearer and provides a high front-to-back ratio. b. The antenna has minimal minor lobes
3	2017	Wool felt	Ultraminiaturized cavity backed	CST	Substrate Integrated Waveguide	An ultra-miniaturized antenna with comparable good efficiency of 76%
4	2017	Wash cotton	Rectangular microstrip patch	CST	Microstrip inset feeding	a. Comparison of an antenna on conventional and EBG planes has been discussed. b. The efficiency of the antenna increases due to surface wave suppression capability
5	2015	Felt fabric	Woven patch (Conductive thread based)	HFSS	Weaving	The resonance frequency and radiation efficiency are affected by thread thickness

(continued)

Table 2 (continued)

References	Year	Substrate material	Antenna structure	Tool used	Fabrication technique/feeding technique	Key features
6	2017	Leather	E shaped patch	CST	Hand fabrication/inset feed technique	a. Air gaps due to wrinkles changed the performance. b. Hand Fabrication introduced some inaccuracy
7	2015	Denim	Rectangular patch	CST	Transmission line feeding technique	Antenna Gain has been reduced with the use of Denim fabric
8	2011	Felt	Square microstrip	Electromagnetic simulation	Sewing	The performance of the antenna was degraded due to user movement, and total loss of bandwidth was also observed
9	2018	Jute	Patch	CST	Microstrip inset feeding	Jute patch is compact as it has higher permittivity, largest bandwidth, and larger angular width but has lower gain
10	2013	Jeans cotton	Rectangular microstrip	*NM	Adhesive	As the thickness of the jeans substrate increases, antenna performance also increases
11	2017	Expanded rubber foam	Circularly polarized cavity backed	HFSS	Substrate Integrated Waveguide	Exhibits high efficiency due to optimal front-to-back ratio and axial ratio

(continued)

Table 2 (continued)

References	Year	Substrate material	Antenna structure	Tool used	Fabrication technique/feeding technique	Key features
12	2018	Fliselin + polyester	Circularly polarized	CST	Hot ironing/probe feeding	a. Despite multiple layers of fabric, the antenna provides structural flexibility. b. The curve exhibits wider bandwidth
13	2014	Foam	Cavity-backed slot antenna	CST	Substrate Integrated Waveguide	Excellent antenna body isolation with impedance bandwidth of 4.5%
14	2017	FR-4	A-shaped planar monopole	HFSS	*NM	Improved gain and increased bandwidth are achieved in the EBG structure
15	2018	Denim gens	Patch	CST	Inset feeding technique	Good gain was obtained
16	2017	Jeans	PIFA	CST	Stitching	The addition of a second same substrate improved the gain and reduces SAR impact with the increased comfort level
17	2016	PTFE	Cavity-backed slot antenna	HFSS	Stitching	a. Due to the half-cylindrical cavity, the surface area was decreased. b. Radiation was not strong in the backward and side directions

(continued)

Table 2 (continued)

References	Year	Substrate material	Antenna structure	Tool used	Fabrication technique/feeding technique	Key features
18	2014	Cotton/polyester and polyester woven fabric	Patch	*NM	Screen printed/inset	Coated antennas are more effective as they protect the ink from degradation and avoid delamination due to washing
19	2016	Cotton/jeans/silk	Patch	HFSS	Synthetic resin adhesive	Silk provides the least return loss whereas jeans provide good isolation between a radiating antenna and the human body
20	2011	Felt	PIFA	CST	Microstrip line feeding	a. During bending, a change in resonant frequency was observed on y-axis b. Crumpling affects the antenna performance differently while placed at different body parts
21	2017	Denim	Rectangular microstrip patch	*NM	*NM	a. Gain and Radiation patterns were influenced by bending curvature. b. The resonant frequency was also altered based on the position along which the antenna was bent

(continued)

Table 2 (continued)

References	Year	Substrate material	Antenna structure	Tool used	Fabrication technique/feeding technique	Key features
22	2017	PDMS	Microstrip monopole	CST	Adhesive	EBG with antenna has reduced radiation, improved gain, and decreased the impact of frequency detuning
23	2012	FR-4 and flexible polyimide	Dipole and a loop	HFSS	Direct/indirect feed line	With a combination of dipole and loop antenna radiation pattern heads in a particular direction
24	2014	Felt/cotton/denim	PIFA	CST	Sewing	The sewing pattern results in an extended current path which further leads to reduced antenna dimensions
25	2017	Denim	Patch	CST	Microstrip line feeding	The combination of strip line loading and rectangular slots induces much lower frequency operation with significant size reduction
26	2018	Felt	Planar dipole	CST	*NM	With the EBG structure, the gain was improved and the SAR value reduces
27	2019	Felt with RIS	Patch	CST	Microstrip line feeding	With RIS, improved bandwidth and efficiency, size reduction, and gain enhancement were achieved

(continued)

Table 2 (continued)

References	Year	Substrate material	Antenna structure	Tool used	Fabrication technique/feeding technique	Key features
28	2017	Denim	Patch	CST	CPW	For EBG-FSS, the antenna shows high efficiency and good impedance matching when placed at different distances
29	2018	Cotton and felt	Dipole	CST	Embroidery	A tradeoff was seen between the satin and contour embroidery pattern
30	2018	Silk	Patch	HFSS	*NM	Silk has a low SAR value and also shows wearable properties in biomedical applications
31	2018	Jeans	Patch	ADS	Edge feeding technique	The relative permittivity and substrate thickness affect antenna performance
32	2018	SIGP	Patch	CST	Printing	SIGP helps in minimizing steps and reducing errors during the fabrication of the antenna
33	2019	Wash cotton and resin	Patch	HFSS	Microstrip line feeding	Wash cotton gives higher efficiency than resin fabric

*Not mentioned

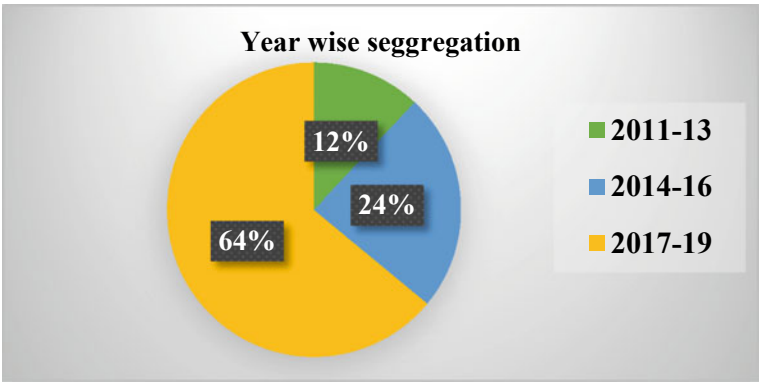


Fig. 2 Number of articles analyzed

articles on various criteria have been selected from initial 919 articles and were taken into the systematic review.

3.2 Years

Wearable Antennas as we all know are vital for body-worn applications. For the last 15 years, researchers have been continuously working in this field to provide the best possible solution to health care.

Our study includes those articles which incorporated textile as their substrates. And hence, the major work for the same has been carried out in the last few years with some new and latest advancements.

So, our second classification is based on the years from which articles have been chosen, i.e., from the year 2009 to 2019, focusing more on the latter years. Figure 2 shows the maximum no. of articles that have been selected from the year 2017 to 2019.

3.3 Substrate Material

The third classification presents the main subject of our systematic review. It helps us in analyzing which textile material has been mostly used in fabricating wearable antennas. The substrate's textile material is selected in a way that it must satisfy the ideal range of values of different parameters (gain, SAR, return loss, efficiency, etc.) of the wearable antenna [10]. Despite this, the environment-friendly fabric should provide enough flexibility and wearability. Table 1 shows various textile materials that can be used as a substrate based on the objective being achieved.

Each material has its strengths and weaknesses, e.g., felt fabric is relatively firm, is inelastic, has a smooth surface, is light in weight, and is easy for fabricating. On the other hand, Silk [11] provides the least return loss as compared to jeans and cotton and is more reflective. Whereas Jeans [12] as a textile material have higher permittivity. Its thickness provides good isolation between a radiating antenna and the absorbing human body. Hence, taking into consideration the different properties of the fabric, it is therefore selected as a substrate for fabricating an antenna.

4 Antenna Structure

The fourth classification relates to the type of antenna being used as per their advantages in the associated field. Based on structures and principles, various antennas exist, namely wire, aperture, lens, microstrip, array, and reflector [13]. But the commonly used antenna in the wearable monitoring field is the Microstrip Patch antenna. It has a very thin strip of metal placed on the ground plane and a dielectric in between.

Commonly, the patch antennas used are square, circular, or rectangular for ease of analysis and fabrication. The major advantages of Microstrip antennas include lightweight, minimal cost, ease of fabrication, and installation. Whereas its inefficient radiation and narrow frequency bandwidth are a matter of concern. But as we have seen from our studies that for flexible wearable textile antennas, a full ground plane is the most effective method to protect the antenna from detuning and also the planar structure [14] helps to ensure proper integration onto the body. Such ground planes are available in microstrip patch antennas; therefore, they are widely used.

4.1 Tools

The fifth classification describes the simulation tool used in the articles. For designing an antenna, two simulation software tools are being currently used namely CST and HFSS.

Computer Simulation Technology (CST) is a high-performance integrated software based on finite integration technique that helps in analyzing antenna with such ease that it even detects the flaws in the working of any model and further enables the use of virtual prototyping.

On the other hand, High-Frequency Structure Simulator (HFSS) is a simulator tool based on the finite element method field solver to compute the electrical behavior of complex components. It is also a commercial tool that provides high-performance computing.

4.2 Fabrication/Feeding Techniques

The sixth classification explores the antenna fabrication method [15] or the feeding technique involved in the articles. The techniques used in the articles show different results and listed below are the currently available techniques for fabricating flexible antennas:

(i) Screen printing: In [16], it is considered to be one of the simplest and environmentally friendly techniques in which a screen with open areas is placed above the substrate through which the ink flows, onto the substrate surface. But this technique also has some drawbacks which are mentioned in.
(ii) Sewing: For a textile-based antenna, the most preferred technique is sewing and it does not alter the electrical properties of the material.
(iii) Adhesive: The technique is used during the fabrication of the patch and ground (i.e., conductive) part of an antenna using either flexible adhesive copper sheet or adhesive conductive fabric or conductive thread. Monti et al. [17] provides a detailed description.
(iv) Direct handwriting: This novel method uses pen and sprays for the design of a wearable antenna. The conductive material can be easily added onto substrates using a pen and sprays on the other hand can be used more in the designing of 3D forms [18].
(v) Inkjet printing: This technology provides a fast solution as it uses highly conductive inks for printing antennas and RF circuits. Khaleel et al. [19] thoroughly elaborated how inkjet printing works.
(vi) Substrate Integrated Waveguide: Substrate Integrated Waveguide (SIW) technology is a cost-effective fabrication process that combines the merits of both planar and non-planar guided structures. There are different SIW structures [20] that provide size miniaturization, increase flexibility of design and bandwidth, and gain improvement. Since this novel technology has been popularized in the past few years, it has its advantages and disadvantages with its unique design presented in [21].

5 Key Features

Lastly, the seventh category presents the notable findings of the articles. Most importantly, the major findings that make an antenna convenient for use in wearable applications are improved gain, good efficiency, and lower value of SAR.

After reviewing these articles and comparing all the textiles that have been used, Denim provides good gain, high efficiency, and impedance matching. The results achieved are mainly due to some changes applied during the fabrication process like the addition of a second substrate, the introduction of EBG structure, patch size reduction, and many more.

6 Conclusion

This paper presented the survey of research literature on how the different textile fabrics based on their properties can be used to fabricate Wearable Textile Antennas. A total of 33 articles describing textile antennas working at the 2.45 GHz ISM band were found to be within our scope.

We may draw a few conclusions from our systematic review. First, several new substrates and conductive materials such as meta composites, MXene ink, polymer nanocomposite, and polymer gel came into existence for antenna design fabrication. Second, for an antenna to be portable and lightweight, researchers are currently working on various new miniaturized antennas like button-shaped, single, and multi-band antennas. Third, for the designing of wearable antennas, several new fabrication methods such as direct handwriting, direct cutting, and 3D laser cutting are getting much attention. Thus, this paper will surely be helpful for new researchers who will try to explore new aspects in the field of wearable antennas.

References

1. Wang, J. C., Lim, E. G., Leach, M., Wang, Z., & Man, K. L. (2016). Review of wearable antennas for WBAN applications. *IAENG International Journal of Computer Science, 43*(4), 474–480.
2. Shokeen, S., & Parkash, D. (2019). A systematic review of wireless body area network. In *2019 International Conference on Automation, Computational and Technology Management* (pp. 58–62).
3. Potey, P. M., & Tuckley, K. (2018). Design of wearable textile antenna with various substrate and investigation on fabric selection. In *2018 3rd International Conference on Microwave and Photonics (ICMAP 2018)*, January (pp. 1–2).
4. Tronquo, A., Rogier, H., Hertleer, C., & Van Langenhove, L. Applying textile materials for the design of antennas for wireless body area networks. In *European Space Agency (Special Publication), ESA SP* (Vol. 626 SP).
5. Ali, U., et al. (2017). Design and SAR analysis of wearable antenna on various parts of human design and SAR analysis of wearable antenna on various parts of human body, using conventional and artificial ground planes, December 2016, 2017
6. Zeouga, K., Osman, L., Gharsallah, A., & Gupta, B. (2018). Truncated patch antenna on jute textile for wireless power transmission at 2.45 GHz. *International Journal of Advanced Computer Science and Applications, 9*(1), 301–305.
7. Noor, W., Wan, N., Abidin, Z. Z., & Dahlan, S. H. (2015). Rectangular patch with partial ground wearable antenna for 2.4 GHz applications. In *2015 IEEE International RF and Microwave Conference* (pp. 104–109).
8. Hussain, S., Hafeez, S., Memon, S. A., & Pirzada, N. (2018). Design of wearable patch antenna for wireless body area networks. *International Journal of Advanced Computer Science and Applications, 9*(9), 146–151.
9. Jais, M. I., Jamlos, M. F., Jusoh, M., Sabapathy, T., & Kamarudin, M. R. (2013). 2.45 GHz beam-steering textile antenna for WBAN application. In *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)* (pp. 200–201).
10. Salvado, R., Loss, C., Gonçalves, R., & Piuho, P. P. (2012). Textile materials for the design of wearable antennas: A survey. *Sensors*, 15841–15857.

11. Rexiline Sheeba, I., & Jayanthy, T. (2018). Design and implementation of a flexible wearable antenna on the thyroid gland in the detection of cancer cells. *Biomedical Research*, *29*(11), 2307–2312.
12. Purohit, S., & Raval, F. Wearable-textile patch antenna using jeans as substrate at 2.45 GHz. *International Journal of Engineering Research and Technology (IJERT)*, *3*(5), 2456–2461.
13. Balanis, C. A. (2005). *Antenna Theory: Analysis and Design.*
14. Rajo-Iglesias, E., Gallego-Gallego, I., Inclan-Sanchez, L., & Quevedo-Teruel, O. (2014). Textile soft surface for back radiation reduction in bent wearable antennas. *IEEE Transactions on Antennas and Propagation, 62*(7), 3873–3878.
15. Monne, M. A., Lan, X., & Chen, M. Y. (2018). Material selection and fabrication processes for flexible conformal antennas. *International Journal of Antennas and Propagation, Hindawi.*
16. Li, Y., Zhang, Z., Feng, Z., & Khaleel, H. R. Chapter 1 Fabrication and measurement techniques of wearable and flexible antennas (Vol. 82).
17. Monti, G., Corchia, L., & Tarricone, L. (2013). Fabrication techniques for wearable antennas. In *10th European Conference on Synthetic Aperture Radar* (pp. 435–438).
18. Han, J., Kim, B., Li, J., & Meyyappan, M. (2014). Carbon nanotube ink for writing on cellulose paper. *Materials Research Bulletin, 50*, 249–253.
19. Khaleel, H., Al-Rizzo, H. M., & Abbosh, A. I. (2016). IntechOpen. *Intech, WOS*, 13.
20. Bozzi, M. (2012). Substrate integrated waveguide (SIW): An emerging technology for wireless systems. In *Asia-Pacific Microwave Conference Proceedings, APMC* (pp. 788–790).
21. Kumar, H., Jadhav, R., & Ranade, S. (2012). A review on substrate integrated waveguide and its microstrip interconnect. *IOSR-JECE, 3*(5), 36–40.
22. Agneessens, S., Member, S., Lemey, S., Vervust, T., Rogier, H., & Member, S. (2015). Wearable, small, and robust: The circular quarter-mode textile antenna. *IEEE Antennas and Wireless Propagation Letters, 14*, 1482–1485.
23. Lajevardi, M. E., Member, S., & Kamyab, M. (2017). Ultraminiaturized metamaterial-inspired SIW textile. *16*, 3155–3158.
24. Nguyen, T. M., Chung, J., & Lee, B. (2015). Radiation characteristics of woven patch antennas composed of conductive threads. *IEEE Transactions on Antennas and Propagation, 63*(6), 2796–2801.
25. Ali, S., Chowdhury, H. R., Ahmed, A., & Selection, A. M. (2017). Experimental characterization of a textile antenna working at 2.4 GHz. In *2017 2nd International Conference Electrical, Electronic and Systems Engineering*, December (pp. 1–4).
26. Amaro, N., Mendes, C., & Pinho, P. (2011). Bending effects on a textile microstrip antenna. In *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)* (pp. 282–285).
27. Roy, B., Sarkar, P. P., & Chowdhury, S. (2013). Wideband rectangular wearable jeans antenna. *Wiley Period, 55*(6), 1270–1273.
28. Moro, R., Agneessens, S., Rogier, H., & Bozzi, M. (2017). Circularly-polarised cavity-backed wearable antenna in SIW technology (pp. 127–131).
29. Joler, M., & Boljkovac, M. (2018). A sleeve-badge circularly polarized textile antenna. *IEEE Transactions on Antennas and Propagation*, *66*(3), 1576–1579.
30. Agneessens, S., Rogier, H., Moro, R., & Bozzi, M. (2014). Robust, wearable, on-body antenna relying on half mode substrate integrated waveguide techniques. In *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)* (pp. 313–314).
31. Desai, S., Nagrale, N. B., & Kadam, M. (2017). Single band planar monopole antenna with A-shaped EBG. In *International Conference on Trends in Electronics and Informatics* (pp. 74–77).
32. Jain, S. K., Baviskar, N., Golait, N., & Jain, S. Design of wearable antenna for various applications. In *Antenna Test and Measurement Society (ATMS)-India* (pp. 2–6).
33. Gil, I., & Fernández-Garcia, R. (2017). Wearable PIFA antenna implemented on a jean substrate for wireless body area network wireless body area network. *Journal of Electromagnetic Waves and Applications, 5071*, 1–11.

34. Ishii, Y., & Shimasaki, H. (2016). Measurement of a slot antenna backed by a half-cylindrical cavity made of conductive textiles. In *Proceedings of ISAP, Okinawa, Japan* (pp. 354–355).
35. Kazani, I., Declercq, F., Hertleer, C., & Rogier, H. (2014). Performance study of screen-printed textile antennas after repeated washing. *Autex Research Journal*, *14*(2).
36. Christina, G., Rajeswari, A., Lavanya, M., Keerthana, J., Ilamathi, K., & Manoranjitha, V. (2016). Design and development of wearable antennas for tele-medicine applications. In *2016 International Conference on Communication and Signal Processing*, April (pp. 2033–2037).
37. Bai, Q., & Langley, R. (2011). Textile PIFA antenna bending. In *2011 Loughborough Antennas and Propagation Conference*, November 2011.
38. Ferreira, D., Pires, P., Rodrigues, R., & Caldeirinha, R. F. S. (2017). Wearable textile antennas. *IEEE Transactions on Antennas and Propagation.*
39. Ashap, A. Y. I., Abidin, Z. Z., Dahlan, S. H., Majid, H. A., Yee, S. K., & Saleh, G. Flexible wearable antenna on electromagnetic band gap using PDMS substrate flexible wearable antenna on electromagnetic band gap using PDMS substrate. *Telkomnika*, *15*(3), 1454–1460.
40. Ha, S.-J., Jung, Y.-B., Kim, Y., & Jung, C. W. (2012). Reconfigurable beam-steering antenna using dipole and loop combined structure for wearable applications. *ETRI Journal, 34*(1), 1–8.
41. Ivši, B., & Bonefa, D. (2014). Implementation of conductive yarn into wearable textile antennas. *IEEE Access*, 2–5.
42. Oguntala, A., Abd-alhameed, R. A., Member, S., & Noras, J. M. (2018). Inverted E-shaped wearable textile antenna for medical applications. *IEEE Access*, e.
43. Khan, S. B., & Ullah, F. (2018). Electromagnetic bandgap wearable dipole antenna with low specific absorption rate. In *2018 International Conference on Computing, Mathematics and Engineering Technologies: Invent, Innovate and Integrate for Socioeconomic Development, iCoMET 2018—Proceedings*, January (pp. 1–4).
44. Suraya, A. N., et al. (2019). Wearable antenna gain enhancement using reactive impedance substrate. *Indonesian Journal of Electrical Engineering and Computer Science, 13*(2), 708–712.
45. Ashyap, A. Y. I., et al. (2018). Highly efficient wearable CPW antenna enabled by EBG-FSS structure for medical body area network applications. *IEEE Access, 6*, 77529–77541.
46. Gil, I., Ferna, R., & Tornero, A. (2018). Embroidery manufacturing techniques for textile dipole antenna applied to wireless body area network. *Textile Research Journal*.
47. Embong, E. N. F. S. E., Rani, K. N. A., & Rahim, H. A. (2018). The wearable textile-based microstrip patch antenna preliminary design and development. In *2017 IEEE 3rd International Conference on Engineering Technologies and Social Sciences (ICETSS 2017)*, January (pp. 1–5).
48. Loss, C., Salvado, R., Goncalves, R., & Pinho, P. (2018). Development of a textile antenna using a continuous substrate integrating the ground plane. In *2018 IEEE Antennas and Propagation Society International Symposium and USNC/URSI National Radio Science Meeting, APSURSI 2018—Proceedings* (pp. 1679–1680).
49. Prabhakar, D., Prasad, V. V. K. D. V., Ramcharan, T. S., Vamsisai, T., Pravallika, Y., & Anil, K. Wearable antennas using different substrates. *International Journal of Engineering and Advanced Technology (IJEAT)*, *8*(4), 820–823.

Artificial Intelligence in Formulation and Product Design of BCS Class I and II Drugs

Jayant Singh Goud, Sanjay Kumar Elisetti, Navneet Kaur, Ranjit Singh, Kamaljit Singh Saini, and Vimal Arora

Abstract The pharmaceutical product development process is a challenging process involving two significant steps, namely formulation development and product manufacturing. A formulation comprises of an API/drug (pharmacological active compound) and a group of inactive substances known as excipients. The process of selecting excipients and their proportion in an intended physical form of the drug for its administration (dosage form or pharmaceutical product) is known as the formulation. The selection of excipient(s) is a complex process that depends upon various factors associated with the drug, drug-excipient interaction, and the impact of the excipient on the product efficacy, i.e., its intended attributes like product stability, drug release, bioavailability, and many more. Thus, it involves extensive experimentation and hence is challenging in terms of carrying out these requisite trial runs. The application of artificial intelligence may help in reducing the time required to carry out trials and wastage of resources via providing limited and promising formulation designs based upon the evaluation and correlation of existing experimental data through various networking models. In this manuscript, we have represented the outcome of an AI-based pharmaceutical formulation design model which supports the active involvement of AI into fully automated computer-assisted pharmaceutical product development solution, leading to optimization of resource and overcoming the financial constraints via avoiding excessive wastages expected during product design trials.

Keywords Artificial intelligence · Formulation · Product design · BCS Class I drugs · BCS Class II drugs · Excipients

J. S. Goud · S. K. Elisetti · V. Arora (✉)
University Institute of Pharma Sciences (UIPS), Chandigarh University Gharuan, Mohali, Punjab 140413, India
e-mail: draroravimal@gmail.com

N. Kaur · R. Singh · K. S. Saini
University Institute of Computer Sciences and Engineering Chandigarh University Gharuan, Mohali, Punjab 140413, India
e-mail: navneet.e11384@cumail.in

K. S. Saini
e-mail: kamaljit.cse@cumail.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_44

1 Introduction

The development of an effective and an efficient physical form for administration of a therapeutic substance or a drug is a complex, expensive, and time-consuming process. When we consider the development of a pharmaceutical product as a process from its initial concept, evaluation of its safety and efficacy, followed by its commercial availability in the market, it is estimated to be a multiphasic process that usually takes about 15–20 years and more than £500 million. This multiphasic process comprises of early screening ranging about 3–5 years, followed by preclinical investigation that takes about 2–4 years, clinical studies of about 3–6 years, and last phase comprises of product design development which also deals with regulatory processes related to product approval and its marketing [1]. The different stages in pharmaceutical product development are illustrated below [2].

- New drug research (laboratory level).
- Preclinical (animal testing) and safety evaluation
- Human trials for safety and efficacy.
- Regulatory approval of drug (FDA)
- Post marketing surveillance (after commercial manufacturing and sales)

2 Pharmaceutical Product Development

The last phase (prior to commercial marketing and distribution) in the pharmaceutical product development involves number of two major steps, namely formulation development and the product manufacturing. A formulation comprises of an API/drug (pharmacological active compound) and a group of inactive substances known as excipients. The process of selection of excipients and their proportion in an intended physical form of the drug for its administration (dosage form or pharmaceutical product) is known as the formulation. The selection of excipient(s) is itself a complex. Process depends upon various factors as illustrated below.

Excipient selection parameters:

- Intended dosage form
- Drug type and dose
- Role in design
- Drug-excipient compatibility
- Route of administration

Therefore, the selection of excipients is a challenging process relying on various experimental procedures or trials involving experimentation data and statistical tools. Two major concerns in this process are type of drug which is affected by physical, physicochemical, and drug substance chemical properties that govern its bioavailability and efficacy, which in turn may called as the product efficacy and the

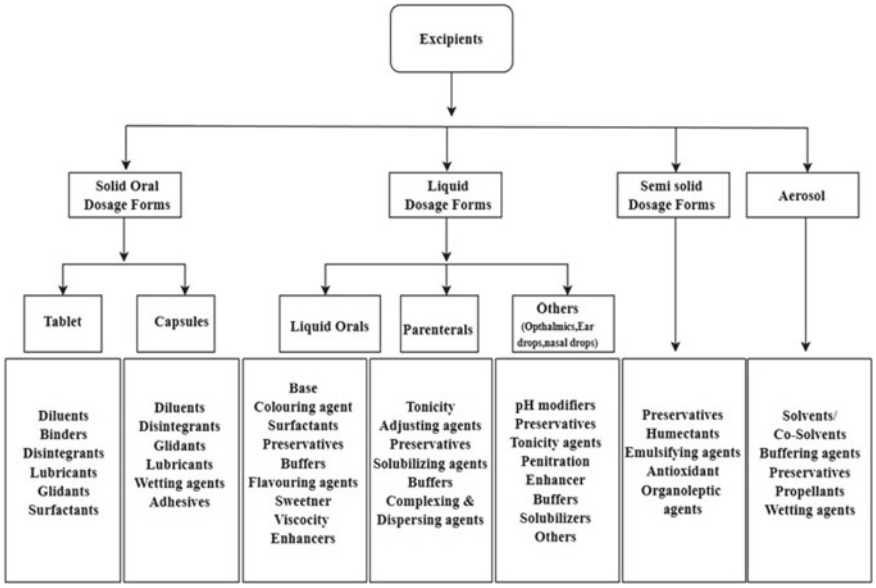


Fig. 1 Classes of excipients of different dosage form

intended dosage form, as different dosage form involves different set of excipients, as illustrated in the Fig. 1.

3 Classification of Drug as Per the Biopharmaceutical System

As per the "biopharmaceutical classification system" (BCS), there are four different classes of drugs, namely Class—I, II, III, and IV [3]. In BCS Class I drug, both solubility and permeability are high, and these compounds are absorbed very well because of which such drug formulations can avoid the use of solubility and permeability enhancer excipients. BCS Class IIcontains compounds with low solubility and high permeability which exhibits a rate of dissolution, but the absorption is limited. Likewise, all drugs from various classes showcase different properties as shown below [4]. And Table 1 is stating the standards used to define the solubility index of a drug.

BCS Classes:

Class I: High solubility and high permeability.

Class II: Low solubility and high permeability.

Class III: High solubility and Low permeability.

Table 1 Applications of artificial intelligence techniques

A	AI in pharmaceutical product design	• Predicting the 3 dimentional target protein structure • Prediction of interactions between drug and protein • AI in determination of drug activity • AI in de novo drug design
B	AI in poly-pharmacology	• Designing bio-specific drug molecules • Design multitarget drug molecules
C	AI in chemical synthesis	• AI in the prediction of reaction yield • AI in the prediction of retrosynthesis pathway • Developing insights into reaction mechanisms • AI in designing the synthetic route
D	AI in drug screening	• Toxicity prediction • Bioactivity prediction • Physicochemical property prediction • Identification of the target cell and classification
E	Applications of AI in product development	*i Clinical trial design and monitoring* • Subject selection • Patient dropout • Monitoring of trails *ii QA and QC* • Regulation of in-line quality • Guide future production cycle • Understand critical process parameters *iii Pharmaceutical manufacturing* • Correlation manufacturing • Automated manufacturing • Errors to set parameters • Personalized manufacturing *iv Pharmaceutical product management* • Market prediction and analysis • Market positioning • Product costing
F	Drug discovery	*i Drug design* • Prediction of targeted protein structure • Interaction between drug and protein • De novo product design *ii Drug screening* • Prediction of bioactivity [11] • Prediction of toxicity [12] • Prediction of physicochemical property

(continued)

Table 1 (continued)

G	Pharmaceutical product development	• Aid in deciding suitable excipients • Monitoring and modifying development process • Ensuring in-process specification compliance

Class IV: Low solubility and Low permeability.

4 Excipients Used in Pharmaceutical Formulations

The different classes of excipients are illustrated in the list bellow [5–8].

Binders: (Used in solid dosage forms—tablet, capsule, powder) Binding agents are materials/substance which holds the materials/substances together which chemically or mechanically forms a cohesive whole.

Example: Starch paste, acacia, PVP, HPMC, methylcellulose, gelatin, etc.

Lubricants: (Used in solid dosage forms—tablet, capsule, and powder) Lubricants are substances typically used to reduce friction between parts in contact.

Example: Boric acid, sodium acetate, sodium oleate, sodium chloride, etc.

Anti-adherent: (Used in solid dosage forms—tablet, capsule, powder) Anti-adherents are the substances which helps in prevention of tablet adhesion properties.

Example: Talc, corn starch, Cab-O-Sil, silicon dioxide, etc.

Glidants: (Used in solid dosage forms—tablet, capsule, powder) Glidants are used as additive substances which enhance the flow property of a powder by reduction of inter-particle friction, cohesion, and surface charge, by which angle of repose was decreased.

Example: Talc, corn starch, Cab-O-Sil, silicon dioxide, etc.

Disintegrants: (Used in solid dosage forms—tablet, capsule, powder) Disintegrants are used to facilitate the disintegration into small fragments of the compressed tablets in aqueous media.

Example: Natural starch (corn, potato), sodium starch glycolate, pregelatinized starch, modified corn starch.

Diluents: (Used in solid dosage forms—tablet, capsule, powder) A diluent/diluting agent is used as the vehicle in a medicinal preparation.

Example: ***Sugars***: A sweet crystal-like substance taken from a number of plants, specially sugar cane and sugar beet, containing essentials of sucrose, and used as a sweetener in food and drink, e.g., dextrose, lactose, sucrose, amylose, inositol, sorbitol, mannitol, etc.

Polysaccharides: A carbohydrate whose particles comprise of amount of sugar molecules fused together, e.g., starches**,** modified starch, microcrystalline cellulose, cellulose, etc.

Inorganic compounds: An inorganic compound which is naturally a chemical compound lacks carbon and hydrogen bonds, e.g.: calcium phosphates, trihydrate, calcium lactate dehydrate, magnesium oxide, magnesium, carbonate, calcium carbonate, etc.

Flavors: Flavoring agents are used to either mask the bitter taste of the API/drug or to provide a flavor or taste to the product, especially pediatric preparations, e.g., citrus oil, cardamom tincture, and other aromatic waters, etc.

Coloring Agent: (Used in both liquid and solid dosage forms—tablet, capsule, powder) Coloring agents are generally used to change or impart the appearance of pharmaceutical dosage forms.

Example: D&C Red 22 (Eosin Y), FD&C Blue 1 (Brilliant Blue FCF), FD&C Yellow 5 (Tartrazine), FD&C Blue 2 (Indigocarmine), FD&C Yellow 6 (Sunset Yellow FCF), FD&C Green 3 (Fast Green FCF), etc.

5 Artificial Intelligence (AI)

"Artificial intelligence" (AI) is a field concerned with developing and applying algorithms for data processing, learning, and interpretations [9]. The field of artificial intelligence is very relevant in the field of pharmaceutical product development, since drug product development is much expensive and time-consuming process. The formulation part of drug product development requires an enormous amount of data, which makes artificial intelligence algorithm techniques unique for the product formulation. One way to reduce this complexity is by making use of artificial intelligence algorithms that are able to predict good drug formulations from the diverse sets of data usually obtained from previously performed researches. In this way, an algorithm that is trained on information such as a set of formulations can predict the best [10].

6 Types of Artificial Intelligence Techniques

There are two types of AI, type 1 and type 2.

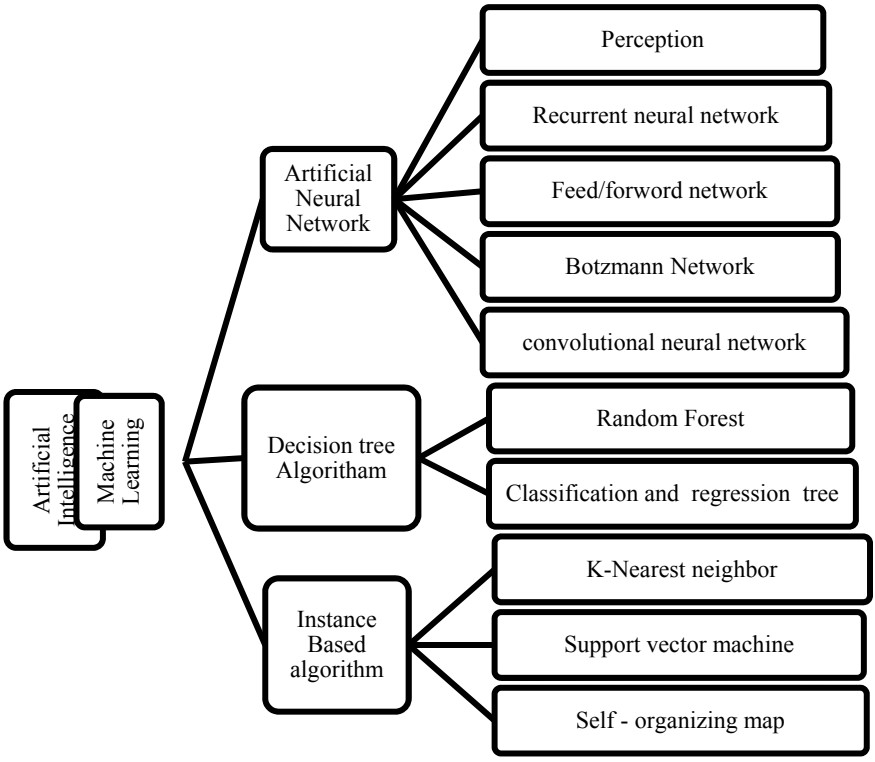


Fig. 2 Different AI methods with subfields that can be helpful in different fields [13]

Type 1: Based on capability:
(i). Weak AI. (ii). General AI (iii). Super AI.
Type 2: Based on functionality:
(i). Reactive missions. (ii). Limited memory.
(iii). Theory of mind. (iv). Self-awareness.

Various applications of AI and types of algorithms helpful in variety of fields are described in the Fig. 2.

7 AI in Product Development

The formulation and process factors must be improved during the pharmaceutical product development process, which is a multivariate optimization problem. These properties make them ideal for solving difficulties in the pharmaceutical product development field, such as formulation optimization. “In studies evaluating the impacts of numerous factors such as formulation and deformation parameters on

tablet physicochemical qualities, these models displayed improved fitting and forecasting abilities in the development of solid dosage forms [14]. It can also be utilized to forecast the phase behavior of quaternary microemulsion-forming systems made up of oil, water, and two surfactants. This type of technology can also be effectively used in the design and assessment of the targeted or specialized drug delivery like. For controlling and making decisions, the integration of neural networks is a potentially useful tool that increases the technique's adaptability and capability while also producing a powerful output" [15, 16].

8 Challenges in Product Design and Application of AI

There are several challenges that make the process of pharmaceutical product design a complicated procedure. The main challenge in product formulation is the selection of excipients which is playing a key role in the pharmaceutical product development and optimization of a range of process variables in the numerous trial formulations to get one best formulation with the desired result. By applying artificial intelligence (AI) in the formulation and product design that can reduce challenges which are facing during product design, which saves a variety of resources such as manpower, money, time, and experimental efforts. So, if we develop the predictive analytics software, we can predict the best formulation without experimenting on different numbers formulation by producing algorithms by using collected set of data related to the drug formulations. AI can also assist in obtaining fast and better pharmaceutical formulations with desired results especially in the case of bioequivalent products via reducing resource usage. Recent advancements in numerous analytical tools and ongoing improvements in the algorithms led to the faster growth of AI applications in many areas in pharmaceutical sciences.

AI in product development:

- AI in product design
- AI in poly-pharmacology
- AI in chemical synthesis
- AI in drug repurposing
- AI in drug screening

The role of artificial intelligence in this work is to predict the best formulation combination via predictive analysis model on the basis of algorithms designed using a set of data collected from previously done experiments which are duly endorsed via their publication in the reputed journals (including Scopus/wos/SCI, etc). At this stage of time, it is offering solution and using non-decisive AI type (designed as a prototype), and this work will be extended further to counter real time issues using a fully functional decisive AI solution covering all possible set of material interactions and limitations.

9 Materials and Method

Methodology:

- The data has been collected from the research/experimental data published in the peered reviewed journals focusing on the product development strategies used for formulating tablet formulation for BCS Class I and II drugs.
- Then, the database has been designed followed by the design of artificial neural networking based on algorithms using various inputs affecting product development.
- Software interface was developed using Python.
- The user interface was designed to allow input of some pre-requisite information about the product.
- The best possible formulation is suggested by the program as an outcome.
- The suggested formulation was designed in lab to validate the outcomes experimentally.

Sample formulation used for the database is given in Tables 2 and 3.
Ofloxacin is a BCS Class II drug used as an antibiotic/antibacterial drug [18].

Table 2 Ofloxacin: 200 mg tablet

Ofloxacin	200 mg	*Excipients*	(*mg*)	Wet granulation technique [17]	85% drug release in 45 min
		Ofloxacin	200		
		Acacia arabica	15		
		Carboxymethyl cellulose	15		
		Dicalcium phosphate	66.5		
		Magnesium stearate	1		
		Talc	2.5		

Table 3 Fluoxetine: 75 mg tablet

Fluoxetine	75 mg	*Excipients*	(*mg*)	Direct compression	96.35% drug release in 1.2 h
		Fluoxetine	75		
		HPMC K4M	50		
		Carbopol 934	20		
		Sodium Bicarbonate	30		
		Citric acid	10		
		Mg stearate	3		
		Lactose	37		

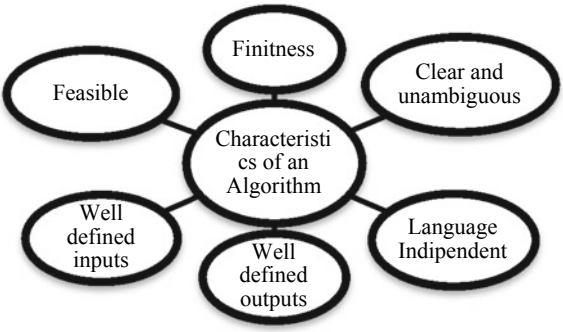


Fig. 3 Characteristics of an algorithm

Fluoxetine is a BCS Class I drug used as antidepressant drug [19].

Therefore, the tables indicate the wide variety of excipients and their variable proportion that have been used in the database for predictive analysis for effective utilization of data using artificial neural networking algorithms.

10 Algorithm

"A computer-implementable algorithm is a finite sequence of well-defined, computer-implementable instructions used to solve a class of problems or conduct a calculation. Simply we can say that algorithms are a set of instructions, which have to give to the program by using that program we can get the predictive analysis result."

There are numerous characteristics of an algorithm to make it fit for use for any given predictive analysis. The major characteristics of an effective algorithm are illustrated in the Fig. 3.

In this experimentation, we have designed an AI-based formulation design solution which is based up on the neural networking, as illustrated in the Fig. 4 [13]:

11 Results

We have designed some pharmaceutical tablets for the BCS Class I and II drugs based on the formulations proposed by the above designed AI model for pharmaceutical formulation design and carried out various quality control tests to assess the product for its intended attributes. It was observed that the products designed using this AI-based formulation design solution were very effective and comply with all the intended quality attributes (Fig. 5).

The trial formulations as predicted by the designed computer solution are given in the Tables 4 and 5.

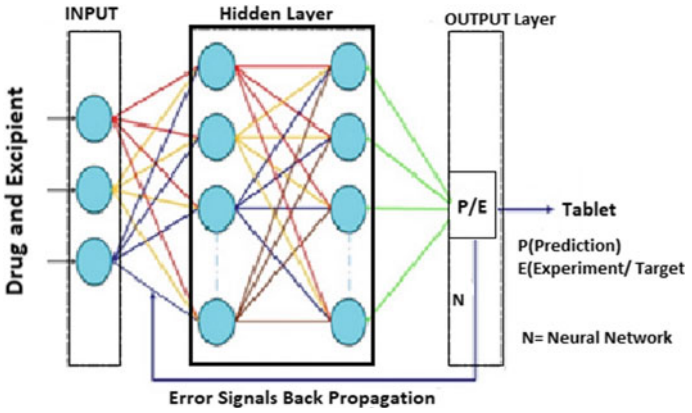


Fig. 4 Illustration of neural networking

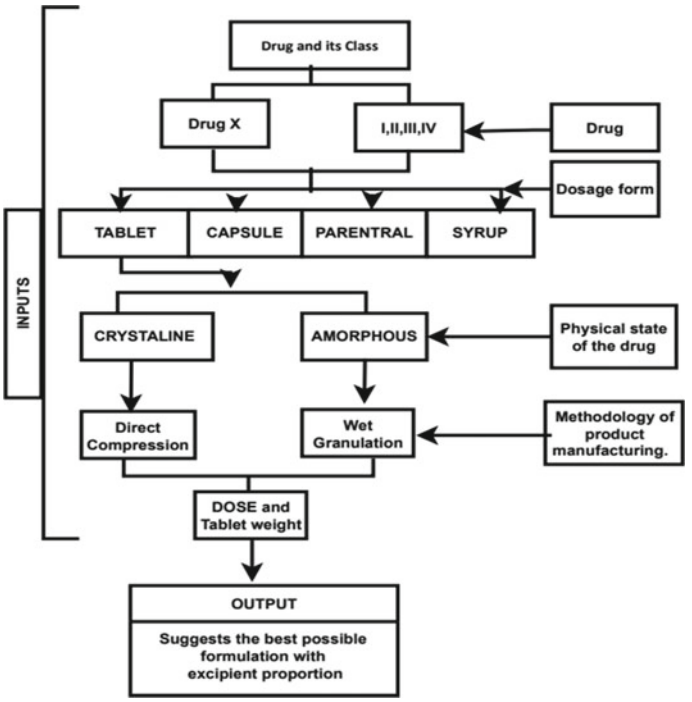


Fig. 5 AI model interface (inputs and outputs)

Table 4 Chlorpheniramine maleate formulation suggested by the computer solution prepared in laboratory

Drug	Excipients	Formulation (mg)
Chlorpheniramine maleate	Chlorpheniramine maleate	4
	Co-processed excipients (CPE)	129.5
	Sodium starch glycolate	12
	Magnesium stearate	3
	Colloidal silicon dioxide	1.5
	Total (mg)	150

Table 5 Amlodipine formulation suggested by the computer solution prepared in laboratory

Drug	Excipients	Formulation (mg)
Amlodipine	Amlodipine besylate	10
	Ocimum basilicum gum	10
	Microcrystalline cellulose (MCC)	100
	Magnesium stearate	1.5
	Talc	2
	Mannitol	76.5
	Total (mg)	200

The quality control of the formulations designed in lab was carried out for the parameters illustrated in the Table 6. All the quality control parameters were observed to be in acceptable limit which represents the viability of this project as a prototype. All the quality control parameters were observed to be in acceptable limit which represents the viability of this project as a prototype.

Table 6 Evaluation parameters were tested for both formulations

Evaluation parameters	Chlorpheniramine maleate	Amlodipine
Weight variation (mg)	152.12 ± 1.53	201 ± 0.80
Friability (%)	0.07 ± 0.091	0.76 ± 0.8
Hardness (kg)	5.9 ± 0.29	3.3 ± 0.56
Diameter (mm)	7.97 ± 0.00	7.98 ± 0.02
Thickness (mm)	3.19 ± 0.03	3.4 ± 0.78

12 Conclusion

i. The results of this experimental study revealed that this sort of approach may be effectively used in the pharmaceutical industries involved in the product design, especially the bioequivalent products.
ii. The outcomes also support this approach for its potential to be economic and time saving solution for pharmaceutical product design.
iii. Furthermore, this approach of using AI in pharmaceutical product development may be extended to the next level of solutions, where the decisive models may be designed in future that may in turn be explored for their commercial viability in pharmaceutical and food industry.

Acknowledgements I would like to acknowledge the inputs given by the team members of University Institute of Computer Sciences and Engineering for their support in compiling and framing the algorithms and networking-related components of the project.

References

1. Institute of Medicine. (2014). *Improving and accelerating therapeutic development for nervous system disorders: Workshop summary.* National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK195047/
2. USF. (2018). *The drug development process.* https://www.fda.gov/patients/learn-about-drug-and-device-approvals/drug-development-process
3. Zhang, X., Xing, H., Zhao, Y., & Ma, Z. (2018). Pharmaceutical dispersion techniques for dissolution and bioavailability enhancement of poorly water-soluble drugs. *Pharmaceutics*, *10*(3). https://doi.org/10.3390/pharmaceutics10030074
4. Papich, M. G., & Martinez, M. N. (2015). Applying Biopharmaceutical Classification System (BCS) criteria to predict oral absorption of drugs in dogs: Challenges and pitfalls. *The AAPS Journal, 17*(4), 948–964. https://doi.org/10.1208/s12248-015-9743-7
5. Rajeswari, S., Prasanthi, T., & Malli, R. (2021). Natural polymers: A recent review. *World Journal of Pharmacy and Pharmaceutical Sciences, 6*, 472–494.
6. Mittal, S., & Pawar, S. (2019). *International Journal of Pharmacognosy and Pharmaceutical Sciences*, *1*(1), 5–6.
7. Nyamweya, N., & Kimani, S. (2020). Chewable tablets: A review of formulation considerations. *Pharmaceutical Technology North America, 44*, 38–44.
8. Parkash, V., Maan, S., Dasari, D., Yadav, S. K., Hemlata, & Jogpal, V. (2011). Fast disintegrating tablets: Opportunity in drug delivery system. *Journal of Advanced Pharmaceutical Technology & Research*, *2*, 223–235. https://doi.org/10.4103/2231-4040.90877
9. Häse, F., Roch, L. M., Friederich, P., & Aspuru-Guzik, A. (2020). Designing and understanding light-harvesting devices with machine learning. *Nature Communications, 11*(1), 4587. https://doi.org/10.1038/s41467-020-17995-8
10. Sellwood, M. A., Ahmed, M., Segler, M. H., & Brown, N. (2018). Artificial intelligence in drug discovery. *Future Medicinal Chemistry, 10*(17), 2025–2028. https://doi.org/10.4155/fmc-2018-0212
11. Quiñones, L., Sasso, J., Tamayo, E., Catalán, J., González, J. P., Escala, M., Varela, N., León, J., Cáceres, D. D., & Saavedra, I. (2010). A comparative bioavailability study of two formulations

of pregabalin in healthy Chilean volunteers. *Therapeutic Advances in Chronic Disease, 1*(4), 141–148. https://doi.org/10.1177/2040622310379932
12. Guengerich, F. P. (2011). Mechanisms of drug toxicity and relevance to pharmaceutical development. *Drug Metabolism and Pharmacokinetics, 26*(1), 3–14. https://doi.org/10.2133/dmpk.dmpk-10-rv-062
13. Amani, A., York, P., Chrystyn, H., Clark, B. J., & Do, D. Q. (2008). Determination of factors controlling the particle size in nanoemulsions using artificial neural networks. *European Journal of Pharmaceutical Sciences*, *35*(1), 42–51. https://doi.org/10.1016/j.ejps.2008.06.002
14. Sarantopoulos, P. D., Altiok, T., & Elsayed, E. A. (1995). Manufacturing in the pharmaceutical industry. *Journal of Manufacturing Systems*, *14*(6), 452–467. https://doi.org/10.1016/0278-6125(95)99917-3
15. Bini, S. A. (2018). Artificial intelligence, machine learning, deep learning, and cognitive computing: What do these terms mean and how will they impact health care? *The Journal of Arthroplasty, 33*(8), 2358–2361. https://doi.org/10.1016/j.arth.2018.02.067
16. Mohs, R. C., & Greig, N. H. (2017). Drug discovery and development: Role of basic biological research. *Alzheimer's & Dementia (New York, N.Y.)*, *3*(4), 651–657. https://doi.org/10.1016/j.trci.2017.10.005
17. Agarwal, R., & Yadav, N. (2011). Pharmaceutical processing—A review on wet granulation technology. *International Journal of Pharmaceutical Frontier Research, 1*, 65–83.
18. Mistry, A. K., Nagda, C. D., Nagda, D. C., Dixit, B. C., & Dixit, R. B. (2014). Formulation and in vitro evaluation of ofloxacin tablets using natural gums as binders. *Scientia Pharmaceutica, 82*(2), 441–448. https://doi.org/10.3797/scipharm.1401-14
19. Pakhale, N., Gondkar, S. B., & Saudagar, R. (2019). Formulation development and evaluation of fluoxetine effervescent floating tablet. *Journal of Drug Delivery and Therapeutics, 9*, 358–366. https://doi.org/10.22270/jddt.v9i4-A.3490

Blockchain Technology for Better Security by Using Two-Way Authentication Process

Ayasha Malik, Jaya Srivastava, Bharat Bhushan, Veena Parihar, V. S. Anoop, and Ahmed Alkhayyat

Abstract In today's era, blockchain is an emerging and successful technology. Blockchain has an incredible impact on many companies or trades that can change society's problems in several regions. Due to the invention of blockchain, the cryptocurrency is manufactured and Bitcoin which is the initial digital crypto-forex. It is a document that can visibly give each Bitcoin's transaction, this is a computer-generated supply of chunks, while the blockchain skills are additionally more consistent and have suitable contributions such as the protection difficulties, and commanding the original or progressive circumstances at the back are also have many dynamic points that need to pay attention. The main problem related to the blockchain is the protection of data with maintaining confidentiality by giving access to the right person; at present, certain studies are there on the blockchain, but there is the absence of a logical assessment on the protection of the data. This research paper delivers a methodical aspect of the protection risks to blockchain and talks about by what means two-way authentication (2-WA) can be established to manage the absence of capacity of individual verification formations. The paper presents the leading fact of blockchain production along with its enhanced confidentiality and

A. Malik (✉)
Delhi Technical Campus (DTC), GGSIPU, Greater Noida, India
e-mail: ayasha07.am@gmail.com

J. Srivastava
ABES Engineering College, Ghaziabad, India

B. Bhushan
School of Engineering and Technology (SET), Sharda University, Greater Noida, India

V. Parihar
KIET Group of Institutions, Delhi-NCR, Ghaziabad, India

V. S. Anoop
Kerala University of Digital Sciences, Innovation and Technology, Technocity Campus, Thiruvananthapuram, Kerala, India
e-mail: anoop.vs@duk.ac.in

A. Alkhayyat
College of Technical Engineering, The Islamic University, Najaf, Iraq
e-mail: ahmedalkhayyat85@iunajaf.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_45

the implementation of 2-WA to the block/chunk for an additional level of protection. 2-WA is the primarily valuable element of security that is used to keep data privately and run smoothly without any intervention. In addition, this research paper contains an assessment of the improvement of security solutions for blockchain that can be utilized in the advancement of various blockchain structures and advise some future instructions to do research attempts hooked on this site.

Keywords Security · Blockchain · Two-way authentication · Data · Transaction · Cybercrime · Privacy · Distributed · Block

1 Introduction

The blockchain and Bitcoin standards were originally suggested in 2008 by Satoshi Nakamoto, who explained how cryptology and an accessible allotted record can be merged into a digital forex function. Bitcoin is a type of digital cryptocurrency which is founded on blockchain knowledge, applied for purchasing and offering items on the net like money exchange inside the real world. Currently, Bitcoin has closed up more common operations, so that blockchain skills can be applied by individuals in various types of areas that can be as subscriptions, economic markets, IoT, stock chain, consulting, scientific solutions, and storage space. The use of these implements or subscriptions in our daily life gives occasion for cyber offenders to interact in cybercrime. Although it was primarily designed for cryptocurrency, blockchain knowledge has been developing its approach with the businesses, and in future, it does not seem to be going away rapidly. The blockchain period will probably be boosted in future. The main advantage of blockchain creation is that it enhanced confidentiality, and the best thing is a feature-factor verification for an additional level of safety. Still, as we utilize those implements or supplies in our everyday routine, cyber offenders get the chance to act together with cybercriminals. For instance, a 51% incident is a usual safety issue in blockchain and Bitcoin while offenders attempt to manipulate the machine procedure, utilizing a similar time cycle procedure. In the blockchain, digital currency operations are documented in "blocks" with the marked time and then miles in a full complicated technological method, but it provides the outcome as a graphic digital operation log which is particularly difficult to disrupt by two. For instance, to begin a transaction operation, you are needed to submit a user ID and password or you have to submit an authentication code that is delivered with the content of the marked phone. Although protection of data in space does not imply, the cryptocurrencies are not obtainable. Hackers struck $534 million and little treasure for $195 million in 2018. Corresponding to Investopedia, hackers do these two greatest cryptocurrency hacks of 2018 [1].

Moreover, the rest of the paper is summarized as follows: Sect. 2 defines the basic concepts and needs of blockchain technology along with its structure, pillars, transmission procedure, and categories. Additionally, Sect. 3 elaborates on the details of blockchain's cryptocurrencies. Here, Bitcoin, Ethereum, and Hyperledger are

discussed. Furthermore, Sect. 4 defines the security concerns and experiments in blockchain technology. Moreover, Sect. 5 discussed the verification process of a user in blockchain, where 1-WA, 2-WA, and M-WA are discussed. In addition, the need for 2-WA is also discussed with its functioning and challenges. Next, Sect. 6 defines the role of 2-WA in the blockchain. Finally, the paper concludes with Sect. 7.

2 Blockchain Technology

The sequence of informative blocks is usually known as a blockchain and it is a dispersed, distributed, unchangeable, and public record. In this kind of behavior, mining of this technique is intended to timestamp digital records; hence, it becomes very difficult to validate or temper with the blocks. The main aim of blockchain is to remove the trouble of dual files without any help from a crucial server. The blockchain mechanism is put together with six key elements discussed below. Additionally, the basic structure of blockchain is shown in Fig. 1.

The blockchain technology is frequently applied for moves of resources such as money, commodities, and bonds without the intervention of third-party agents such as a bank or agencies. Once records are stored within a blockchain, it is always impossible to exchange them. Furthermore, the pillars of blockchain technology that make it more secure are discussed below.

- **Dispersed**—The main aspect of the blockchain method is to record all transaction data, that is, continuously saved and updated the distributed data that are not controlled in the middle. The majority of the blockchains are distributed in systems, and their applicants are competent to link either directly or with a set of nodes that are not controlled in the middle.
- **Translucent**—The documented figures with blockchain mechanism are understandable to each system, and it is also clear on apprising the figures because clearness of documents is reflected the very significant assurances of blockchain technology that offers an entirely auditable and authentic record of transactions.
- **Vulnerable**—Generally, blockchain systems are accessible software, it is accessible to everyone, and entire data can be verified by all creators that can also utilize blockchain skills to make any type of software that they required with the assistance of the application of blockchain technology.

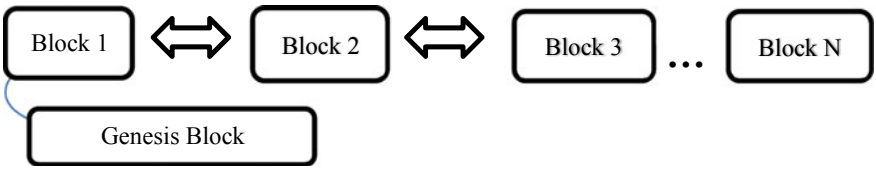


Fig. 1 Structure of blockchain

- **Irreversible**—Hashing is the method of getting a string and providing a set period of the outcome string, and this aspect makes the blockchain so reliable. Every record could be protected for the entire time and cannot be altered until or unless somebody will get control power for more than 51% nodes in an equivalent period, so the movement of data or transaction can be feasible if knowing the individual's deal with the blockchain. This feature makes the blockchain unchangeable [2].

2.1 Structure of Blockchain

A blockchain is a sequence of blocks that contain information and data which is saved within it depending on the kind of blockchain. The primary block in the sequence is known as the genesis block, and all other new-found blocks in the sequence are linked to the preceding block. Each block includes data, hash, and hash of the preceding block. For instance, a blueprint is given for every block and recognizes the block beyond all extra substances, and that blueprint is shared between owners. Therefore, the moment when any modification is done in the block; then, whole interlinked things get disturbed, and owners get to know about unauthorized access [3]. The basic structure of a block in the blockchain is shown in Fig. 2.

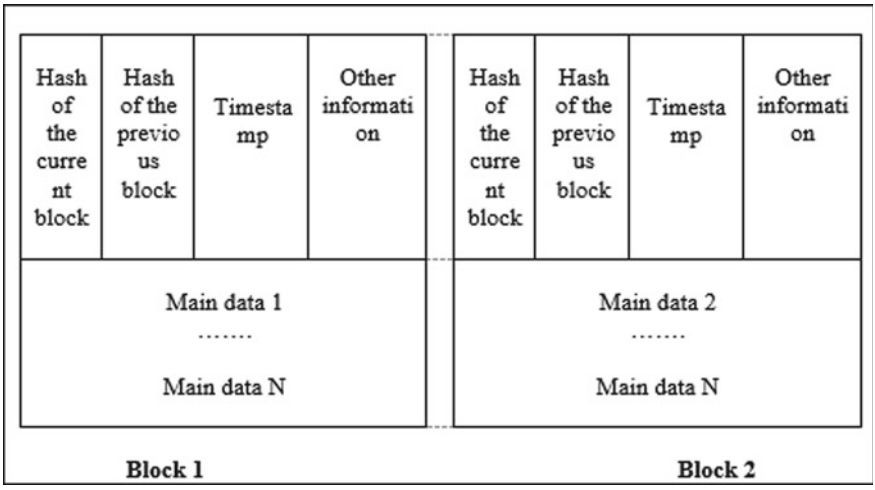


Fig. 2 Structure of block

2.2 Transmission Procedure in Blockchain

Stage 1: When an individual is demanding a transaction. This stage includes activities that may involve cryptocurrency, agreements, particulars, or other kinds of details.

Stage 2: The demanding action is transmitted on a peer-to-peer Web with regional support.

Stage 3: Currently through the support of additional optical procedures, the Web of blocks guarantees operations and customer favorites.

Stage 4: A new-found node is attached to the current blockchain as soon as the assignment is done. In these aspects, it is infinite and unchangeable [4].

2.3 Requirement of Blockchain

Blockchain supports the authentication and tracking of multistage transactions requiring authentication and tracking. It can offer reliable transactions, decrease agreement expenses, and momentum of data transmission management.

- **Safety**—Protection is extremely valuable for the whole kind of online events. A bunch of information has been theft, and information has been violated in this digital globe. Blockchain presents an extremely high ranking of protection that create it hard to split by anybody because of the limited behavior of the blockchain.
- **Reasonable**—Blockchain knowledge is the greatest practical economic standard on the globe. Contrasted to conventional monetary standards, it is extremely costly. Currently, various corporations need to apply blockchain skills as they can store plenty of wealth in their financial standing.
- **Less trading time**—Activities created by applying blockchain expertise need an extremely tiny period to accomplish. It is considerably quicker in respect of what has been accomplished in the conventional expertise.
- **Prevention from fraud**—Because of the superior openness of transactions in blockchain knowledge, every kind of scam can be effortlessly discovered.
- **Zero involvement of the third party**—Through blockchain expertise, there is the possibility of some type of arbitrator or negotiator in any operation such as digital settlement, coverage demands, property supervision, stock transaction, property registry, and a lot more [5].

2.4 Categories of Blockchain

The blockchain can be open, confidential, permissioned, or assembled by a variety of individuals known as a confederation, explained beneath.

Table 1 Difference between three categories of blockchain

Property	Public blockchain [6]	Private blockchain [6]	Consortium blockchain [6]
Immutability	Almost impossible to interfere	Could be interfered	Could be interfered
Efficiency	Low	High	High
Centralized	No	High	Partial
Consensus process	No required of permission	Restricted	Restricted
Consensus determination	All nodes	One identity	Selected nodes
Read permission	Public	Private/public	Private/public
Delay	High	Very low	Low
Speed	Slow	Fast	Fast/slow

- **Public blockchain**—Public blockchain is an unauthenticated blockchain, as records are viewed by everybody on the Web. It allows everyone to authenticate and transmit chunks of communications to the blockchain. Public Webs have motivations for an individual to join in and are relaxed for use.
- **Private blockchain**—Non-public blockchain is a consent blockchain that is inside a specific organization. It permits the greatest exclusive individuals of the corporation to authenticate and transmit business transaction units.
- **Consortium blockchain**—In consortium blockchain, simply a variety of organizations can authenticate and enhance transactions. At this point, the record can be public or restricted to select companies [6]. Furthermore, the major difference between these three categories of blockchain is shown in Table 1.

3 Blockchain's Cryptocurrencies

Cryptocurrency is a technique to modify just as conventional money replacement techniques through USD, but it is intended particularly to modify virtual documents with a method that becomes achievable by process of definite perceptions of cryptography method. The cryptocurrency is described as digital money and applied to evaluate just as a subcategory of other exchanges and virtual money.

- **Digital currency: Bitcoin**—Bitcoin is a homologous method that can continually be monitored by precise organizations or reserves. Presently, this is the planet's biggest cryptocurrency, and everybody can apply Bitcoin for transactions with no procedure fees. Simultaneously, trading with Bitcoin, the source and recipient created a contract instantly deprived of applying the third party.

- **Smart contract: Ethereum**—A smart contract is a product that operates on the Ethereum blockchain. This is a collection of code and intelligence which belong to a specific contract together with the Ethereum blockchain. Smart contracts are a kind of Ethereum account, and this implies that they have found a steady balance and they are capable to send payments over the Web. Though presently, they are not regulated by a customer; as an alternative, they are employed by the public and managed as a designed program. These contracts can also be applied to implement confidentiality securities, for instance, facilitating the discerning release of secrecy-covered documents to meet a chosen demand.
- **Hyperledger**—A Hyperledger is an accessible-resource group dedicated to developing a catalog of strong structures, devices, and archives for organization-quality blockchain operations. It is a landmark worldwide collaboration, presented on the foundation of Linux in December 2015, and contains managers in economics, finance, net elements, purchasing, production, and skills [7].

4 Security Concerns and Experiments

Crypto exchanges are normally made by using blockchain, and it explains by what means transactions are documented in "blocks" by a static period. It is a complicated or scientifically complicated method, although the outcome is a digital record of cryptocurrency payments which is complicated for attackers to own. Likewise, a payment involves a 2-WA procedure. A customer may apply his/her user ID and secret code to begin a recent payment. Afterward, the customer may be requested to submit an authentication code forwarded to the registered mobile number. A few illustrations are here:

- **Coding manipulation**—Decentralized autonomous organization (DAO), a wealth-founded blockchain investment, focused on the way of Bitcoin, was robbed to a greater extent than 60 million imported exchanges—about 3 to 1/3 of its cost. With the development of computer code, in DAO, independent/autonomic estate specifies the self-flexibility of the structure, and this self-adaptability property incorporates four main features self-alignment, self-treatment, self-optimization, and self-defense.
- **Public keys**—Robbery of 73 million USD Bitcoins in earth's biggest cryptocurrency trades, Hong Kong-centered Bitfinex, has developed that currency stays the main threat. The probable object is transferred to non-communal means, which may be non-community digital signatures.
- **Hacking**—When Bithumb, which is the biggest trade of Ethereum and Bitcoin cryptocurrencies trades, has been converted in the most recent attack, attackers smashed 30,000 individual documents and robbed 870,000 costs of USD-Bitcoin [8].

5 Verification of User in the Blockchain

Organizations keep on fighting to discover an excellent approach to obtain solid and trustworthy estates. From the starting of the Internet to the extension of society clouds and fusions, the components of validity are exchangeable. It is extremely significant to select a solution that helps solid solutions to confirm validity. Organizations guarantee that the tools are evidence of the coming time and interoperable. The subsequent diagram explains in what way the verification mechanism has been replaced from one-way authentication (1-WA) to multi-way authentication (M-WA).

- **One-Way Authentication (1-WA)**—Mainly depends on earlier distributed individual data, key or password, or possibly a safety question.
- **Two-Way Authentication (2-WA)**—This authentication is applied to conquer the customer's movement to overlook earlier distributed data depending on what they find. Includes suggestions with mobile, card pin, or one-time password verification.
- **Multi-Way Authentication (M-WA)**—It has numerous customer authentication approaches for many levels, together with vocal sound bio-metrics, face predilections, fingerprints, optical-based approach, finger pattern, location, and many more [9]. Evaluation of authentication is shown in Fig. 3.

5.1 Necessity of 2-WA

2-WA enables equally to protect the customer and company security, and there are several advantages to applying it, including the following:

- **Extraordinary safety**—In addition to the aid of a 2° combination of verification, SMS-cantered passwords decrease the probabilities of hackers standing as real consumers. It is lowering the threat of account hacking and violation of data. Although the attacker obtained the customer's user id or password, they cannot get the next element of the credential necessary to achieve the verification.

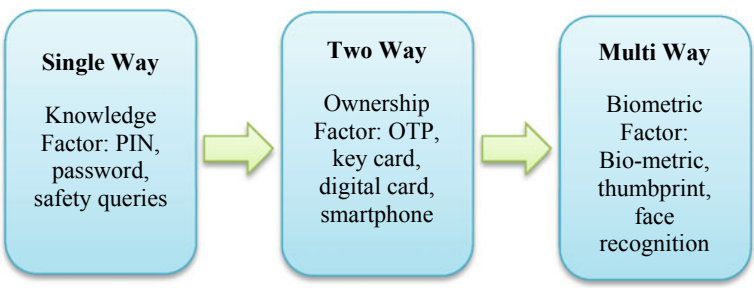


Fig. 3 Evaluation of authentication

- **Improved efficiency**—2-WA improves the worldwide business to utilize second-degree smooth verification. Workers can safely secure entrance to commercial platforms, records, and third-party structures from a few distributed means or places without any secret facts.
- **Decrease in the scam, as well as development, is reliable with 2-WA**—Individuals who passed with a significant scam case stay away from trustworthy dealers, although the retailer did not react to breaches of data. 2-WA produces a massive level of certainty along with the individual and decreases scam efforts on the vendor's sites too.

5.2 Functioning of 2-WA

2-WA can be allocated in two aspects, such as cloud-based response and in-site result. We can recognize both aspects and can find out what is related.

- **Resolution based on the cloud**—This is broadly applied in e-business, net banking, and other assistance-concerned Web functions.
- **Quick reaction**—Corporations are hesitant to permit property-based safety reactions and the operation taking on results in the region where a worker logs on to network function and puts a sequence of the user ID and secret code. At this point, these details went to the inner VPN compiler, which considers 2-WA businesses a great means to create a one-time password and communicate it to the worker through SMS on a registered mobile number. This edition allows business reliable success, as it does not require communicating info to a 2-WA third-party supplier [10].

5.3 Challenges in 2-WA

Within the 2-WA method, the level-1 authentication applies a sequence of user IDs and secret codes, then for level-2 authentication, this communication is mentioned from a distinct protected position. This crucial container is liable for maintaining all crucial data to validate the customer. Even though 2-WA enhances the degree of safety through a subsequent verification, but still, realizes the drawbacks of retrieving a moderate-sized data file and maintaining a directory of customer personal data. An essential internet site can be interrupted or damaged with static strands, and this goes ahead to significant information violations.

6 2-WA in Blockchain

Blockchain is regarded as classified among the very distracting and innovative skills. Blockchain may disturb the virtual protection-based reaction configuration, particularly the CIA security triangle law. 2-WA has been significant in the protection of data for numerous years; though, invaders are occasionally deceived into damaging these structures. The network of blockchain in association with 2-WA is shown in Fig. 4.

6.1 Blockchain Transforming 2-WA

A blockchain in structure is a control-assigned creation that permits each type of payment concerning more contributors by excluding the participation of a third party. With the assistance of blockchain, we can make sure that these delicate documents do not inhabit some database; the other option is that they can be occupied in blockchain blocks which are constant and are not able to change or eliminate. In these devices, customer tools will be verified through the 2-WA which is given by the blockchain Web. All companies inside the blockchain system will collect the information in a safe place and allow the 2-WA structure to create a second-level specific secret code. After that, it will be shared inside a social area or on a personal Web by using the name of an exterior enterprise application programming interface (API). The Ethereum-based architecture of 2-WA in the blockchain is shown in Fig. 5.

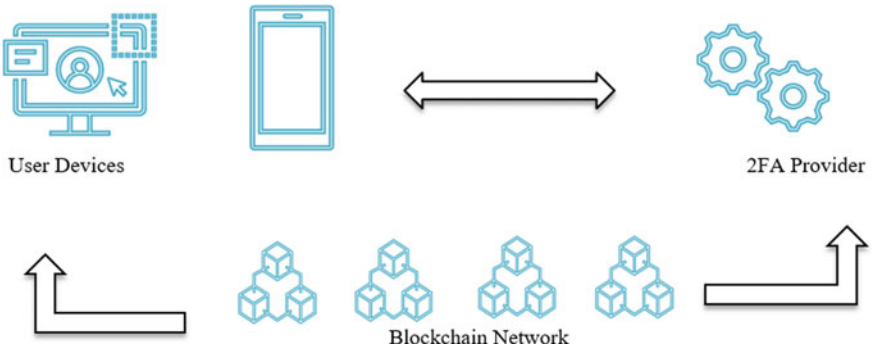


Fig. 4 Blockchain network for 2-WA

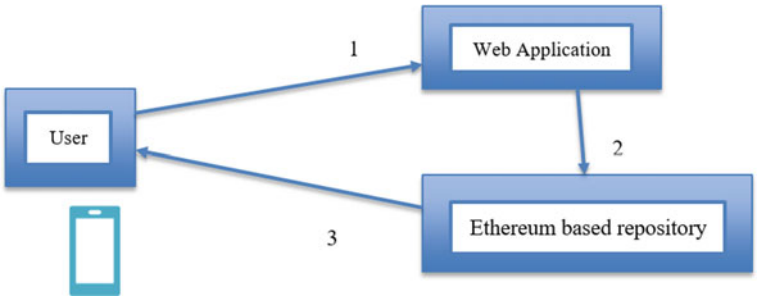


Fig. 5 Architecture of 2-WA based on Ethereum

6.2 Constructing Resolution

Although it is the most recent invention, the blockchain persists in its investigational stage with many organizations. In this paper, we are applying the blockchain that depends on Ethereum to start the use of the 2-WA inbuilt devices. The Ethereum method permits the requesting customers to make up a smart contract. The purchaser gains access to the transportable Internet and moves into the primary stage of possession. The online request will focus on the last place which is open on Ethereum for one-time password construction and assessment by the user. Ultimately, the customer establishes a comparable one-time password and logs on to the Web application [11]. The block diagram of 2-FA is shown in Fig. 6.

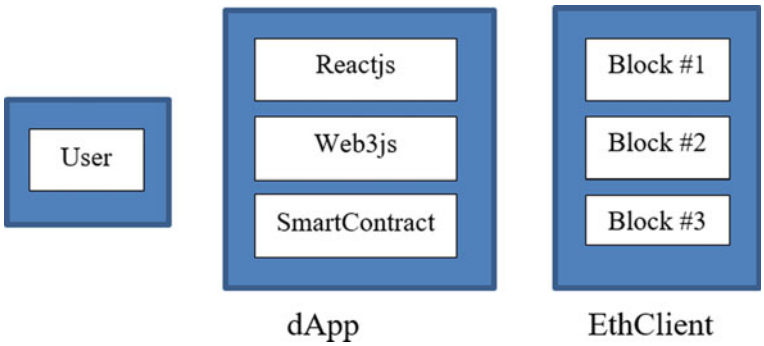


Fig. 6 Block diagram of 2-FA

7 Conclusion

There is no question that the current study has fully centered on the blockchain area and growing rapidly in the last few years, while there is a requirement of emphasizing some security subjects and that should be settled. A few topics are previously reviewed and improved by recent approaches in the developing area that achieve more progress and strength. Blockchain has been breaching the protection of data that depends on the cyber security rule of the CIA security triad. The 2-WA process had a significant role in providing security for countless years, but sometimes, hackers are able to deal with this system. Organizations should create coherent authorized standards for this technique, and corporations should be ready to implement blockchain techniques, avoiding it from creating over effect on currently available tools. Though, it has been realized that the advantages of blockchain techniques are a blessing that needs to be utilized in a proper way, simultaneously, by using the 2-WA technique, the blockchain technology has to gain more momentum toward increasing the security of digital devices in real world.

References

1. Malik, A., Gautam, S., Abidin, S., & Bhushan, B. (2019). Blockchain technology-future of IoT: Including structure, limitations and various possible attacks. In *2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)*, Kannur, India (pp. 1100–1104). https://doi.org/10.1109/ICICICT46008.2019.8993144
2. Nakamoto, N. (2017). Centralised bitcoin: A secure and high performance electronic cash system. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3065723
3. Christidis, K., & Devetsikiotis, M. (2016). Blockchains and smart contracts for the Internet of things. *IEEE Access, 4*, 2292–2303. https://doi.org/10.1109/access.2016.2566339
4. Perboli, G., Musso, S., & Rosano, M. (2018). Blockchain in logistics and supply chain: A lean approach for designing real-world use cases. *IEEE Access, 6*, 62018–62028. https://doi.org/10.1109/access.2018.2875782
5. Kumar, N. M., & Mallick, P. K. (2018). Blockchain technology for security issues and challenges in IoT. *Procedia Computer Science, 132*, 1815–1823. https://doi.org/10.1016/j.procs.2018.05.140
6. Malik, A., Kashyap, R., Arora, K., & Bhushan, B. (2022). NutriChain: Secure and transparent midday meals using blockchain and IoT. In H. S. Saini, R. K. Singh, M. Tariq Beg, R. Mulaveesala, & M. R. Mahmood (Eds.), *Innovations in electronics and communication engineering* (Vol. 355). Springer. https://doi.org/10.1007/978-981-16-8512-5_41
7. Tian., F. (2016). An agri-food supply chain traceability system for China based on RFID and blockchain technology. In *2016 13th International Conference on Service Systems and Service Management (ICSSSM)*. https://doi.org/10.1109/icsssm.2016.7538424
8. Hofmann, E., Strewe, U. M., & Bosia, N. (2017). Concept—Where are the opportunities of blockchain-driven supply chain finance? In *Supply chain finance and blockchain technology* (pp. 51–75).https://doi.org/10.1007/978-3-319-62371-9_5
9. Malik, A., Yadav, N., Srivastava, J., Obaid, A. J., & Saracevic, M. (2022). Blockchain in the pharmaceutical industry for better tracking of drugs with architectures and open challenges. In *Blockchain technology in healthcare applications: Social, economic, and technological implications* (1st edn.). CRC Press. https://doi.org/10.1201/9781003224075

10. Mohanty, D. (2018). Ethereum architecture. In *Ethereum for architects and developers* (pp. 37–54). https://doi.org/10.1007/978-1-4842-4075-5_2
11. Malik, A., Kumar, A., Srivastava, J., & Bhushan, B. (2022). Blockchain technology with supply chain management: Components, opportunities and possible challenges. In D. K. Sharma, S. L. Peng, R. Sharma, & D. A. Zaitsev (Eds.), *Micro-electronics and telecommunication engineering* (Vol. 373). Springer. https://doi.org/10.1007/978-981-16-8721-1_11

A Survey of Human Emotion Recognition Using Speech Signals: Current Trends and Future Perspectives

Radhika Subramanian and Prasanth Aruchamy

Abstract In this research work, a detailed review has been conducted to provide the current research scenario of speech emotion recognition (SER). The key purpose is really to look into what is being done in this research as well as the areas where research is lacking. The investigation reveals that "speech emotion recognition" work is a significant field of research, with a large number of research papers published each year in articles and journals. To optimize the detection results of SER systems, the majority of research consists of three main components of SER: (i) datasets, (ii) speech attributes, and (iii) classifiers. After conducting an interrelation study of the essential components, the efficiency of the SER system is determined in terms of identification rate. We researchers established that even a mixture of datasets, speech signal attributes, as well as classification methods affects the recognition performance of the SER system. Based on our review, we also suggested SER features that could be considered in future work.

Keywords Human speech emotion recognition · Emotional speech corpus · Human speech attribute · SER system

1 Introduction

The most effective and popular way for people to interact with one another is through speaking. This experience causes many academicians to consider speech signals as a fast and efficient procedure to act among humans and machines. It expresses that the machine must possess sufficient intelligence to determine an individual speech and voice. Despite significant progress in speech recognition, investigators are still far from a realistic interaction among both machines and people because computers

R. Subramanian (✉) · P. Aruchamy
Department of Electronics and Communication Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India
e-mail: sradhika@svce.ac.in

P. Aruchamy
e-mail: aprasanthdgl@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_46

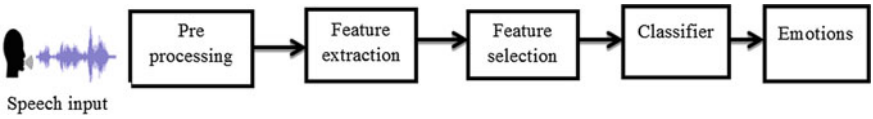


Fig. 1 Stages involved in SER

are incapable of recognizing the emotional condition of a person. The purpose of speech feature identification is to detect and recognize a person's emotional state by using his or her speech.

Figure 1 represents a block diagram for identifying emotions from human speech. It reflects the general operation of how speech segments are processed at various phases to determine a person's emotional state. Before feature extraction, speech samples are first preprocessed. The first stage of feature extraction collects relevant features, and the second phase of attribute choice identifies the most appropriate features to classify the emotion. Finally, one of the classifiers uses the finest feature set as input to identify the speech sample's emotional state. Speech emotion recognition is generally advantageous for tasks that need people–machine communication like speech analysis, customer support, educational activity, forensic work, and human health study. Distinguishing a state in speech signals is extremely difficult in the field for various reasons. The main problem with every speech emotional approach is deciding on the best attribute which is strong enough to recognize different emotions.

2 Features for Speech Emotion Recognition

Researchers have employed numerous different sets of features for developing their systems. In [3], Pitch, mel frequency cepstrum coefficients, intensity, formants, and speaking speed are referred to as speech signal parameters. These features revealed the emotional state of a person. Prosody and voice quality has been considered the most essential feature in distinguishing between various emotions in human perception. Followed by the invention of MFCC, researchers have shown an interest in line spectral pairs (LSP) and linear predictive coding (LPC) features [13]. Aside from existing features, the feature fusion technique increased the accuracy of recognizing a person's emotions [19]. According to Ancilin and Milton [17], the energy distribution across the magnitude spectrum, frequency, and coefficients of speech signals may be easily determined, which helped the author in enhancing overall accuracy. A novel statistically linked feature set was used in [20] to improve accuracy over prior approaches. By considering features such as the mean of emotion and shift between emotions, the author has shown improvement in accuracy.

3 Speech Database

A speech corpus (also known as a spoken corpus) is a database that contains audio files as well as written transcriptions of spoken words. The speech corpus is critical for emotion recognition when speech is taken in a diverse environment. The amount of naturalness of the speech database used to test the emotional speech recognizer's performance is a crucial criterion to consider while evaluating it. If a very low-quality speech database is used, incorrect results may be obtained. Furthermore, the establishment of the database is critical to the categorization work under consideration. There must be some methodologies that can be implemented to decide how well a particular emotional database performs in a real-world environment. Many of the formulated speech databases are not accessible for public usage. Hence, there are only a few standard databases that can be used by the researchers. The majority of the databases express the following emotions: boredom, disgust, neutral, rage, happiness, surprise, and sadness.

Actors' speech was used in the early stages of the review on "SER", and the current trend has been changed toward more realistic speech data. The databases used in SER are divided into three major categories. Class 1 is a human-labeled emotional speech act. Speech that has been acted or imitated is delivered in a professional and purposeful manner. They are achieved by requesting an artist to talk with a preset emotion, e.g., EMODB and DES. Class 2 seems to be a reliable human-labeled emotional speech database. Here, the speech is spontaneous, and all emotions are realistic. These speech utterances come from real-life applications, e.g., call centers. Class 3 is an evoked emotional speech database in which feelings are prompted through individual reports rather than labeling, sentiments are aggravated, and labeling is governed by self-behavioral reports. Neither neutral nor simulated speech is used in this simulation.

4 Literature Survey

The proper selection of speech features has a big effect on the efficiency of classification. Another important factor in determining which type of classifier or learning algorithm is best suited for "speech emotion recognition". The most frequently employed techniques for SER involve decision tree (DT), support vector machines (SVMs), Gaussian mixture models (GMMs), and hidden Markov models (HMMs), artificial neural networks (ANNs), multilayer perceptron (MLP), random forest (RF), and linear discriminant analysis (LDA) [15, 16, 18].

Liogienė et al. [1] suggested a multistage classification scheme for "SER". To evaluate the proposed method, experiment results on a Lithuanian spoken language and Berlin emotional speech database designate, and this approach attained improvement in accuracy of the recognition rate. According to the empirical findings, multistage

classification has a greater order of multilevel characteristics than single-stage classification. A novel spectral component has been established to identify emotions and classify groups [2]. Also, this method is applied to the partial-naturally available Egyptian Arabic Speech Emotion dataset which includes approximately 500 speech signal from professional actors for the sad, angry, neutral, and happy emotions.

For anger detection, the addition of the parameters long time average spectrum and wavelet to the standard prosodic and spectral attributes enhanced the overall efficiency [2]. A fresh set of acoustic features for "SER" was introduced by Tahon et al. [3]. The set of features was extracted and applied to a real-time speech corpus in this approach. They then evaluated the emotion models using an appropriate collection of auditory features while also optimizing the parameters. The outcome of selecting features has been examined in the cross-corpus condition in the complete form to determine the emotion recognition outcome.

In [4], a multi-scale amplitude feature that identifies the human emotion in the database was employed. The proposed method was tested on a very popular speech emotional (EMODB) dataset, interactive emotional dyadic motion capture (IEMOCAP) dataset, simulated stressed speech (SSD) dataset, and speech with enhanced vocal tract information (SEVTI). When compared to other features, the suggested multi-scale magnitude characteristics with audio signal have a greater identification range. Experimental results reveal an estimated classification performance of 86.4% for the German database, 68.1% for the dyadic motion capture (IEMOCAP) database, and 81.8% for the SSD database when all features are combined with enhanced vocal tract information.

Koduru et al. [5] introduced a new feature extraction algorithm to enhance a system's capability to detect speech emotion. This approach has the following process: To begin, concentrate on the pre-processing stage of the obtained human speech data first, which involves applying filters to eliminate noise from speech samples. Further, energy, the mel frequency cepstrum coefficients (MFCCs), pitch, discrete wavelet transform (DWT), and zero crossing rate with an order (ZCR) algorithms were utilized to extract the features.

A new method has been invented for investigating the emotion of speech signals using the EGG waveform [6]. This method is used for a vast massive dataset of generated emotions in four languages (Malayalam, Tamil, Indian, and British English). The experimental results are compared to those of the conventional German emotional database (EMODB), which also includes speech and EGG recordings, to determine the typical correlation in the variations of well-known emotion-dependent excitation features like instantaneous F0 and SoE, which are anticipated from voice signal and EGG utterances. For the suggested database, the outcome indicates improved emotion discrimination during emotion recognition.

Recognizing emotion from phonological features of human speech and implementing the technique to assess the database using deep learning is proposed in [7]. The multi-modal emotional (IEMOCAP) database was employed to evaluate the classification method. The relationship between phonology and emotions has been addressed using this way. Discrete phonological representations are also

advantageous in improving emotion recognition performance, according to the findings.

For speaker-independent speech emotion identification, Wang et al. [8] created an improved Fourier transform-based parametric quantity model employing the physiological content of vocal signal and the first- and second-order degree differences. This method works by detecting harmony features for the Berlin emotional dataset (EMODB), the Chinese speech utterance, and the Chinese elderly emotion speech dataset (EESDB). The outcomes expose that the improved Fourier parameter (FP) attributes are successful in discriminating different inner feelings. The approach was evaluated by the SVM and a Bayesian classifier. The empirical findings show that the suggested approach, which integrates FP and MFCC features, enhances the execution of emotion recognition. The result shows specially to recognize speech emotions, utilizing the Fourier parameter is very effective. A feature fusion method has been implemented by integrating both prosody and spectral features for detecting emotions [9]. The approach was validated by testing on both the Germany and Spanish language emotional speech (SES) datasets. Furthermore, the results show that RDA is a better alternative for emotion detection since it eliminates the singularity problem and produces better results by utilizing regularization criteria.

Emotion identification based on different classifiers using the energy spectra information and Gaussian normalization is proposed in [10]. This technique, which is dependent on a number of filter banks, is also used to alter the temporal intensity of passive voice signals. In this work, the initial modification of the pitch contour has been done by employing the technique of Gaussian normalization. The quality of the resulting speech is contrasted to speech produced by just altering the pitch contour after the spectral energy has been converted. The result represents that there is an improvement in expressing emotions due to the integration of the proposed spectral energy modification. Furthermore, the findings indicate that spectral energy modification is effective for neutral to sad transformation.

An optimal strategy for recognizing human emotions from speech signals was presented by Divya et al. [11]. Also, the approach was used to optimize parameters for feature selection and integrate the best features to detect a person's emotional conditions through speech signals. Different datasets such as EMODB, SES, IEMOCAP, IITKGP-SESC, and IITKGP-SEHSC have all been validated with different configuration and input attributes to optimize the selection of fused features for the categorization of emotions. Experimental results in the Berlin speech utterance demonstrate that the support vector machine learning model on IITKGP-SEHSC with attribute choice achieves better performance compared to other classifiers. The results demonstrate that a model's ability to predict both positive and negative emotions behave differently.

A multi-modal method has been proposed by utilizing relevant features for SER [12]. The novelty of the suggested method is the following things: First, the acoustic speech signal has been divided into small frames, and second, a fast Fourier transform was employed over the frames. Finally, the pertinent features were taken out using MFCC and varying spectrum features. These methods were utilized to divide the

emotions into seven categories, and the new system was then trained and tested using the RAVDEES private dataset.

In [13], a fusion of prosody and several speech features was used. For emotion recognition, classification and feature selection methods were focused on in this research. The experimental result represented in the Berlin database contained 500 utterances including both male and female. The database achieved the highest recognition rate of 94.1, 82.54, 81.65, and 79.13% under MFCC, prosodic, line spectral pairs (LSP), and linear predictive coding (LPC) features. Gamma-tone filters (GTF) were considered an important feature in identifying emotions [14]. These filters were spaced at mel scales, equivalent rectangular bandwidth, and BARK scales. GTF energy and gamma-tone filters cepstrum coefficients (GTFCCs) features were taken from the test utterances in the first stage and employed to the emotional-based particular modeling techniques in a set.

5 Comparison Analysis and Feature Direction

Mostly, the purpose of the investigation into speech emotion detection is to show progress in the classification accuracy against speech attributes. To decrease dimension, SVM is commonly used alone or in combination with other classifications methods like ANN and RBF. This depicts the most of classification accuracy in Table 1, in which it employs the Gamma-tone energy features and cepstral features configured to achieve above 95% in the best of circumstances. Furthermore, SVM and the K-nearest neighbor (KNN) classifier remain one of the most widely used in human speech emotion recognition. According to Kuchibhotla et al. [9], the KNN approach can increase the recognition rate by 20% in the optimistic scenario. Employing SVM and LTAS as characteristic factors, Abdel-Hamid et al. [2] achieve the highest classification performance in this study, that is, 90.7% under the worst case and 76.42% on average.

6 Conclusion

In this paper, we discussed and analyzed different human "speech emotional recognition systems" based techniques. Researchers also examine traits, classifiers, datasets, and classification performance to see how well it works. Optimized algorithms possess a good prediction accuracy for numerous sorts of emotions. "HMM with a very small duration log frequency power coefficients (LFPC) as a speech parameter" is shown to have better accuracy at varying tiers there in a graph in this review. The majority of current investigation focuses on analyzing distinct characteristics of spoken speech and their links with emotional states. Also, few researchers create unique features like MLS to accomplish an excellent performance in identification rates. The majority of available datasets are unable to assess speech emotion

Table 1 Multiple kind of speech features, dataset, and classification algorithms in SER system

References	Classification methods	Categories of speech features	Classification accuracy	Database used	Approaches
Liogienė and Tamulevičius [1]	Multistage classification scheme	MFCC, amplitude	Improved accuracy by 20% approximately	Lithuanian spoken language and Berlin emotional speech dataset	For a multistage emotion categorization approach, the sequential forward selection (SFS) technique was used
Abdel-Hamid [2]	SVM	Pitch, intensity, formants and MFCC, LTAS, and wavelet parameters	90.71%	Egyptian Arabic speech utterance	Linear SVM
Deb and Dandapat [4]	SVM	MFCCs, Teager energy operator (TEO)-based feature (TEO-CB-Auto-Env), and the breathinesss feature	EMODB database-86.7%, IEMOCAP dataset-68.3%, SSD dataset-81.8%, and FAU AIBO dataset-45.2%	German emotional EMODB database	Multi-scale amplitude features and statistical analysis
Koduru et al. [5]	SVM, DT, LDA	Discrete wavelet transform, zero crossing rate, MFCC, pitch, energy	SVM-70%, Decision tree-85%, and LDA-65%	RAVDESS	The suggested system outperforms existing findings in terms of accuracy and speech recognition rate

(continued)

Table 1 (continued)

References	Classification methods	Categories of speech features	Classification accuracy	Database used	Approaches
Wang et al. [7]	Deep learning-based classifier	Phonological features	60.02%	Interactive emotional dyadic motion capture (IEMOCAP)	SER uses a combination of phonological representations and acoustic features to distinguish emotions
Kuchibhotla et al. [9]	LDA, RDA, SVM, and KNN	Pitch prosody features, energy, and MFCC spectral features	Recognition accuracy is improved by 20% approximately	Berlin language and Spanish language emotional speech databases	Instead of employing individual features, feature fusion was used to improve recognition performance
Haque and Sreenivasa Rao [10]	Gaussian approximation method	Pitch contour + spectral energy	80.63% for anger 16% for sad	Hindi simulated-emotional database	Method of Gaussian normalization

recognition. Even a human being finds it difficult to detect distinct emotions in specifically collected utterances in most circumstances; for example, the human speech recognition accuracy for Berlin was 87.54% [3]. Finally, it seems that there is very little research work that investigate at using multiple classifiers to recognize speech emotion [9, 14]. We believe that combining multilevel classification techniques (MCT) with feature fusion techniques are a promising future research direction. Some physiological signals, such as the glottal response, can be added to the existing speech parameters to improve emotion recognition significantly. Additionally, other temporal and frequency blended speech parameter combinations can be utilized as the main attribute, and excitation parameters like TEO and ZCR can be combined to determine the emotions alone, such as anger or happiness.

References

1. Liogienė, T., & Tamulevičius, G. (2015). SFS feature selection technique for multistage emotion recognition. In *IEEE 3rd Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE)*. IEEE.
2. Abdel-Hamid, L. (2020). Egyptian Arabic speech emotion recognition using prosodic, spectral and wavelet features. *Speech Communication, 122*, 19–30.
3. Tahon, M., & Devillers, L. (2015). Towards a small set of robust acoustic features for emotion recognition: Challenges. *IEEE/ACM Transactions on Audio, Speech, and Language Processing, 24*(1), 16–28.
4. Deb, S., & Dandapat, S. (2018). Multiscale amplitude feature and significance of enhanced vocal tract information for emotion classification. *IEEE Transactions on Cybernetics, 49*(3), 802–815.
5. Koduru, A., Valiveti, H. B., & Budati, A. K. (2020). Feature extraction algorithms to improve the speech emotion recognition rate. *International Journal of Speech Technology*, *23*(1), 45–55.
6. Pravena, D., & Govind, D. (2017). Development of simulated emotion speech database for excitation source analysis. *International Journal of Speech Technology, 20*(2), 327–338.
7. Wang, W., Watters, P. A., Cao, X., Shen, L., & Li, B. (2020). Significance of phonological features in speech emotion recognition. *International Journal of Speech Technology*, *23*(3), 633–642.
8. Wang, K., An, N., Li, B. N., Zhang, Y., & Li, L. (2015). Speech emotion recognition using Fourier parameters. *IEEE Transactions on Affective Computing, 6*(1), 69–75.
9. Kuchibhotla, S., Vankayalapati, H. D., Vaddi, R. S., & Anne, K. R. (2014). A comparative analysis of classifiers in emotion recognition through acoustic features. *International Journal of Speech Technology, 17*(4), 401–408.
10. Haque, A., & Sreenivasa Rao, K. (2015). Analysis and modification of spectral energy for neutral to sad emotion conversion. In *2015 Eighth International Conference on Contemporary Computing (IC3)*. IEEE.
11. Lingampeta, D., & Yalamanchili, B. (2020). Human emotion recognition using acoustic features with optimized feature selection and fusion techniques. In *2020 International Conference on Inventive Computation Technologies (ICICT)*. IEEE.
12. Christy, A., Vaithyasubramanian, S., Jesudoss, A., & Praveena, M. D. (2020). Multimodal speech emotion recognition and classification using convolutional neural network techniques. *International Journal of Speech Technology, 23*(2), 381–388.
13. Jermsittiparsert, K., Abdurrahman, A., Siriattakul, P., Sundeeva, L. A., Hashim, W., Rahim, R., & Maseleno, A. (2020). Pattern recognition and features selection for speech emotion recognition model using deep learning. *International Journal of Speech Technology, 23*(4), 799–806.

14. Singh, R., & Sharma, D. K. (2020). Fault-tolerant reversible gate based sequential QCA circuits: Design and contemplation. *Journal of Nano-electronics and Optoelectronics*, *15*(4), 331–344. American Scientific Publications.
15. Sharma, R., Kumar, R., Sharma, D. K., Son, L. H., Priyadarshini, I., Pham, B. T., Bui, D. T., & Rai, S. (2019). Inferring air pollution from air quality index by different geographical areas: A case study in India. In *Air quality, atmosphere and health.* Springer Publication.
16. Sharma, D. K., Kaushik, B. K., & Sharma, R. K. (2014). Impact of driver size and interwire parasitics on crosstalk noise and delay. *Journal of Engineering, Design and Technology*, *12*(4), 475–490. Emerald Pub., U.K.
17. Ancilin, J., & Milton, A. (2021). Improved speech emotion recognition with Mel frequency magnitude coefficient. *Applied Acoustics*, *179*, 108046.
18. Jayachitra, S., & Prasanth, A. (2021). Multi-feature analysis for automated brain stroke classification using weighted Gaussian Naïve Bayes classifier. *Journal of Circuits, Systems and Computers, 30*(2150178), 1–22.
19. Issa, D., Fatih Demirci, M., & Yazici, A. (2020). Speech emotion recognition with deep convolutional neural networks. *Biomedical Signal Processing and Control*, *59*, 101894.
20. Özseven, T. (2019). A novel feature selection method for speech emotion recognition. *Applied Acoustics, 146*, 320–326.

Artificial Intelligence-Based React Application (Powered by Conversational ALAN-AI Voice Assistance)

Ayasha Malik, Veena Parihar, Bharat Bhushan, Jaya Srivastava, and Lamia Karim

Abstract The field of conversational AI is growing at a fast pace. It basically includes the methods for developing software agents that are capable of involving in a conversation with humans just like other humans. This research paper is an effort of presenting a glimpse of how a conversational React news application controlled by voice can be developed by making use of ALAN-AI. ALAN-AI is an innovative technology that allows the inclusion of voice capabilities in any application. It enables an application to be controlled completely by the voice, and it is very easy to integrate it. The paper describes several npm commands and discusses the functionality of ALAN-AI in the proposed react application along with the ALAN Studio itself. A brief differentiation of react, Angular, and Vue is also presented to give an idea of the certain advantages that react has over other libraries and frameworks. The paper elaborates how voice scripts can be created via the Web portal of ALAN Studio which provides a set of tools for convenient scriptwriting and testing, including a source code editor, testing and debugging tools, and analytics tool. The paper ends up by explaining the ALAN-AI's ability to mimic human look-like communication between the user and the app. They work together to allow ALAN to understand human speech, create answers, and complete the app's tasks.

Keywords ALAN-AI · React.js · Dynamic entities · Visual state objects · News API · Voice assistants

A. Malik (✉)
Delhi Technical Campus (DTC), GGSIPU, Greater Noida, India
e-mail: ayasha07.am@gmail.com

V. Parihar
KIET Group of Institutions, Delhi-NCR, Ghaziabad, India

B. Bhushan
School of Engineering and Technology (SET), Sharda University, Greater Noida, India

J. Srivastava
ABES Engineering College, Ghaziabad, India

L. Karim
Hassan 1st University, National School of Applied Sciences of Berrechid (ENSA), Berrechid, Morocco

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_47

1 Introduction

React (which is also known as React.js or ReactJS) is a free and open-source front-end JavaScript library for creating user interfaces. It is run by Facebook and a community of independent developers and businesses. React can be used to build single-page or mobile applications. React, on the other hand, is solely concerned with state management and rendering that information to the DOM, and so constructing React apps typically necessitates the usage of extra frameworks for routing and client-side functionality. The term "Virtual DOM" is used in React. Assume that the HTML has transpired the generated output JavaScript that generates your HTML. Suppose that a component changes every time something in it is altered. These updates are now made to Virtual DOM rather than the DOM directly. Thus, there is a difference between the Virtual DOM and the real HTML DOM, and the modifications are pushed to the Real DOM. Although React is frequently referenced alongside other JavaScript frameworks, "React versus Angular" is a misnomer because the two are not directly comparable. React is not at all a complete framework (it does not have a view layer). That is why React is so difficult to grasp, and it is part of a larger ecosystem of frameworks. To essentially render HTML, React also provides a template language and function hooks. HTML is the only thing React produces. The HTML/JavaScript components can save their internal state in memory (such as which tab is chosen in a tab view); but in the end, HTML is merely barfed out. ALAN offers a comprehensive Artificial Intelligence (AI) voice platform. That is, there is no need to configure speech components, set up a voice processing infrastructure, or create or train some sort of speech recognition software. ALAN is in charge of all deployment, maintenance, and voice processing. ALAN performs the role of AI backend. It allows the app to figure out the human language and allows users to communicate with it via voice. To create a voice interface with ALAN, the following steps may be performed: First, create a dialog for your voice assistant in ALAN Studio, and second, integrate the ALAN voice into the application with ALAN SDKs [2]. Furthermore, the summary of the involvement of this effort is enumerated below.

- The proposed work describes the background of ALAN-AI along with its applications in different domains.
- The work presents the importance of ALAN and highlights how an application can be connected and how the effects on the react application can be figured out.
- The study and work discuss the working of ALAN in context with the voice processing and presents an overview of several interactions as provided by the ALAN-AI to control and manipulate the voice effects of ALAN-AI.
- The project aims at describing how the News API key can be acquired to use in the proposed application.

The remainder of the paper is organized as follows—Sect. 2 enumerates the importance of AI in today's world. Furthermore, Sect. 3 highlights ALAN-AI and gives the basic overview of ALAN-AI voice assistants with different categories of voice

assistants, and how the react is connected with ALAN-AI is discussed. Additionally, Sect. 4 describes the React.js and its connectivity with ALAN-AI along with answering the question that why to choose to React by comparing it with Angular and Vue. Along with the implementation of React.js and methodologies part as to how to get started by creating new React application and its basic starting npm commands. Additionally, the elaboration of the voice control functionality of ALAN-AI is also describes. Finally, Sect. 5 concludes with the importance of Reactjs and their industrial applications.

2 Artificial Intelligence

You merely need to grab the ALAN Client SDK and drop it into your app to voice-enable your app with no or minimal UI modifications. The environment with no servers: there are no infrastructure or speech components to prepare for implement or manage. ALAN is in charge of your app's maintenance and voice processing. Updates on the fly: all modifications to the dialogs are instantly available. ALAN Studio includes comprehensive capabilities for testing your dialog flows as well as for analytics data on user interactions, all in one console. AI enables users to comprehend the inquiry and searches their datasets (memory) to appropriately respond. It is designed to see patterns, learn from past mistakes, and deliver answers. The technology enables us to swiftly do repetitive jobs using simple controls. Object identification, translation, speech recognition, and Natural Language Processing (NLP) are some of the most popular applications of AI today. It uses Automated Speech Recognition (ASR) and NLP to provide automatic transcription [3].

3 Glimpses on ALAN-AI

ALAN develops models containing phrases and intentions for your app by automatically training on modest existing datasets. As a result, your app's UI, workflow, and business logic are all well understood by an intelligent voice assistant. All voice processing is performed in the ALAN cloud. The ALAN cloud is the AI backend of the ALAN-AI platform. This is where voice scripts are hosted, and Spoken Language Understanding (SLU) and NLP tasks are accomplished. Under the hood, the ALAN cloud engages a combination of voice AI tools and technologies to simulate human-like dialog between the user and the app. Together, they allow ALAN to interpret human speech and generate responses and perform the necessary actions in the app. All voice processing in the ALAN infrastructure is done in the ALAN cloud. The ALAN-AI Platform's AI backend is the ALAN cloud. This is where speech scripts are stored, as well as tasks like SLU and NLP. To simulate human-like communication between the user and the app, the ALAN cloud uses a variety of speech AI tools and technologies. They work together to allow ALAN to understand human speech,

create responses, and complete the app's tasks [4]. ALAN offers a comprehensive AI voice platform. That is, you will not have to configure speech components, set up a voice processing infrastructure, or create or train some sort of speech recognition software. ALAN is in charge of all deployment, maintenance, and voice processing. ALAN performs the role of AI backend. It allows the app to figure out the human language and allows users to communicate with it via voice.

3.1 Why Choose ALAN

ALAN-AI is probably the most natural method through which one can interact with computers. There is just a need to grab the ALAN Client SDK and drop it into the app for making it voice enabled with no or minimal UI modifications. The environment is with no servers. There are no infrastructure or speech components to prepare for, implementation, or management. ALAN is in charge of the app's maintenance and voice processing. Also, all modifications to the dialogs are instantly available. ALAN Studio includes comprehensive capabilities for testing the dialog flows as well as for analytics data on user interactions, all in one console [5].

3.2 Working of ALAN-AI in Context with Voice Processing

All voice processing is done in the ALAN cloud on the Alan infrastructure. The ALAN-AI platform uses the ALAN cloud as its AI backend. This is where speech scripts are stored, and SLU and NLP tasks are completed. To simulate human-like communication between the user and the app, the ALAN cloud employs a variety of speech AI tools and technologies. They work together to enable ALAN to understand human speech, create responses, and complete the app's tasks. The ASR engine turns speech to text during voice processing. The language model is an important component of ASR. The language model calculates the probabilities of word sequences, allowing ASR to distinguish between similar-sounding words. ALAN generates a Domain Language Model (DLM) for each app in addition to the global language model. The DLM is built on your company's or domain's unique terms, names, and phrases. It allows ALAN's ASR to accurately predict what a user would say in a given situation and resolve ambiguities. There is no need to offer a big dataset of utterance variants or establish spoken language models to create a DLM [6]. Furthermore, we are spending approx. 5–6 hours to read a newspaper in detail but this app we only spent 5 min for the same. Also, the news about certain topics, categories, and more can be retrieved. Here, not only the latest news can be searched, but also ALAN-AI can read it for humans in case, one does not want to read the news by himself. The most interesting thing is it not only asks us to read the news for ourselves but also scrolls as it reads line by line on the website automatically. While the ALAN-AI reads news for us, it also keeps on highlighting the section box of current news that

it reads and thus makes it easy to recognize what section it is currently reading. The summary of news can be seen here and clicked to open the actual article of the news of interest. Also, the navigations can be performed through the different articles via different numbers assigned to each of them by asking ALAN-AI.

3.3 Different Categories of Voice Assistance that AI Uses

- **Rule-Based Bots**: These bots are commonly employed to fulfill intents with a limited scope of criteria, such as "how can I regain my password"? The solution to this query does not require a sophisticated algorithm, and it may be programmed in the backend. However, when there is a lot of analysis and creating dialog flows, the design process may be rather difficult (or conversation paths). After you have created a dialog flow, you can test it by filling in the parts with samples before putting it through its paces with real users.
- **AI Assistants**: These assistants are capable of analyzing the user, answering complicated inquiries, and anticipating the user's actions. Rather than following pre-programmed rules, AI learns to create its own rules. The AI system is given instructions and a collection of training data to create these algorithms. As a result, AI-assisted assistants can do jobs that would be hard to accomplish with standard programmed algorithms.
- **Text-Based Bots**: Due to their narrow reach, text-based bots are frequently utilized for certain areas of an application. The bot that appears when a user is exploring things on an e-commerce site.
- **Grouping Voice Assistants**: Multiple voice assistants can be employed to provide a voice user experience, albeit this is uncommon. Multiple artificial assistants are used in this sort of encounter, which may boost credibility and engagement.
- **Custom Voices and Celebrities, Podcasts, and VUIs**: As celebrities began giving their voices to VUIs, with John Legend being the first (for a time), key opinion influencers who became popular through YouTube, Facebook, Instagram, Twitter, and other social media platforms now have the option to do the same.

4 ReactJS

React (also known as React.js or ReactJS) is an open-source advanced JavaScript library and is free for building user links or user interface and UI modules. It is preserved by Facebook and the community of single designers or corporations. React can be used as a basis for creating single-page or applications for mobile. Conversely, it only cares about state organization and providing that state to DOM, so producing applications based on react often needs supplementary libraries and some customer-side functionality. Figure 1 shows the interconnection between our application, virtual machine, server, and ALAN Studio.

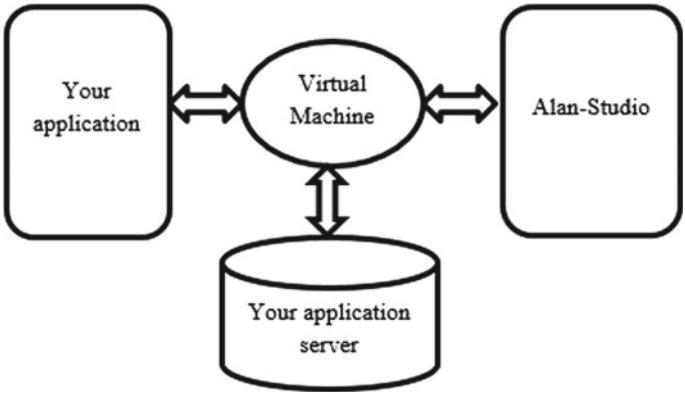


Fig. 1 Relation between application and virtual machine

React.js is more than just a coming-and-going mechanism in the above group. React is a free and open-source JavaScript framework for creating user interfaces. For network and mobile applications, developers utilize React to design interchangeable UI modules and control display layers. Synthetic DOM, a JavaScript object, is also used in React development. It improves app efficiency because the JS DOM is faster than the conventional one. It is primarily meant to quickly and reliably construct rich and compelling mobile applications with minimal coding. Instead of a comprehensive Web app, ReactJS allows individual components to run independently, allowing for the greatest possible rendering output. With its increased adaptability and ease of use, React development has emerged as the future of Web development. Some issues are linked. ReactJS is projected to be used on over 94,000 pages, with over 1300 developers actively developing with it. The most well-known applications using ReactJS include Facebook, PayPal, Instagram, Uber, and Airbnb.

4.1 Why ReactJS

ReactJS is preferable to Angular or VueJS due to its superior Virtual DOM features, powerful community support, extensive documentation, lightweight properties, reasonable learning curve, and flexibility to offer mobile functionality with React Native. React includes two crucial JavaScript features: virtual DOM and JSX, in addition to reusable library code (which saves development time and reduces the likelihood of coding errors). For years, Facebook, Instagram, Netflix, etc., have relied on React over Angular in production [8].

Table 1 Difference between React, Angular, and Vue

Framework	Angular [10]	React.js [10]	Vue [10]
Type	Framework	Library	Framework
Year of release	2010	2013	2014
Written in	Typescript	JavaScript	JavaScript
Support	It is led by the angular team at Google	It is maintained by Facebook and a community of individual developers and companies	Created by Evan You, developer, previously worked at Google company
Which companies use it	Google, Forbes, Upwork, YouTube, Wix, Telegram, PayPal, etc	Facebook, Uber, Netflix, Walmart, PayPal, Asana, etc	Xiaomi, WizzAir, AliBaba, GitLab, Adobe, Euronews, etc
What does it fit for	Angular is better suited for large-scale feature-rich apps	With React, we can build apps with dynamic content, where there is no formatting	Web development and single-page applications, not for bigger projects
List of popular components and libraries	Material design for angular, PrimeNG, Ngx-bootstrap, Flex-Layout	Material UI, Ant design, Storybook, Gatsby, Enzyme, Blueprint, Spectacle, Mozaik	Vueify VueMaterial, KeepUI element, Bootstrap-UI, AT-UI, Quasar, Mus UI, Vux

4.2 How React is Connected with ALAN-AI

The on Command function, which is similar to an arrow function, can be used. Here, we may utilize switch statements or if statements. By writing our instructions into our App.js file, we can make Alan-AI listen to them. In our new ALAN Studio project, we may create certain questions that a user can ask, and ALAN-AI will respond accordingly [9]. Using React, we can combine ALAN-AI with our JavaScript code to add unique effects to our screen interface that will run on our server. Table 1 shows the difference between react, angular, and Vue.

4.3 Installation of React.js Application

To get started, we first run the command npx-create-react-app. A single-page app is the most common type of React application. A command-line tool named create-react-app was developed to enable setting up single-page apps easier. React applications may be quickly built with the CLI tool [11]. The commands for creating a React application with Create React App are as follows.

- npx create-react-app my-new-app
- cd my-new-app

- yarn start.

After completion of first step. We install all the necessary dependencies. In our terminal, we type npm i @alan-ai/alan-sdk-web @material-ui/core class names words-to-numbers. @alan-ai/alan-sdk-web allows you to use and access all the voice capabilities and then we are going to use material UI, i.e., the UI kit that we are going to use for our styling. Then finally comes the class name because we are going to have multiple components that have multiple class names and finally a neat little library, i.e., words to numbers. When we need to run the command article number 15, we need to parse 15 to actual numbers. So that is why we have to use it. And then, we press enter. In our src folder, some of the basic folder/files that we are going to use is, firstly the index.js, app.js, and our general styling index.css [12]. Starting from the most basic and important file of the entire react, i.e., index.js, we do some classic things like:

- import React from "react";
- import ReactDOM from "react-dom";
- import "myappindex.css";
- import App from "myappApp" (Fig. 2);

Without reloading the page, React allows developers to create huge Web applications that employ data that changes over time. Its primary purpose is to be quick, easy, and scalable. In applications, React just handles the user interface. This is the same as view in the Model-View-Controller (MVC) template, and it may be used with other JavaScript libraries or frameworks in MVC, such as AngularJS [13]. React is an open-source project, similar to Angular. This means that anyone can get the source code and modify it for free. Individual UI aspects to full React libraries are available in React libraries. Here, we will also encounter some npm commands and their basic packages. Node.js uses the npm package management. It began as an open-source initiative in 2009 to make it easier for JavaScript developers to share packaged code modules. The npm registry is a public repository of open-source code packages for

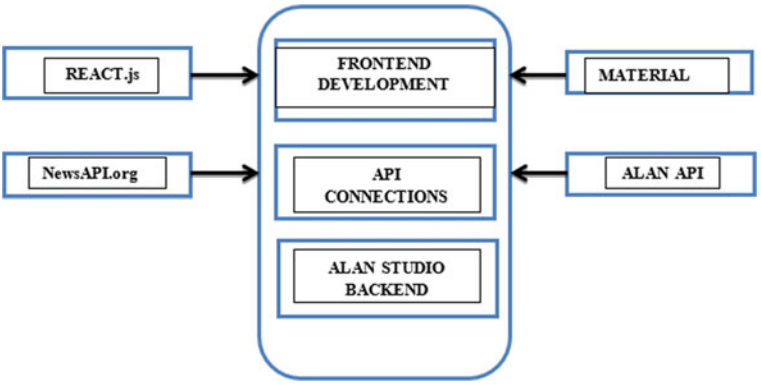


Fig. 2 Flowchart of React app

Fig. 3 Sign in page

Node.js, front-end Web apps, mobile apps, robots, routers, and a variety of other JavaScript-related needs. npm is a command-line tool for installing and publishing packages [14]. The following are some necessary dependencies that we have in our package.json file that we have to deal with:

```
{
 "dependencies": {
  "@alan-ai/alan-sdk-web": "^1.8.28",
  "@material-ui/core": "^4.12.3",
  "classnames": "^2.3.1",
  "words-to-numbers": "^1.5.1"
 }
```

Also, to enable full fletched voice capabilities, we have to use several node modules defined in package-lock.json file regarding styling and number parsing. Figure 3 shows the sign in page of our application. The home page of our developed ALAN-AI-based application is shown in Fig. 4 where we divided the screen into four categories, named latest news, categorical news, news by keywords, and news, by sources as well as a mic is also added there to record the user's voice. Furthermore, Fig. 5 shows the latest news page where all the trending news will show that taken from the Internet.

5 Conclusion

Voice products have dominated the worldwide market for the past decade, but there is still an opportunity for them to reach new clients. However, the B2B industry has a greater addressable market. Voice assistants acquired popularity fast with millions of users, and the same thing might happen in the workplace. The ALAN-AI Platform

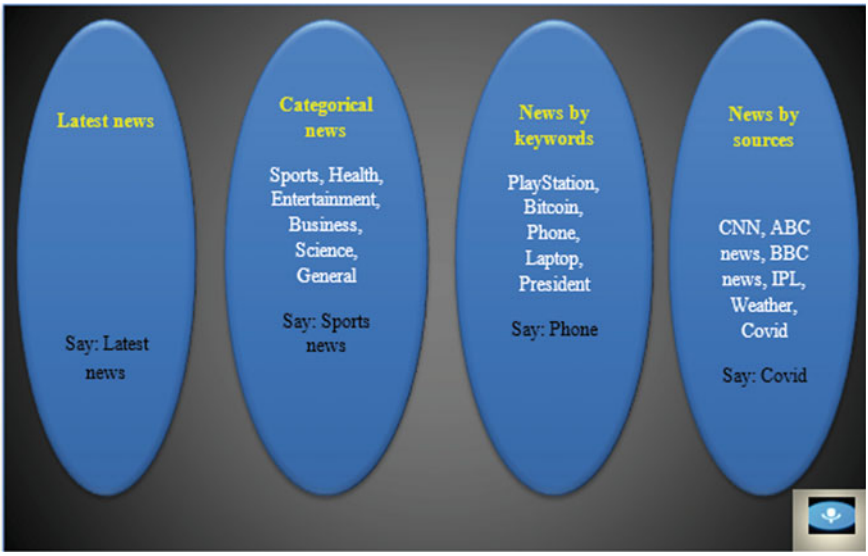


Fig. 4 Homepage of our application

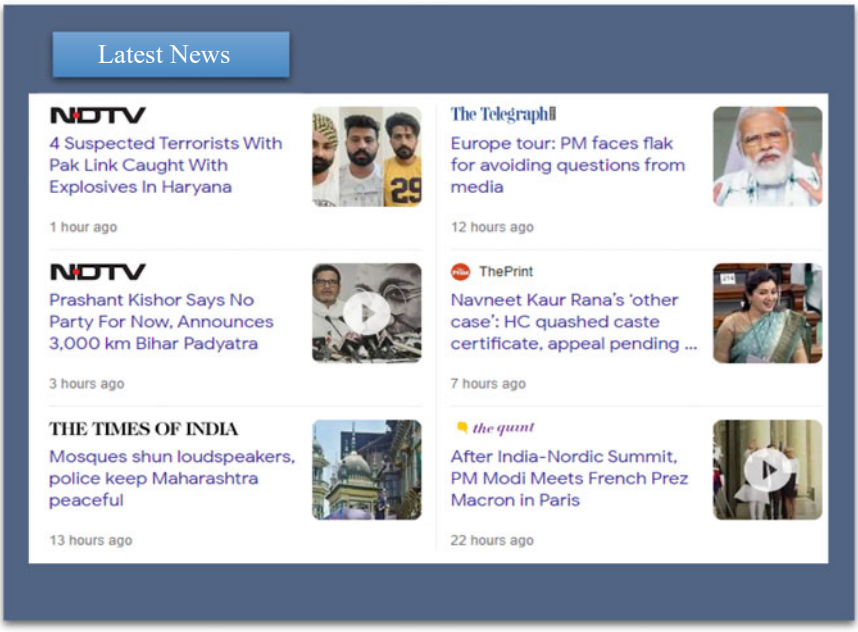


Fig. 5 Latest news page

uses foundational AI technologies for contextual language comprehension to deliver conversational speech experiences to all apps. Furthermore, it is capable of handling increasingly difficult jobs. Moreover, the paper explored the concept of AI, ALAN-AI, and the working of ALAN-AI in the context of voice processing with its various categories and need for Reactjs. In future research, an application can be designed to provide ease in today's world such as spoken language understanding. It uses probabilistic models to detect what the user said, as well as their purpose, by filtering out anaphoras and filler words such as "like" and "uh" that people use in regular conversation. With the help of ALAN-AI, some real-life applications can also be designed such as—a voice assistant to get information about the Bitcoin price from the external server or a chatbot to conduct customer surveys and get user feedback about the product.

References

1. React—A JavaScript library for building user interfaces. Reactjs.org. [Online]. Available https://reactjs.org/
2. Ivanov, A., Zakiev, A., & Tsoy, T., & Hsia, K. H. (2021). Online monitoring and visualization with ROS and ReactJS. In *2021 International Siberian Conference on Control and Communications (SIBCON)* (pp. 1–4). https://doi.org/10.1109/SIBCON50419.2021.9438890
3. Material-UI: A popular react UI framework. Materialui.com. [Online]. Available https://material-ui.com/
4. React Card component—Material-UI. Material-ui.com. [Online]. Available https://materialui.com/components/cards/
5. Documentation—News API. Newsapi.org. [Online]. Available https://newsapi.org/docs
6. 6 Major Branches of Artificial Intelligence (AI) | Analytics Steps. Analyticssteps.com. [Online]. Available https://www.analyticssteps.com/blogs/6-majorbranches-artificial-intelligence-ai
7. Person Does Not Exist. Thispersondoesnotexist.com. [Online]. Available https://thispersondoesnotexist.com/
8. ALAN-AI | Conversational Voice AI Platform. Alan. [Online]. Available https://alan.app
9. NewsAPI, A news broadcasting site. Available https://newsapi.org/docs/endpoints/sources
10. News from source. https://newsapi.org/v2/topheadlines?apiKey=${API_KEY}
11. News by termse. https://newsapi.org/v2/everything?apiKey=${API_KEY}
12. News by categories. https://newsapi.org/v2/topheadlines?country=in&apiKey=${API_KEY}&category=${YOUR-VALUE}
13. alan.app,how-tos&tutorial. https://alan.app/docs/tutorials/how-tos#how-to-capture-the-entire-user-input
14. alan.app,how-tos&tutorial. https://alan.app/docs/tutorials/how-tos#how-to-send-data-from-the-voice-script-to-the-app

Comparative Analysis of Three Waves of COVID-19 in India: A Deep Study of Three Waves Based on Selected Parameters

Ayasha Malik, Veena Parihar, Bharat Bhushan, Jaya Srivastava, and Rohit Sharma

Abstract The coronavirus disease-2019 (COVID-19) has drastically impacted each and everyone's life in the whole duration, and those critical impacts can be seen in today's life also. A very less number of studies are there which present a detailed comparison among the hospitalized patients, during the distinct three waves of this disease in India. So, this particular study aims at presenting a comparison of the clinical data and laboratory results of the patients who were infected by this virus and were hospitalized for the duration of wave 1, wave 2, and the ongoing, wave 3. The duration of wave 1 was from January to August 2020, from March 2021 to October 2021, and was wave 2 duration, whereas the impact of wave 3 started in December 2021. The goal is also to find the risk aspects for the criticality of this virus and to discuss the causes of infection. This paper is an effort to perform a thoughtful study by analyzing the medical data of 500 distinct patients of which 200 were from wave 1, 150 from wave 2, and 150 patients from wave 3. The analysis considering various aspects and factors was performed for all three waves. This particular study discusses various symptoms of COVID-19, mediums of spread, standard characteristics such as gender, age, and disease, analysis of the result data of laboratory testing, and finally presents the cure provided to the different infected patients. Lastly, on the basis of this study, it is concluded that wave 1 was more dangerous as compared to wave 2 and wave 3.

A. Malik
Delhi Technical Campus (DTC), GGSIPU, Greater Noida, India

V. Parihar
KIET Group of Institutions, Delhi-NCR, Ghaziabad, India

B. Bhushan
School of Engineering and Technology (SET), Sharda University, Greater Noida, India

J. Srivastava
Noida Institute of Engineering Technology (NIET), Greater Noida, India

R. Sharma (✉)
SRM Institute of Science and Technology, Ghaziabad, India
e-mail: rohitapece@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_48

Keywords COVID-19 · Symptoms · Statistical study · Wave · Diseases · Virus · Patients · Infection · Cure · Analysis

1 Introduction

The first case of novel coronavirus disease-2019 (COVID-19) was identified in a city of China named Wuhan at the end of 2019 and by the time of January 2020, almost 800+ new patients had been identified in different countries such as China, South Korea, Thailand, Singapore, Japan Vietnam, Nepal, and USA. The fatal disaster happened to the patients who already had some severe disease. The actual and detailed reasons for the emergence and spread of this virus remained undiscovered for most of the time but according to the medical study assumption, it was found that most of the cases arise due person-to-person transmission of the virus. There are variants of COVID-19 such as Severe Acute Respiratory Syndrome of COVID-19 (SARS-CoV) and Middle East Respiratory Syndrome of COVID-19 (MERS-CoV) which have already outburst in some countries in the year of 2002 and 2012. The 2019-nCoV is the third variant of COVID-19 which affected drastically the humans and shook off the roots of global public health organizations and the World Health Organization (WHO). China informed quickly the WHO about the outburst of the virus on the discovery of initial cases and shared the information with the international communities [1]. The WHO reacted quickly to this by issuing a public advisory on the spread and precautions for the virus, directing the measures of diagnostics, monitoring of patients, sample collections, and testing. The COVID-19 is a family of a large number of viruses that can affect humans as well as birds or animal species, according to the WHO. These variants of viruses have already affected some areas of the world earlier that include SARS-CoV, an outbreak in 2002, or MERS-CoV, which spread in the middle of 2015 in South Korea [2]. The most recent variant is SARS-CoV-2, has triggered in December 2019 in China and became a concern for international health. Some variants were less powerful, whereas some have devastating impacts that lead to severe infections [3]. The primary goal of this research is to present the statistical analysis of all the three waves of COVID-19 in India based on different aspects such as medium of spread, the impact of existing diseases, age, gender, a habit of smoking, and many more. Analysis of laboratory data has also been presented for a detailed overview [4]. This research study considers the data of 500 patients for analysis who were hospitalized due to the infection of COVID-19 in which 200 are from wave 1, 150 from wave 2, and the remaining 150 are from wave 3, the paper has considered the impacts of all the three waves of COVID-19 in India.

The rest of the paper is organized as follows: Sect. 2 deliberates the facts and figures of COVID-19 along with a brief of its seven variants, three waves, and the various ways of transmission of this virus. Here, a table is presented to show the various sources of this virus. Furthermore, Sect. 3 discussed the statistical studies of COVID-19 based on some characteristics. A table is projected here to show the symptoms of patients infected with COVID-19. Additionally, a comparison of three

waves of COVID-19 based on some standard characteristics such as gender, sex, body mass index, and diseases is presented. Moreover, this section is also compared the three waves based on some serious and important laboratory findings such as temperature, blood pressure, and oxygen level of infected patients [5]. It also presents an analysis of the total number of deaths and recovered patients in the considered durations. Section 4 explained the selected curing procedure of infected patients taken from three waves. Finally, the paper concluded with Sect. 5 and followed by future research direction.

2 Coronavirus Disease-2019 (COVID-19)

The disease, named coronavirus diseases-2019 or COVID-19, has been declared a global epidemic by WHO with almost 250 million identified cases by October 2021 to the worldwide. Various countries have detected a wave pattern in the cases of COVID-19 cases as the cases increased in the peak months of 2020. India detected its first COVID-19 case on January 27, 2020, in the city of Kerala with the symptoms of throat infection and dry cough, and after that more cases were discovered with the high level of criticality. Till March 2020, a high number of cases were reported, and the rate of infection has started to get less till September 2020, when the recovery rate got higher [6]. The second wave knocked in March 2021 which has proven to be more critical and harmful due to the lack of medical facilities in comparison with the number of infected cases, i.e., shortage of medical supplies, oxygen cylinders, beds, medicines, etc. According to the worldwide data, India has reported the second highest number of COVID-19 cases, and in the number of deaths, it is the third highest in the world [7].

2.1 Variants of COVID-19

COVID-19 is a group or family of different viruses that change with time by replicating themselves. When a virus has more than one mutation, it is said to be a new variant of the original one. COVID-19 is further divided into four classes such as alpha, beta, gamma, and delta variants [8]. The human COVID-19 strains are HCoV-229E, HCoV-NL63, HCoV-HKU1, HCoV-OC43, MERS-CoV, SARS-CoV, and SARS-CoV-2, explained as follows:

- **MERS-CoV**—In accordance with the sources of WHO, it firstly appeared in Saudi Arabia in September 2012, and the infected cases were also traced in Jordan. Humans are infected by MERS-CoV through contact with infected camels. Further, the virus was spread by coming into close contact with the already infected person. Till the time of 2012, almost 27 countries have confirmed 2500+ cases of the MERS variant. In the duration of 2015, an outburst occurred in South Korea

and around 186 cases and 36 deaths were reported from the sources. According to the trusted sources of the centers for disease control and prevention (CDC), almost 200+ cases of this variant have been detected in the year 2019 [9].

- **SARS-CoV**—The very first infected human through this variant was found in the southern part of China during the period of November 2002 as per WHO information. According to an assumption, SARS-CoV had its origin in bats and then spread to other animal species. Later on, it infected humans also through contact. In the duration of 2002–2003, almost 8000 people around the globe were infected with SARS-CoV, and deaths were reported around a number of 774. In the middle of 2003, the possible measures of infection control have been taken like isolation of infected persons.
- **SARS-CoV-2**—This variant is the cause of the ongoing disease, COVID-19. This new mutant of COVID-19 was first detected in Wuhan, China at the end of the year 2019. An increase was noticed in the cases of pneumonia without any known reason. These cases of pneumonia were associated with seafood and poultry products. According to the assumptions, the virus has its origin in the animals but its exact actual origin is still not known. Within a duration of a few months, this variant has spread through human interactions and affected a huge number of countries [10].

2.2 Way of Spreads

The very popular reason for the spread of COVID-19 is the person-to-person contact, but a limited study is available about the transmission of the human COVID-19 virus (HCoV). Moreover, the researcher's assumption states that transmission of virus takes place via fluids, present in the respiratory system like mucus. The virus can be transmitted through sneezing or coughing in public with an uncovered mouth that scatters droplets into the environment. Shaking hands with infected people or touching may also spread this virus among people. Touching an object or surface with having a virus and then touching the eyes, nose, or mouth may also cause infection [11]. The Feline Coronavirus (FCoV), i.e., animal virus can also result in infections through contact with feces. Although, it is still not clear whether this is true for human COVID-19 too, or not. According to the National Institutes of Health (NIH) suggestion, distinct groups of people are prone to severe complications because of COVID-19. The mutation process of this virus makes it more contagious and harmful. For preventing the transmission of this virus, people should avoid coming in contact with others and should remain at home until the symptoms are visible. While sneezing or coughing, the nose and mouth should be covered to prevent the spread [12]. Furthermore, Table 1 shows the various source where people get infected from COVID-19.

According to the data shown in the table, around 42% of the cases have a known source of infection, and for the rest, the origin of infection remained unknown. Almost 11.5% of people got infected from the hospital, whereas around 12.5 people

Table 1 Sources of infected people from COVID-19

Source [13, 14]	Number of patients (NoP) = 500	Wave 1, NoP = 200	Wave 2, NoP = 150	Wave 3, NoP = 150	Critical cases
Institute	13	8	2	3	169 (wave 1), 64 (wave 2), and 19 (wave 3)
Inside home	18	11	4	3	
Outside home	43	26	10	7	
Market	64	33	9	22	
Hospital	58	29	11	18	
Office	18	10	3	5	
Unknown	286	169	74	43	

got infected by vising market areas [11]. The people infected from the other sources have a percentage from 2.6 to 8.6%. Moreover, the number of critical cases is approximately high in wave1, i.e., 84.5% when compared to wave 2, i.e., 42.6% and wave 3, i.e., 12.6%.

3 Statistical Studies

This section represents a statistical analysis based on the symptoms of COVID-19 in different patients of all three waves. The data was managed by the REDCap tool, a tool for online data capture and management. All the missing values were properly handled, and the analysis part was completed using Stata 17. The NoP variable represents the number of patients [15]. Hence, the symptoms of patients infected with COVID-19 are shown in Table 2.

According to the data, the primary symptoms were fever, cough, sour throat, body pain followed by dyspnea, and a sense of taste. There were several other impacts also in different patients. A higher percentage (90.2%) of patients have not felt the sense of taste and smell, and it was almost similar for all the three waves. Around 89% of patients felt the sense of vomiting and nausea as the impact of COVID-19. Moreover, also other impacts were there such as chest pain, diarrhea, irritation in the eyes, headache, runt nose, and skin rashes, and these symptoms in infected patients were quite low than the ones discussed above [18]. Thus, pointedly, a greater number of patients experienced fever, cough, dyspnea, and sour throat during wave 1 in comparison with wave 2 and wave 3.

Table 2 Symptoms of COVID-19

Symptoms [16, 17]	NoP = 500	Wave 1, NoP = 200	Wave 2, NoP = 150	Wave 3, NoP = 150
Fever	500	200	150	150
Cough	500	200	150	150
Sore throat	500	200	150	150
Runny nose	86	49	16	21
Dyspnea	445	163	143	139
Body pain	500	200	150	150
No sense of taste	451	166	145	140
Diarrhea	115	59	25	31
Headache	426	159	134	133
Aches	97	42	23	32
Tiredness	500	200	150	150
Difficulty in speech and mobility	353	174	96	83
Red or irritated eyes	95	40	23	32
Confusion	51	29	13	9
Chest pain	247	120	68	59
Vomiting	443	186	136	121
Rash on skin	91	53	26	12
Malaise	213	106	58	49
Discoloration of fingers or toes	220	123	41	56
Nausea	440	188	137	121

3.1 Standard Characteristics

According to the data presented in Table 3, of the patients infected with COVID-19, around 47.6% were male, 42.8% were female, and 9.6% were from the transgender category. Comparatively, less number of females were infected in wave 2 than in wave 1 and wave 3. The percentage of infected people in the age group > 40 is greater than the age group < 40. The persons having a habit of smoking had a higher infection rate. Also, the persons who already have any prior diseases were affected more. A prior history of any disease made the effects of COVID-19 more critical to the patients [19]. Nearly, 65% of patients had more than one disease, and the very common diseases were cancer, tuberculosis, nephrological, and urological disease. Moreover, the count of recovered and death rate in 500 patients of three waves are shown in Fig. 1.

Table 3 Comparison of three waves of COVID-19 based on some standard characteristics

Characteristics [12, 20]	Sub-characteristics	NoP = 500	Wave 1, NoP = 200	Wave 2, NoP = 150	Wave 3, NoP = 150
Duration	–	–	Jan 2020 to Aug 2020	March 2021 to Oct 2021	Dec 2021 to onwards
Gender	Male	238	96	86	56
	Female	214	82	53	79
	Transgender	48	22	11	15
Age in years	0–20	18	4	2	12
	21–40	53	19	23	11
	41–60	155	59	42	54
	61–80	182	79	64	39
	81+	92	39	19	34
Average body mass index	–	500	29.5%	31.6%	32.9%
Smoker	Never	82	50	24	8
	Current	262	91	82	89
	Prior	156	59	44	53
Diseases	One	171	63	42	66
	More than one	329	137	108	84
Name of disease	Diabetes	29	11	9	9
	Stroke	10	4	5	1
	Asthma	11	5	4	2
	Heart disease	35	14	11	10
	Cancer	40	17	9	14
	Nephrological and urological disease	46	17	14	15
	Osteoarthritis	18	8	5	5
	Chronic bronchitis	36	14	12	10
	Cystic fibrosis	41	18	10	13
	Tuberculosis	49	19	14	16
	Rheumatoid arthritis	21	9	6	6
	Neurological disease	18	8	5	5
	Metabolic disease	27	10	9	8
	Psychiatric disease	27	11	7	9
	COPD	37	15	12	10
	Emphysema	55	20	18	17

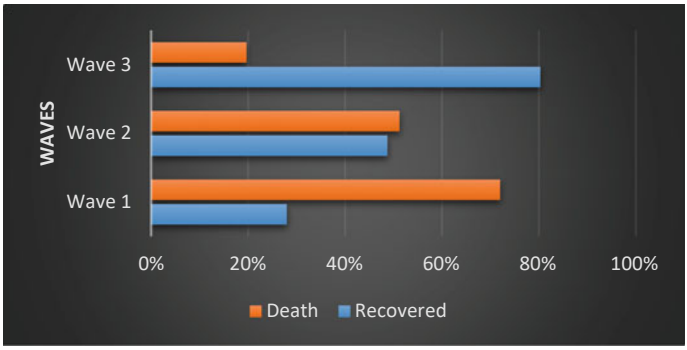


Fig. 1 Death and recovery rate of three waves in India

3.2 Lab Outcomes and Important Indications

The analysis of normal clinical data and laboratory result data has been shown in Table 4. It considers the vital signs at the time of admission and primary lab tests. Information on vital signs and lab results was not openly available because of the clinical research. The comparison of lab outcomes and vital signs is presented for wave 1, wave 2, and wave 3. Throughout the study, higher levels of inflammatory markers were observed. The median values of CRP levels and lactate dehydrogenase were more than the normal range of values (< 8 mg/l and 105–205 U/l, respectively) [21].

All the infected patients have observed the symptom of fever where patients of wave1 have a higher temperature than the wave 2 and wave 3 patients. There is not so much distinction in lab results of the patients of wave 1, wave 2, and wave 3. Moreover, high CRP and creatinine along with high thrombocyte and leucocyte levels are observed in wave1 patients in comparison with wave 2 and wave 3 patients. Patients with any existing serious disease have observed a higher respiratory rate and body temperature as well as low oxygen levels with diastolic blood pressure at the time of hospital admission. Lower levels of hemoglobin with higher creatinine as well as CRP levels were observed among the patients already having any critical disease. Furthermore, patients having a critical disease with fatal outcomes were observed with high creatinine levels in comparison with the patients who survived despite the critical disease [24].

4 Cure and Results on the Basis of Analysis

The particulars and details of the treatment opted for the COVID-19 infected patients are shown in Table 5. In total, we have observed the data of 500 patients with COVID-19 admitted to the hospital during the different waves of COVID-19. Around 7.2% of

Table 4 Laboratory results

Category [22, 23]	Laboratory results	NoP = 500	Wave 1, NoP = 200	Wave 2, NoP = 150	Wave 3, NoP = 150
Normal hospitals results	Pulse (> 60–100 beats/min)	405	181	121	103
	Temperature (> 40 °C)	500	200	150	150
	Oxygen level (> 50)	402	164	112	126
	Respiratory rate (> 34/min)	417	174	124	119
	Diastolic blood pressure (> 120 mm Hg)	390	162	119	109
	Systolic blood pressure (> 120 mm Hg)	410	152	126	132
Laboratory results	Hemoglobin (< 6 gm/dL)	421	156	131	134
	Leucocytes (> 11)	375	129	121	125
	Thrombocytes (< 10,000)	404	169	116	119
	Alanine aminotransferase (7–54 U/L)	385	171	115	99
	Alkaline phosphatase (42–146 IU/L)	453	186	129	138
	Lactate dehydrogenase (105–332 IU/L)	415	182	106	127
	Sodium (135–145 meq/L)	428	172	124	132
	Potassium (3.5–5.2 meq/L)	395	167	101	127
	C reactive protein (> 81 mg/l)	381	159	99	123
	Creatinine (0.7–1.4 mg/dl)	402	142	134	126
	Bilirubin (0–1.2 mg/dl)	392	158	120	114
	Lymphocytes (1000–4800)	375	172	98	105

Table 5 Ways of treatment of patients

Cure [25]	NoP = 500	Wave 1, NoP = 200	Wave 2, NoP = 150	Wave 3, NoP = 150
ICU care	36	21	12	3
Days at ICU	39	19	13	7
Oxygen cylinder	332	183	98	51
Days with oxygen	30	16	9	5
Ventilation	63	39	18	6
Days on ventilation	17	9	5	3
Days at the hospital (> 20 days)	110	59	35	16
Isolated at home	283	184	73	26
Readmit	178	109	43	26

all the hospitalized patients were treated in the ICU of which 10.5% belong to wave 1, 8% from wave 2, and 2% from wave 3. Almost 66% of patients were provided oxygen supplementation which is more than half the number of patients, and more than 12% of patients were provided ventilation. Patients cured by observing home isolation only were around 56%. Moreover, 10% of patients died at the time of admission or within the duration of one month of diagnosis. The calculated median value for the number of days of hospitalization was four days.

5 Conclusion

The work of this paper is an inclusive examination associated with the human, medical, and laboratory standard features as well as the sources of infection among the three waves of COVID-19. The outcomes carry a new and important conclusion to this arena by confirming and validating the previous outcomes. Finally, we have taken 200 patients from wave 1, 150 patients from wave 2, and 150 patients from wave 3, after investigating all the patients on the basis of various attributes, it is concluded that the progression of the COVID-19 was poorer in wave 1 patients among 500 admitted patients in hospitals from wave 1, wave 2, and wave 3. The total number of days of admitted patients was more in wave 1 as lots of patients experienced the serious impact of the virus of COVID-19. Conversely, it is seen that there is a slight difference between the standard and laboratory data of 500 admitted patients. Most likely, the health circumstances of COVID-19's infected admitted, and treated patients were better in wave 3 as related to wave 1 and wave 2. Furthermore, a huge

amount of patients who are infected with COVID-19 remains unknown according to their statement, and most of the patients infected from COVID-19 after a visit to the market. In line with other studies involving the patients from wave 1, wave 2, and wave 3, it is examined that aged and male people who are addicted to smoking and have some diseases, furthermore, such as influenza, body pain, vomiting, infection, and dyspnea are the major risk factors and symptoms of COVID-19. In addition, it has seen a significant increase in CRP and creatinine levels in infected patients, as well as lesser hemoglobin levels in critical patients. Finally, it is concluded on the basis of various investigations that the birth rate of patients is more in wave 1 than in wave 2 and lower in wave 3. In future research direction, further research investigation on the laboratory outcomes of COVID-19 patients can be done and in addition, and future studies on comparing and reducing dangerous risk factors of different COVID-19 waves may be interesting and helpful to the healthcare system to prevent death.

References

1. Zhang, S., Yang, S., & Yang, H. (2021). Statistical analysis of spatial network characteristics in relation to COVID-19 transmission risks in US counties. In *2021 43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 2278–2281). https://doi.org/10.1109/EMBC46164.2021.9629892
2. Vo, M. T., Vo, A. H., Nguyen, T., Sharma, R., & Le, T. (2021). Dealing with the class imbalance problem in the detection of fake job descriptions. *Computers, Materials and Continua, 68*(1), 521–535.
3. Zhang, Y., Liao, Q., Yuan, L., Zhu, H., Xing, J., & Zhang, J. (2021). Exploiting shared knowledge from non-COVID lesions for annotation-efficient COVID-19 CT lung infection segmentation. *IEEE Journal of Biomedical and Health Informatics, 25*(11), 4152–4162. https://doi.org/10.1109/JBHI.2021.3106341
4. Sachan, S., Sharma, R., & Sehgal, A. (2021). Energy efficient scheme for better connectivity in sustainable mobile wireless sensor networks. *Sustainable Computing: Informatics and Systems*, *30*, 100504.
5. Ghanem, S., Kanungo, P., Panda, G., et al. (2021). Lane detection under artificial colored light in tunnels and on highways: An IoT-based framework for smart city infrastructure. *Complex and Intelligent Systems*. https://doi.org/10.1007/s40747-021-00381-2
6. Sachan, S., Sharma, R., & Sehgal, A. (2021). SINR based energy optimization schemes for 5G vehicular sensor networks. *Wireless Personal Communications*. https://doi.org/10.1007/s11277-021-08561-6
7. Zhang, S., Ventura, M., & Yang, H. (2021). Network modeling and analysis of COVID-19 testing strategies. In *2021 43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 2003–2006). https://doi.org/10.1109/EMBC46164.2021.9629754
8. Priyadarshini, I., Mohanty, P., Kumar, R., et al. (2021). A study on the sentiments and psychology of Twitter users during COVID-19 lockdown period. *Multimedia Tools Applications*. https://doi.org/10.1007/s11042-021-11004-w
9. https://www.kaggle.com/datasets/sudalairajkumar/novel-corona-virus-2019-dataset
10. https://ourworldindata.org/explorers/coronavirus-data-explorer?zoomToSelection=2020USA~GBR~CAN~DEU~ITA~IND

11. Azad, C., Bhushan, B., Sharma, R., et al. (2021). Prediction model using SMOTE, genetic algorithm and decision tree (PMSGD) for classification of diabetes mellitus. *Multimedia Systems*. https://doi.org/10.1007/s00530-021-00817-2
12. https://www.tn.gov/health/cedep/ncov/data/downloadable-datasets.html
13. https://ourworldindata.org/covid-hospitalizations
14. https://ourworldindata.org/covid-deaths
15. Priyadarshini, I., Kumar, R., Tuan, L. M. et al. (2021). A new enhanced cyber security framework for medical cyber physical systems. *Software-Intensive Cyber-Physical Systems*. https://doi.org/10.1007/s00450-021-00427-3
16. https://data.humdata.org/event/covid-19
17. https://datascience.nih.gov/covid-19-open-access-resources
18. Priyadarshini, I., Kumar, R., Sharma, R., Singh, P. K., & Satapathy, S. C. (2021). Identifying cyber insecurities in trustworthy space and energy sector for smart grids. *Computers and Electrical Engineering*, *93*, 107204.
19. Singh, R., Sharma, R., Akram, S. V., Gehlot, A., Buddhi, D., Malik, P. K., & Arya, R. (2021). Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. *Safety Science*, *143*, 105407. ISSN 0925-7535.
20. https://app.dimensions.ai/details/data_set/dataset.57704629?search_2019COVID&search_facet_year=2022&or_facet_year=2021&or_facet_year=2020
21. Sahu, L., Sharma, R., Sahu, I., Das, M., Sahu, B., & Kumar, R. (2021). Efficient detection of Parkinson's disease using deep learning techniques over medical data. *Expert Systems*, e12787. https://doi.org/10.1111/exsy.12787.
22. https://www.mygov.in/corona-data/covid19-statewise-status/
23. https://covid19.who.int/table
24. Verma, R., & Sharma, R. (2022). Dual notched conformal patch fed 3-D printed two-port MIMO DRA for ISM band applications. *Frequenz*. https://doi.org/10.1515/freq-2021-0242
25. https://www.worldometers.info/coronavirus/

Genetic Algorithm: An Approach for Software Testing Based on a Given Source Code

Jaya Srivastava, Ayasha Malik, Bharat Bhushan, Veena Parihar, and Shyam Nair

Abstract In the progression of computer-based structures and products, software has turned out to be a vital element. Software testing is an utmost effort of an intense segment in the software development life cycle. In the same manner, everyone like to minimalize the struggle and distinguish the most of the number of errors. Automatic test case production helps to minimize the price and time effort. Worldwide a single or most significant method of automatic test case production is a crucial issue in software testing and a warm problem in the study of software testing. The paper proposed a genetic algorithm (GA) to improve the test case and the submission of the artificial intelligence (AI) approaches that is applied in software testing for automatic software testing. The data of test cases are produced randomly by put on the conditional coverage on the source code and creating the control flow graph (CFG) of the source code and then applying GA test cases that are automatically generated. GA makes the test cases optimized and outperforms which is produced by a type of testing named random testing (RT). It is an effective technique for enhancing test cases by applying GA and conditional coverage as well that implemented in MATLAB. Automated test case production improves the software testing approaches and advances the quality of software. Like this automated test, case production decreases the complete cost of software development for software-based systems.

Keywords Source code · Software testing · Genetic algorithm · Software · Test cases · STLC · SDLC

J. Srivastava
ABES Engineering College, Ghaziabad, India

A. Malik (✉)
Delhi Technical Campus (DTC), GGSIPU, Greater Noida, India
e-mail: ayasha07.am@gmail.com

B. Bhushan
School of Engineering and Technology (SET), Sharda University, Greater Noida, India

V. Parihar
KIET Group of Institutions, Delhi-NCR, Ghaziabad, India

S. Nair
School of Graduate Studies, Bluecrest University College, Monrovia, Liberia

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_49

1 Introduction

As the system software and hardware skills grow day-by-day, the practice area of computer is progressively widespread; the practice of software in numerous fields is ever more powerful that making the use of software very difficult and the complexity of software increases gradually. Software testing is like an auditor of the Software Development Life Cycle (SDLC)'s phase named software requirements, designing phase, and coding phase earlier the software is placed into operation. Software testing is the process of executing a software system or a single program intending to discover errors. Testing is a procedure of guaranteeing that software is functioning as stated by the requirement and sustaining the client's requirements. The stage of testing is the ultimate strainer for all faults of oversight and instruction. Software testing is more difficult rather than testing an individual program for its functioning. Every assessment, examination, audit, walk-through, and cluster code recites all are the one kind of testing. Software testing is a procedure that can be moved with different types of testing, namely, unit testing, integration testing, validation testing, and system testing. Software testing plays a vital role in producing reliable and useful software, as the test case is precise; then, software testing can discover faults in software. In contrast, producing a huge amount of precise test cases is a complex task, and to finish this huge task, if we depend on manual effort, there is a probability of errors in software [1].

Consequently, it is a complex issue to understand the requirement of automatic test case production. In this paper, we proposed a version for automated and improved test case production. In our proposed approach, the primary test case is produced by applying the type of coverage named conditional coverage to traverse all the paths of the control flow graph (CFG), and then, the genetic algorithm (GA) is applied for producing the optimized test cases. This is an effective method of producing optimized test cases by applying GA and as well as conditional coverage. The practice of artificial intelligence (AI) approaches is applied in Software Testing Life Cycle (STLC) for automatic testing of software. Random number generators are not effective for such kinds of problems as they generally not provided the essential information that covers the whole program. According to Huayao et al. [2], random testing is particularly suggested for the final phase of software testing. Priyanka et al. [3] presented a genetic algorithm for the generation of test cases applicable to Equivalence Class Partitioning (ECP). It was a revolutionary approach for generating a completely automated test case design for ECP. Researchers have developed GA-based generators for test data generation by applying some effective calculations. Numerous methods have been already developed for the generation of test data which can be classified as structural testing and functional testing. Xiangjuan et al. [4] presented a construct of GA for detecting error-prone paths that occurred mostly in software. GA can also be utilized for the optimization of the test cases which are generated by applying test harness and category partitioning. The major contributions of the study are as follows:

- In our proposed model, the primary test cases are produced by applying a kind of conditional coverage to track all the paths of CFG. Further, GA is applied for producing the optimized and enhanced test cases.
- It is an effective and well-organized technique for improving the quality of test cases and producing a huge amount of optimized test cases automatically by applying one application of AI named GA.
- GA generating enhance test cases that are able to discover all the errors possible in the software system. We polished the test case by applying GA castoff by the user. The handler has the power to test the source code by applying enhanced test cases.
- This practice is an auspicious technique for completely automatic test case production for the testing method. This methodology of producing test cases automatically minimizes the tester effort and overall cost of the testing procedure.

The remainder of the paper is summarized as Sect. 2 discusses the detail of software testing with its two testing approaches, its categories, and various types of software testing processes. Moreover, Sect. 3 deliberates the proposed model or technique based on GA; here, the stages of GA are explained in detail that need to be followed for testing the software. Additionally, the preprocessing steps of the proposed algorithm and phases of post-processing of the proposed algorithm are listed. Furthermore, Sect. 4 presents the results of the proposed algorithm. Finally, the paper concluded with Sect. 5 and followed by future research direction.

2 Software Testing

In the SDLC model, the software testing phase plays a vital role in software system development; the testing phase is an audit report of all previous phases of SDLC. The cost of this phase in software development has a higher portion of the overall cost of software development. Different kinds of approaches used for testing the software are discussed below. There are numerous testing approaches are used for the testing process. Some testing approaches need the perception of code. Some testing processes are performed manually although some others can securely work automatically. Apparently, different software testing approaches need dissimilar heights of technical ability, information, and tools. Basically, two kinds of approaches are explored here.

- **Top-Down Approach**—Firstly, the top-down approach is founded on creating the highest control software system. In the approach of top-down, testing begins from the topmost of the hierarchy and then gradually enhances the components that are used for testing the novel collective software system. A stub is a replica procedure that is put on the components. In this method, the component (or a collection) cannot be verified in separation as they raise a call for some additional components. For testing the components, it is needed to test it previously when their dependents have been coded, stubs put on the behavior of the subsidiary.

- **Bottom-Up Approach**—The method of bottom-up is begun from the bottommost of the hierarchy. At all phases, the dependent components are available, and they are tested previously. To execute the bottom-up method, drivers are required for arranging a suitable atmosphere for raising the call for the component. It is the task of the driver to raise the call for components beneath the testing procedure with a diverse group of test cases.

2.1 Software Testing Categories

Software testing techniques can be explained as the different ways and methods of testing the source code to ensure that the specific program is functioning well and carries out the specific task. There are mainly two main categories of software testing techniques named static testing and dynamic testing.

- **Static Testing**—Static testing denotes testing the software requirement specification (SRS), software design specification (SDS), and other non-performing items through examination of requirements, audits, desk examination, reviews, and walk-throughs, etc. Static testing will examine afresh developed or already used code for observance of recognized standards.
- **Dynamic Testing**—Dynamic testing is denoted by 3 +++ as defines the progress of test cases and testing process, the implementation of test cases, and the assembly and practice of test records and variance or occurrence reports. There are mainly two general customs to execute dynamic testing called black (functional) box testing and white (glass) box testing. These two approaches need a group of well-matured and well-organized test cases. Dynamic testing is not able to detect the complete error of a software invention until it is not executed in a comprehensive way.

2.2 Software Testing Techniques

Testing techniques are a skeleton that defines the testing method of the STLC. A testing approach for testing the software system takes part in the design phase of STLC and produces test cases into a well-organized sequence of steps, and the outcome of that step is effectively an expansion of the software [5]. There are numerous kinds of testing approaches which are shown in Fig. 1.

- **Unit testing**—It focuses on the individual module role of the software system employed in the source code; then, modules are collected and combined for the testing purpose.
- **Integration testing**—It emphasizes the strategy and creation of the software-based system. It also concentrates on software input and outcome and also checks that modules are suitable together and work in an organized way.

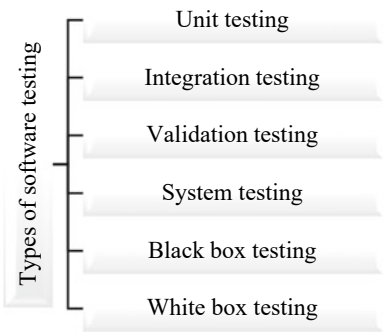


Fig. 1 Types of software testing

- **Validation testing**—It validates the needs of the developed software; it delivers the ultimate guarantee that the software encounters all functional requirements and presentation requirements.
- **System testing**—In this kind of testing, software and all other software system foundations are tested entirely to find that the complete software system is functioning well and attained the performance. In this paper, we applied unit testing as we capture source code and emphasis every module role of the source code and inner construction of the program's source code.
- **Black box testing**—The black box testing does not test the inner construction and functioning of the source code. The main aim of this testing is to detect exclusively when the input–output functioning of the source code does not approve its requirements. In this method, data for test cases are created from its requirement. It can perceive absent logic errors; black box testing is also termed functional or description-based testing.
- **White box testing**—In white box testing, the inner construction of the program is measured, by executing the code. The inner construction of the program is inspected, and the test cases are derivate from the inner construction of the program. This is also termed structure based or structural testing [6].

Furthermore, the key issue of testing is that it solitary tested those inputs that are particularly nominated as the test cases. The accuracy of the source code can only be guaranteed by the broad testing that tests the source code is test either with all probable input standards or with all the probable test cases that are produced beneath all imaginable limitations [7].

3 Proposed Model or Technique Based on Genetic Algorithm

The period and cost consumed in developing the software can be condensed by applying GA; thus, it improves the software testing approaches. The elementary

principle of GA is the existence of the fittest. GA explores the random hunt space logically to resolve the issue of producing test cases. The exploring technique of GA begins with a group of starting explanations that are called the initial population. That initial population is also known as the chromosome. The searching technique is going on by the principle of searching the fittest standard and then by using these new productions of initial population proceeds the search operation. After that, there are mainly three significant stages named reproduction, crossover, and mutation. This rotation iteratively reappears for making the new product while the convinced standards are encountered. The chromosome which has the finest fittest value is located for further steps, and then, the condition ended. There are mainly five stages in GA. The summary of these stages of the GA is as follows:

- **Initialization**—Produce a random initial population that is also named chromosomes which provide the appropriate result for new productions.
- **Fitness Value**—From the initial population, calculate the fittest value for every chromosome for further procedure.
- **Reproduction**—Generate a fresh population by iteratively using subsequent stages while the fresh population is produced.
- **Selection**—In the selection phase, any two parental chromosomes are nominated from a population. The population with highest fitness value has more possibility to be nominated as a new chromosome.
- **Crossover**—In this stage with nominated chromosomes, new children are generated. There is the possibility that the parent chromosome and children's chromosome are exactly the same if the crossover procedure was not performed well.
- **Mutation**—With a mutation possibility, children's chromosomes are mutated at every location of the chromosome.
- **Accepting**—Initial population is exchanged with new children's chromosomes.
- **Replace**—New produced population is further applied to run the algorithm.
- **Test**—When the termination statement is fulfilled, then stop the algorithm and come back to the finest solution. Figure 2 shows the flow graph of the purposed algorithm.

In our proposed model, we begin the testing procedure by carrying a source code. For the testing procedure, test cases are required which are produced by grouping the input and output. In our procedure, we create CFG for the source code and then put on the Boolean coverage on the CFG, and randomly, test cases are produced. These test cases are advanced by applying GA for generating a group of enhanced test cases that can perceive all probable errors in the source code. The condition coverage performs each correct and wrong output of every condition, and the testing capability is assessed by coverage condition that to which limit the source code is practiced by the coverage, and among all, coverage condition coverage is very useful as it traverses all the tracks of the source code in CFG. An elementary algorithm for a GA is as follows the pseudo-code for GA is.

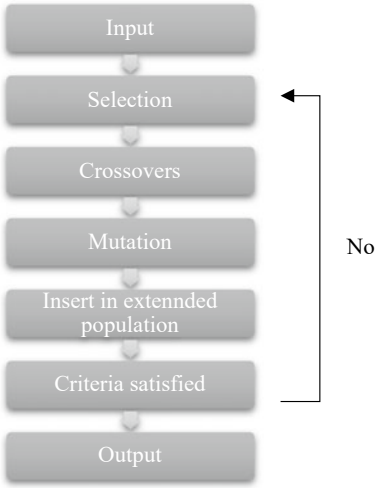


Fig. 2 Proposed algorithm flowchart

```
Initialize (Input)
Evaluate (Input)
While (stopping condition not satisfied)
        do {
        Selection (Input)
        Crossover (Input)
        Mutate (Input)
        Evaluate (Input)
         }
```

3.1 Preprocessing of Algorithm

In our proposed model, we apply GA for producing test cases automatically. GA has mainly five stages. The first step is to take the initial population which is taken randomly by making the CFG of the source code by applying condition coverage which traces all the paths of the source code. In our proposed model, the working of the algorithm is as follows:

Step 1—The first step in the algorithm is to make CFG for the source code.
Step 2—Random test cases are produced by applying the conditional coverage on CFG for the initial population.
Step 3—Conditional coverage is also used for searching for the fittest value for all chromosomes.
Step 4—The test cases that have the finest fitness value are used for crossover and mutation operator for further production.
Step 5—After that produced new test cases are exchanged with initial test cases.

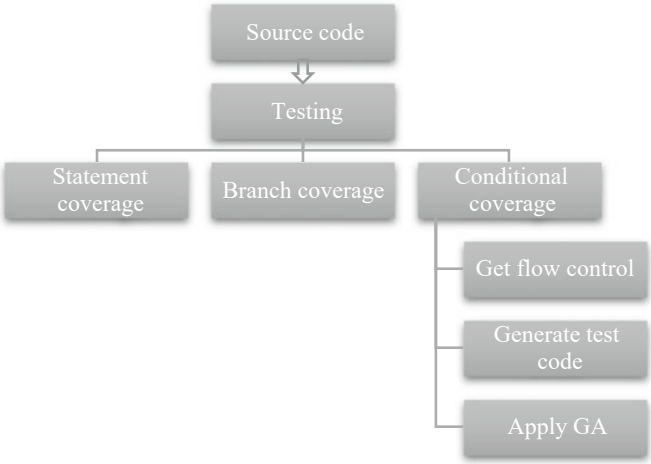


Fig. 3 Flow of data

Step 6—Turn back to step 3. Moreover, Fig. 3 shows the flow of data in our proposed model.

3.2 Post-processing of Proposed Algorithm for Optimizing Final Test Cases

The important stage in STLC is to create a test case, and this stage of STLC is time-consuming; so, if the procedure of this phase is accomplished automatically, then it saves the time and overall cost of the project and also improves the testing procedure. Hereafter, our proposed model is advantageous for the testing procedure in the following way:

- Test cases can be produced efficiently.
- Time consumed in the testing process will be shortened.
- Testing is completed more understandingly.
- Testing procedures turn out to be more elastic.
- Testing procedure completed very promptly.

In this research paper, the source code is taken for searching for the result of a quadratic equation. So, for this purpose, a CFG is made for the source code and then uses conditional coverage. The benefit of conditional coverage is that it practices each edge of the CFG at least once whether it is true or false. The test cases are produced by random testing by applying for conditional coverage. Test cases are polished by the GA for enhancing the test cases; additionally, the phases to perform GA are explained below.

- **Initialization**—In the preliminary stage, there is a need for test cases, and we do not recognize which test cases are right and which are wrong for further procedure; therefore, test cases are produced by random testing. The test cases are produced is called the initial population. At present, time path testing and branch testing are applied for producing the test cases, but these approaches are not successful in producing the right test cases for all types of source code. Hence, most corporations are applying random test case data production tools.
- **Fitness function**—The fitness value applied for each initial population is based on one of three aspects that are likelihood, a value near to boundary value, and different coverage of source code. In this paper, we are applying for conditional coverage so that the finest fittest function can be determined by applying for conditional coverage on the source code.
- **Coverage of source code**—Conditional coverage is worked on each edge of the CFG whether it is right or wrong. It will execute each edge at a minimum one time. In the source code, the coverage for any test cases suit T is symbolized as $R(T)$. To estimate $R(T)$, the very first step is to make the CFG for the source code then for every test case of a test case suite (T) evaluate the group of branches that enclosed the true and false path of the graph. In the end, the coverage is evaluated as:

$$R(T) = \text{average of}(T(e)/e + F(e)/e)$$

  where e defined the entire count of edges in the CFG, $t(e)$ is defined as the count of true edges, and $f(e)$ is defined as the count of false edges for implementing the test case.
- **Selection**—In the selection phase, the roulette wheel selection technique is applied. The procedure of the roulette wheel selection method is to do the summation fitness value of entire chromosomes. Create the random count among the break of the summation accordingly as the summation is superior to the value produced arbitrarily then select that chromosome for further production.
- **Crossover**—In the crossover phase, the uniform crossover technique is used. The uniform crossover selects randomly two test suits produced in the selection phase as parents and then swaps a few of the parent test cases. In this procedure, the test cases same for both parent test suit are overlooked. The outcome of this process produces new offspring test suits.
- **Mutation**—In the mutation phase, a test suit produced from the above step is selected as a parent on a random basis. So, a few test cases selected on a random basis as the parent test suit are exchanged with the fresh produced test cases which do not exist in the prior parent test suit, and the new offspring test suit is generated.

4 Result

The paper displayed the result of applying the proposed algorithm on MATLAB, and the test cases are produced automatically. Firstly, test cases are produced randomly by using conditional coverage and then GA generates the enhanced and improve test cases automatically that can discover all the probable errors from the source code. In our algorithm, we take the source code to find the result of a quadratic equation. So, according to the algorithm,

- The initial population size for the algorithm is 0.
- The bit size of all strings is 5.
- The lower limit of the variable is taken as 32,768.
- The upper limit of the variable is taken as 32,767.
- The number of loops taken to execute the procedure of GA is 10.
- The count of iterations of the selection process to execute tournament selection is 10.
- The ultimate finest solution is specified below (Fig. 4).

$$\text{Initial population} = \begin{matrix} 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,1 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \\ 0\,0\,0\,0\,0 \end{matrix}$$

The complete outcome of MATLAB displays that this proposed model is a capable method for completely automatically test case production for the testing method that applies for condition coverage on the source code for random test case creation. To enhance the effectiveness and usefulness of testing techniques and to shorten the total development cost of software systems, an efficient and automatic test case producer is essential. GA examines for appropriate test cases in the input field of the software system beneath the testing procedure, and the proposed methodology generates test cases automatically by applying GA.

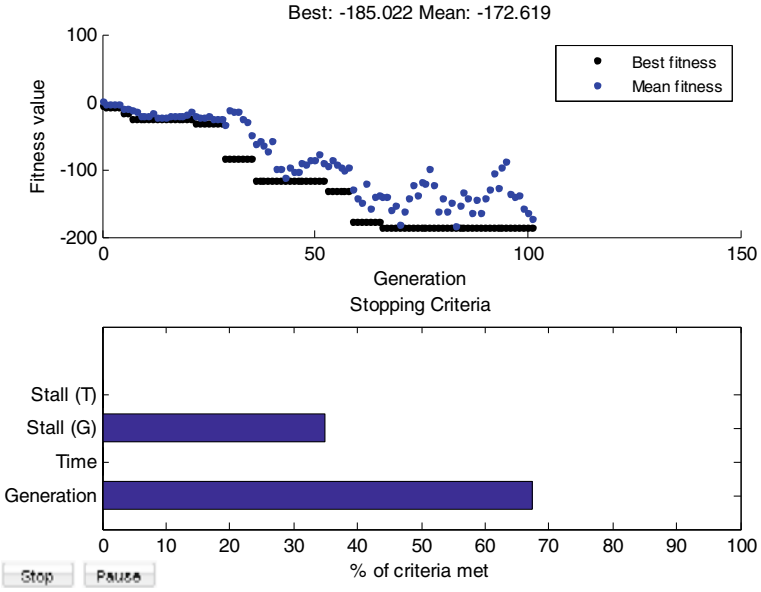


Fig. 4 Automatic test case generation using genetic algorithm

5 Conclusion and Future Research Direction

In this paper, a model is proposed for automatic test case production for software systems by concentrating on coverage based on the condition of the source code. In starting, initial test cases are produced randomly and polished by applying GA. GA has definite phases in which the important phase mutation and crossover operator generate new enhanced test cases. A group of enhanced test cases spots all possible errors from the source code. Thus, automatic test case production improves the software testing approaches and also enhances the software quality. The main objective of this research paper is to propose an algorithm based on GA for automatic test case production and also display its feasibility. In our proposed algorithm, GA displays a fine outcome in generating the new test cases for the source code. GA may not be the response to originate any software testing approach but deliver an efficient approach. The practice of GA can have a future opportunity that each method of testing can be executed by applying GA. The fitness value is carried out is the average of the three exposed aspects. But, the finest outcomes can only be attained if the aspects are allocated with diverse weights, bestowing to the source code, as few aspects are best for choosing test cases for a specific source code, but few are not so fine. So, some system experts are required to examine the type of the source code and then allocate the weights to each aspect that provides the actual fittest function value. Other phases such as crossover and mutation can also be polished so that GA can provide extra effective outcomes which makes the optimization procedure informal and quicker.

References

1. Khan, R. A., Khan, S. U., Khan, H. U., & Ilyas, M. (2021). Systematic mapping study on security approaches in secure software engineering. *IEEE Access, 9*, 19139–19160. https://doi.org/10.1109/ACCESS.2021.3052311
2. Wu, H., Nie, C., Petke, J., Jia, Y., & Harman, M. (2020). An empirical comparison of combinatorial testing, random testing and adaptive random testing. *IEEE Transactions on Software Engineering*, *46*(3), 302–320. https://doi.org/10.1109/TSE.2018.2852744
3. Priyanka, S., & Subhashni, R. (2021). Automatic test case generation using hybrid genetic algorithm. In *2021 Second International Conference on Electronics and Sustainable Communication Systems (ICESC)*. https://doi.org/10.1109/icesc51422.2021.9532880
4. Yao, X., Gong, D., Li, B., Dang, X., & Zhang, G. (2020). Testing method for software with randomness using genetic algorithm. *IEEE Access*, *8*, 61999–62010. https://doi.org/10.1109/ACCESS.2020.2983762
5. Di Nucci, D., Panichella, A., Zaidman, A., & De Lucia, A. (2020). A test case prioritization genetic algorithm guided by the hypervolume indicator. *IEEE Transactions on Software Engineering*, *46*(6), 674–696. https://doi.org/10.1109/TSE.2018.2868082
6. Moawad, A., Islam, E., Kim, N., Vijayagopal, R., Rousseau, A., & Wu, W. B. (2021). Explainable AI for a No-Teardown vehicle component cost estimation: A top-down approach. *IEEE Transactions on Artificial Intelligence, 2*(2), 185–199. https://doi.org/10.1109/TAI.2021.3065011
7. Ye, C., Ding, Y., Wang, P., & Lin, Z. (2019). A data-driven bottom-up approach for spatial and temporal electric load forecasting. *IEEE Transactions on Power Systems, 34*(3), 1966–1979. https://doi.org/10.1109/TPWRS.2018.2889995

Crop and Weed Detection From Images Using YOLOv5 Family

Katakam Koushik and S. Venkata Suryanarayana

Abstract Weed is the main field element in agriculture that has an impact on crop quality and productivity. So, it is crucial to find and categorize weeds in the field when they are still in the early stages of development. Farmers often use cultural, biological and mechanical approaches to prevent weed development in their fields. Later, as technology developed, farmers started use chemical substances like herbicides and insecticides to control pests and weeds in their fields. Farmers also sprinkle herbicides on the crops after evenly spraying them throughout a field. Crop growth, crop quality and crop output are all impacted by the herbicides' chemical composition. Therefore, it is crucial to find weed in the field when it is still in the early stages of development. Herbicides must be sprayed selectively on weeds in order to prevent damage to crops from the herbicides' chemical components. This allows for site-specific weed control. We are proposing YOLOv5 model to detect crop and weed from the images. In this paper, we compared the performance of versions with the various existing deep learning-based object detection methods like YOLOv3, YOLOv3-tiny YOLOv3-spp with three different parameters named map 0.5, map 0.5:0.95 and dataset used. This information will be helpful for practitioners to select the best technique for the crop and weed dataset.

Keywords Weed detection system · YOLOv5s · YOLOv5l · YOLOv5l6 · YOLOv5x6

1 Introduction

Wild vegetation known as weed develops in fields in between crops, competing with the crop for space and nutrients. Weed consumes crop-supplied water, sunlight, minerals and nutrients, and it also takes up area designated for crop output; as a result, the field's crop development is hampered. Farmers suffer significant losses due to weed since it lowers crop growth, quality, yield and land value. Farmers spray

K. Koushik (✉) · S. Venkata Suryanarayana
IT Department, CVR College of Engineering, Hyderabad, India
e-mail: 20B81DB004@cvr.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_50

herbicides consistently across the field to keep the weeds under control, but this is expensive for them to do only to keep the weeds under control. A weed detection system [1] that particularly identifies and categorizes weeds in the field is created using information technology as part of a precision agriculture strategy called "site-specific weed management." This method allows herbicides to be sprayed just on weeds, which reduces the amount of herbicides required in agriculture.

Deep learning technology may be utilized to create a successful weed detection system because it is already being used for facial recognition, natural language processing, object identification, picture categorization, sentiment analysis and automated self-driving cars. Convolution neural networks (CNNs), a deep learning technique frequently employed in object recognition and picture categorization, can be applied to construct a weed identification system. One or more robots, drones, computer vision systems or image recognition systems might be used to accomplish the weed detecting system. For autonomous self-driving cars, object identification, sentiment analysis and picture classification, deep learning technology is already in use. It might be implemented to develop a successful weed detection system.

In the field where a wide range of crops are grown, different forms of weed development can be noticed depending on the soil quality. It is crucial to first identify the types of weeds and crops present in the land. The data required to train the model must then be extracted using this information.

2 Literature Survey

In [2], the authors developed a Faster R-CNN detector and the fully convolutional model that trains the detector on shared characteristics from several layers of a deep neural network. A Region Proposal Network (RPN) [3] accepts any size picture and generates a set of rectangle bounding boxes. Faster R-CNN employs anchor boxes instead of picture pyramids. A scale and aspect ratio reference box is known as an anchor box. When numerous anchor boxes are used, there are many different scales and aspect ratios for the same place. Each zone is then transferred to each reference anchor box, enabling for the detection of objects of varying sizes and aspect ratios. The ROI [4] pooling layer extracts each proposed region in the image.

In [5], the authors developed R-FCN which is based on region of interest. The region-of-interest (RoI) pooling layer divides a popular family of deep networks used for object recognition into two sub-networks. They utilized classification architectures like as AlexNet [6] and VGG Nets [7] to divide the sub-network. Between two sets of convolutional layers, a deeper RoI-wise sub-network is placed to address this issue. Then, RoIs are classified into object categories and background using the R-FCN architecture. Convolutional weight layers are used for all learnable weight layers, and they are computed on the complete picture. SPPnet and Fast R-CNN are "semi-convolutional" that means one sub-network computes the full picture while another analyses selected areas. Sliding multi-scale windows on shared feature maps are used by OverFeat to recognize objects. Similarly, sliding windows that replace

region suggestions are examined. For obtaining holistic item identification results on a whole picture, another family of object detectors uses fully connected (fc) layers. They achieved the mAP of the class-specific RPN as 67.6%, which is around 9 points lower than the 76.4% of the regular Faster R-CNN.

Jafari et al. [8] evaluated two methods based on farm features investigated with different strategies to create a weed identification system. The photos were shot when the weeds had four leaves, and they had a resolution of 960 × 1280 pixels to capture the farm characteristics of the plant. The photos were recorded in RGB format, and there are 60 sets of 120 images in the collection. The photos are first analysed to identify any green content and then transformed to greyscale images so that features may be extracted. For the discrimination procedure, texture characteristics were added in ANN [9], and PCA [10] was utilized to condense the dimensionality of the input data. To categorize plant types, the support vector machine is utilized, and its accuracy is assessed using R^2 and RMSE values. They constructed the confusion matrix in order to assess how well the ANN performed. Both ANN [9] and SVM [11] achieved accuracy of 86% and 88%, respectively.

Faroq et al. [12] analysed weed detection systems for classifying and detecting weeds based on spectral bands and spatial resolution which are essential in agriculture if area-specific weed management is to be achieved. The author's primary goal is to decrease the use of herbicides in fields because they are bad for both crops and people's health. The effectiveness of weed detection is measured by contrasting CNN and HOG. For the purpose of classifying weeds, the spectral bands and spatial resolution of the hyperspectral pictures were examined. Convolution neural networks, a type of deep learning technique, can automatically extract features and effectively learn high-level characteristics from hyperspectral pictures. Using a Brimrose VA210 filter and a JAI BM-141 camera, the collection's photos were captured. 200 picture patches of each type of weed were created using a data augmentation method during the pre-processing stage, and the spatial resolution of the hyperspectral image was assessed. They used two criteria to analyse the weed categorization: one based on batch size and band number sensitivity, the other based on patch size and resolution sensitivity.

Gao et al. [13] developed machine learning technique to classify various types weed and crop. Hyperspectral and NIR cameras are used to take the pictures in the institute for agriculture and fisheries research's plant laboratory. Arvensis, mays, and Rumex are the three weeds listed in this study. The raw picture is divided into five 5 × 5 single-band subimages as part of the pre-processing, and each of these images is then further cropped to determine the region of interest for the reflectance calibration. They categorized weeds and crops using the random forest method. When estimating the significance of permuted characteristics, the random forest technique offers useful information. They were able to classify three weeds with accuracy of 0.785, 0.663 and 0.713, respectively, whereas maize was classified with 94% accuracy. Since the classifier is unable to distinguish between the three separate types of weeds, the findings show that crops are better identified than weeds. The major drawback of this model is, it will work only when the data distribution was uncertain and untested.

In [14], the author revealed that weed detection using a convolution neural network can be done well without data pre-processing. As a result of experimental hardware limitations, they considered 5000 pictures with 45,600 labelled patches randomly selected for training and validation. During the pre-processing step, they changed the pictures' RGB to HSV scalar coordinate systems to normalize them. They opt to categorize the data using the CNN method, which comprises of a final SoftMax layer, three convolutional layers, three fully connected layers and three additional layers. The model produced two models after 40 h of training, one of which was trained using the original photographs and the other using colour-normalized picture data. Finally, the validation score only varies by 0.2%, having no effect on the model classification result, and both models have the same accuracy. In future investigations, they suggested using GPU processors, which have a larger computing capability than CPU systems, to complete the work with more patches.

3 Methodology

The primary factor in the agricultural land that affects the yield and quality of a crop is weed. Therefore, it is essential to identify weeds in the field when they are still in the incipient phases of development. We use YOLOv5 model to detect weed in agriculture lands because YOLOv5 model has a focus layer with cable to detect low-level features accurately. The workflow of YOLOv5 for the crop and weed dataset is as shown in Fig. 1.

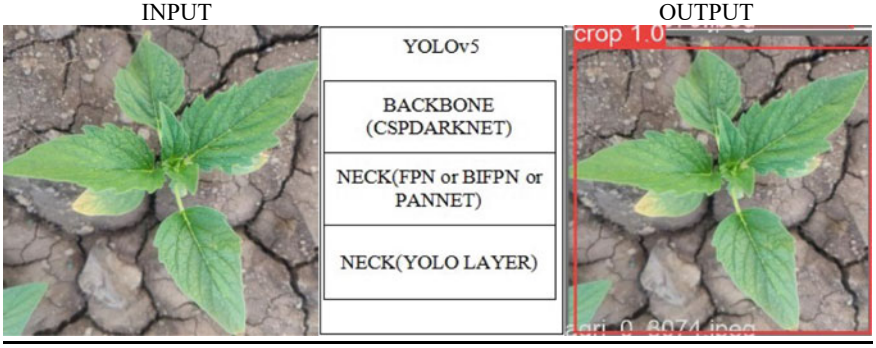


Fig. 1 Workflow of YOLOv5

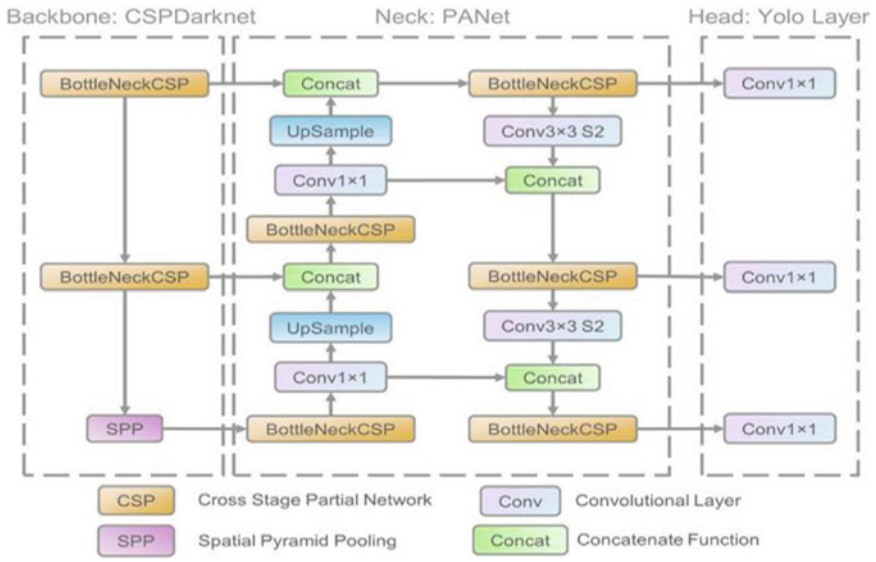


Fig. 2 YOLOv5 architecture

3.1 YOLOv5

YOLOv5 which uses the MS COCO [15] with AP 0.5:0.95 and AP50 is a cutting-edge detector that is both more accurate and faster (FPS) than any other detector in the market. YOLOv5 uses feature pyramid network (FPN) and path aggregation network (PAN) identification of the same object in various sizes and scales. In FPN, top-down augmentation path is used, and in PAN, bottom-up data augmentation path is used. YOLOv5 uses Focus structure along with CSPdarknet53 as a backbone. The major goal of the Focus layer is to minimize layers, parameters, FLOPS, CUDA memory and boost forward and backward performance with the least amount of mAP effect.

The MS COCO dataset demonstrates that various object detection techniques make use of anchor boxes. In reality, older versions of YOLO, such YOLOv2, only k-means clustering was used for it.

Whereas YOLOv5 uses an alternative approach is genetic algorithm to create anchor boxes. Autoanchor is the term for this process, which recomputes the anchor boxes to suit the data if the default ones are insufficient. The architecture of YOLOv5 is as shown in Fig. 2.

Table 1 YOLOv5 versions

S. No	YOLOv5p5 models	YOLOv5p6 models
1	YOLOv5n	YOLOv5n6
2	YOLOv5s	YOLOv5s6
3	YOLOv5m	YOLOv5m6
4	YOLOv5l	YOLOv5l6
5	YOLOv5x	YOLOv5x6

3.2 YOLOv5 Architecture

1. **Backbone**

Model backbone's primary function is to draw out crucial details from an input image. The Cross Stage Partial Networks (CSP) architecture is used in YOLO v5 to extract highly advantageous characteristics from an input picture.

2. **Neck**

Using the model neck, features are frequently arranged into pyramids. Feature pyramids improve models' ability to generalize to the target context when it comes to object scaling. It facilitates the recognition of the same entity in various scales and sizes.

Feature pyramids enable models to perform well on undiscovered data. Other models use other feature pyramid techniques, such as FPN, BiFPN and PANet. PANet is used in YOLOv5 as a neck to get feature pyramids.

3. **Head**

The model head is mostly in charge of the final detecting step. With the use of anchor boxes, bounding boxes, objectness scores and class probabilities, it creates final output vectors, and the different versions of YOLOv5 based on p5 and p6 model are as shown in Table 1.

4 Results

4.1 Experimental Setup

To implement YOLOv5 model, we require the following hardware and software support.

Hardware requirements: Processor: i3 or better, RAM: 8 GB or more, Storage: 120 GB or more, Nvidia GPU recommended are used.

Software requirements: OS: Windows, Python 3.7 or later, Pytorch, OpenCV other necessary Python modules are used.

Precision, recall, F1 score, map 0.5, map 0.5:0.95 are used to evaluate the performance of the model.

4.2 Dataset: (Crop and Weed)

The crop and weed dataset contains images from agriculture lands collected using UAVs, the dataset collected https://www.kaggle.com/datasets/ravirajsinh45/crop-and-weed-detection-data-with-bounding-boxes website.

The crop and weed detection dataset contains 701 images across two classes, namely crop and weed. The whole dataset is divided into train/test sets by ratio 70 and 30% within each event class, so 501 images used for training and 200 images used for testing.

Sample output of crop and weed for YOLOv5l6 shown in Fig. 3 with probability values.

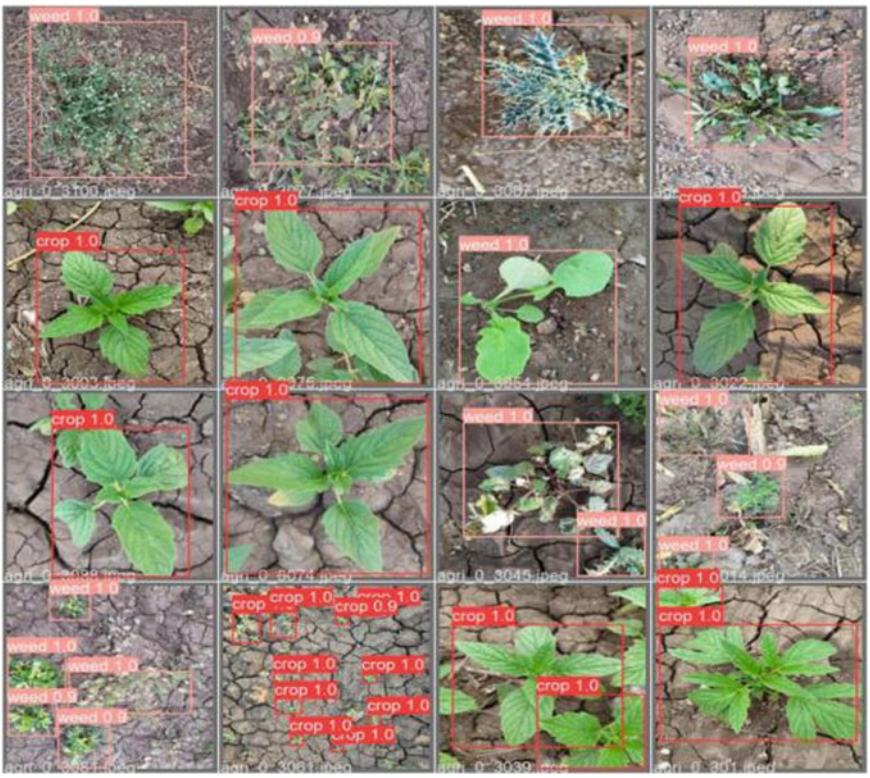


Fig. 3 Sample output crop and weed for YOLOv5l6

The performance of YOLOv3 and YOLOv5 family for the given image dataset is listed in Tables 2, 3 and 4. We also compared the accuracy of all models in the form of bar chart as shown in Fig. 4.

Table 2 Precision, recall, F1 score, map 0.5 and map 0.5 to 0.95 values for crop

YOLOv3 and YOLOv5 models	Crop				
	map 0.5	map 0.5:0.95	Precision	Recall	F1 score
YOLOv3-tiny	94.2	63.3	0.86	0.956	0.9054
YOLOv3	99.5	93.2	0.997	0.997	0.997
YOLOv3-spp	99.5	95.8	0.997	1	0.99849
Yolov5n	96.1	67.2	0.905	0.928	0.9163
Yolov5s	96.7	68.1	0.924	0.952	0.9378
Yolov5m	99.3	89.1	0.98	0.981	0.9804
Yolov5l	99.5	94.7	0.994	0.999	0.99649
Yolov5x	99.5	95.3	0.991	0.995	0.99299
Yolov5n6	99.2	89.8	0.982	0.991	0.98647
Yolov5s6	99.5	94.7	0.994	0.999	0.99649
Yolov5m6	99.5	98.3	0.996	1	0.99799
Yolov5l6	99.5	99.2	0.999	1	0.99949
Yolov5x6	99.5	99.4	0.999	1	0.99499

Table 3 Precision, recall, F1 score, map 0.5 and map 0.5 to 0.95 values for weed

YOLOv3 and YOLOv5 models	All				
	map 0.5	map 0.5:0.95	Precision	Recall	F1 score
YOLOv3-tiny	93.5	62.7	0.821	0.952	0.8816
YOLOv3	99.5	93.9	0.995	0.998	0.9964
YOLOv3-spp	99.5	96.2	0.996	0.999	0.9974
Yolov5n	96.3	69.6	0.889	0.938	0.9128
Yolov5s	96.5	69.8	0.911	0.944	0.9272
Yolov5m	99.4	91.4	0.982	0.987	0.9844
Yolov5l	99.5	95.4	0.995	0.996	0.9954
Yolov5x	99.5	95.9	0.998	0.995	0.9964
Yolov5n6	99.4	90.9	0.987	0.992	0.9894
Yolov5s6	99.5	95.6	0.996	0.996	0.996
Yolov5m6	99.5	98	0.998	0.999	0.9984
Yolov5l6	99.5	99	1	0.999	0.9994
Yolov5x6	99.5	98.6	1	0.999	0.9994

Table 4 Precision, recall, F1 score, map 0.5 and map 0.5 to 0.95 values for all (crop and weed)

YOLOv3 and YOLOv5 models	All				
	map 0.5	map 0.5:0.95	Precision	Recall	F1 score
YOLOv3-tiny	93.5	62.7	0.821	0.952	0.8816
YOLOv3	99.5	93.9	0.995	0.998	0.99649
YOLOv3-spp	99.5	96.2	0.996	0.999	0.99749
Yolov5n	96.3	69.6	0.889	0.938	0.91284
Yolov5s	96.5	69.8	0.911	0.944	0.9272
Yolov5m	99.4	91.4	0.982	0.987	0.98449
Yolov5l	99.5	95.4	0.995	0.996	0.99549
Yolov5x	99.5	95.9	0.998	0.995	0.99649
Yolov5n6	99.4	90.9	0.987	0.992	0.9894
Yolov5s6	99.5	95.6	0.996	0.996	0.996
Yolov5m6	99.5	98	0.998	0.999	0.99849
Yolov5l6	99.5	99	1	0.999	0.99949
Yolov5x6	99.5	98.6	1	0.999	0.99949

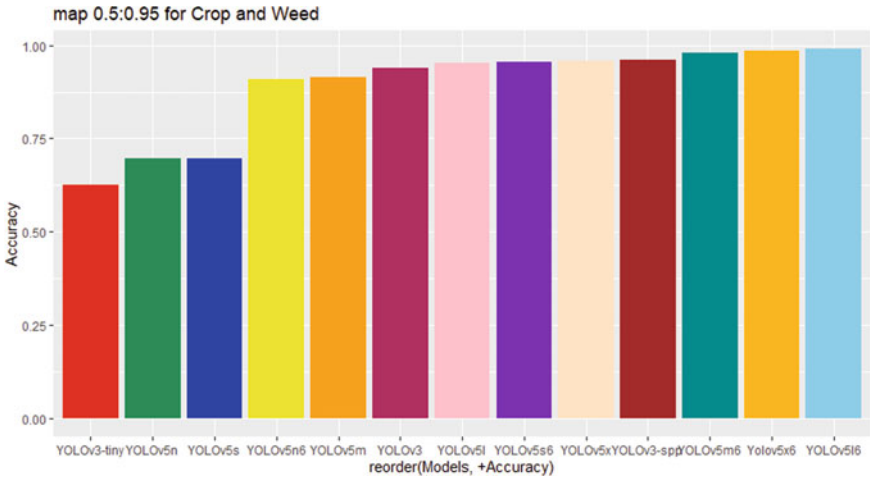


Fig. 4 Accuracy comparisons of all models for all (crop and weed) category

5 Conclusion

In most computer and robot vision systems, object detection is crucial. Despite recent improvements and the implementation of some current approaches into various

consumer devices or assistance driving systems, we are still a long way from human-level performance, especially in open-world learning. Object detection isn't extensively employed in a variety of scenarios when it may be quite useful. Object detection systems are becoming increasingly vital as mobile robots and autonomous gadgets become more widely used (e.g. quadcopters, drones). Accuracy (map 0.5), accuracy (map 0.0.5–0.95), precision, recall and F1 score for YOLOv5l6 model are 99.5, 99, 1, 0.999, 0.99949, respectively. Accuracy (map 0.5), accuracy (map 0.0.5–0.95), precision, recall and F1 score for YOLOv5x6 model are 99.5, 98.6, 1, 0.999, 0.99949, respectively. For crop and weed classes, accuracy (map 0.5), accuracy (map 0.0.5–0.95), precision, recall and F1 score results show that YOLOv5l6 achieved the best performance.

6 Summary

On comparing the YOLOv3 family and YOLOv5 family on the crop and weed dataset, YOLOv5l6 can able to predict crop and weed accurately than the other models.

7 Future Enhancement

YOLOv7 is the latest version of the YOLO series network and was developed in August 2022. YOLOv7 improves speed and accuracy by introducing several architectural reforms like extended efficient layer aggregation network (E-ELAN), model scaling for concatenation-based models and several trainable bag of freebies (BoF) like planned re-parameterized convolution, coarse for auxiliary and fine for lead loss. Expand, shuffle, and merge cardinality is a technique used by E-ELAN to constantly improve the network's capacity for learning while preserving the original gradient route.

References

1. Suryanarayana, S. V. (2021). A survey on weed detection system using deep learning. *Turkish Online Journal of Qualitative Inquiry (TOJQI)*, *6*, 6147–6151
2. Ren, S., He, K., Girshick, R., & Sun, J. (2017). Faster R-CNN: Towards real-time object detection with region proposal networks. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 39*(6), 1137–1149. https://doi.org/10.1109/tpami.2016.2577031
3. Vu, T., Kim, K., Kang, H., Nguyen, X. T., Luu, T. M., & Yoo, C. D. (2021). Sphererpn: Learning spheres for high-quality region proposals on 3D point clouds object detection. In *2021 IEEE International Conference on Image Processing (ICIP)*. https://doi.org/10.1109/icip42928.2021.9506249

4. Rossi, L., Karimi, A., & Prati, A. (2021). A novel region of interest extraction layer for instance segmentation. In *2020 25th International Conference on Pattern Recognition (ICPR)*. https://doi.org/10.1109/icpr48806.2021.9412258
5. Rasmussen, C. B., Nasrollahi, K., & Moeslund, T. B. (2017). R-FCN object detection ensemble based on object resolution and image quality. In *Proceedings of the 9th International Joint Conference on Computational Intelligence*. https://doi.org/10.5220/0006511301100120
6. Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2017). ImageNet classification with deep convolutional neural networks. *Communications of the ACM, 60*(6), 84–90. https://doi.org/10.1145/3065386
7. Kim, J., Lee, J. K., & Lee, K. M. (2016). Accurate image super-resolution using very deep convolutional networks. In *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*. https://doi.org/10.1109/cvpr.2016.182
8. Bakhshipour, & Jafari, A. (2018). Evaluation of support vector machine and artificial neural networks in weed. *Computers and Electronics in Agriculture*, *145*, 153–160.
9. de Brebisso, A., Simon, E., Auvolat, A., Vincent, P., & Bengio, Y. (2015). Artificial neural networks applied to taxi destination prediction. arXiv:1508.00021v2[cs.LG], 21 Sep 2015
10. Mu, N., & Qiao, D. (2019). Image classification based on convolutional neural network and support vector machine. In *2019 6th International Conference on Information, Cybernetics, and Computational Social Systems (ICCSS)*. https://doi.org/10.1109/iccss48103.2019.9115443
11. Kartikadarma, E., Wijayanti, S., Wulandari, S. A., & Rafrastara, F. A. (2017). Principle component analysis for classification of the quality of aromatic rice. *International Journal of Computer Science and Information Security (IJCSIS)*, *15*(8).
12. Farooq. (2019). Analysis of spectral bands and spatial resolutions for weed classification via deep convolutional neural network. *IEEE Geoscience and Remote Sensing*, 183–187.
13. Gao, J., Nuyttens, D., Lootens, P., & He, Y. (2018). Recognising weeds in a maize crop using a random forest machine-learning algorithm and near-infrared mosaic hyperspectral imagery. *Biosystems Engineering, 170*, 39–50.
14. Wu, J. (2018). Weed detection based on Convolutional Neural network. In *IT and cognition* (pp. 1–13).
15. Ning, Z., Wu, X., Yang, J., & Yang, Y. (2021). MT-yolov5: Mobile terminal table detection model based on YOLOv5. *Journal of Physics: Conference Series, 1978*(1), 012010. https://doi.org/10.1088/1742-6596/1978/1/012010

Fuzzy DEMATEL Approach to Identify the Modifiable Risk Factors of Cardiovascular Disease

M. Stephen and A. Felix

Abstract Cardiovascular disease is the world's most lethal non-communicable disease. Cardiovascular disease killed approximately 17.9 million people in 2019, taking account for 81% of all deaths in developing countries. Every disease has a risk factor, which also plays a vital role in disease diagnosis in early stage; by identifying and emphasizing the most significant risk factor, death rates can be reduced. As a result, to identify the most significant cardiovascular disease risk factors, this present study employs a fuzzy decision-making trial and evaluation laboratory (Fuzzy DEMATEL) approach with a trapezoidal fuzzy number. At first, 13 risk factors are chosen and classified as modifiable or non-modifiable. According to the findings of this study, modifiable risk factors like total cholesterol, blood pressure, body mass index, and diabetes are influenced by lifestyle factors such as smoking, exercise, food, stress, and alcohol consumption. Finally, the results are validated by comparing proposed method with classical DEMATEL method.

Keywords Cardiovascular disease · Risk factors · Trapezoidal fuzzy number · Fuzzy DEMATEL

1 Introduction

Through the "Global action plan for non-communicable disease (NCD) prevention and control 2013–2020," the World Health Organization (WHO) planned global strategies for reducing the preventable NCD burden in 2013. This scheme seeks to reduce early mortality from NCDs by 25% by 2025 [13]. WHO offered two objectives to prevent and control cardiovascular disease (CVD), which are (1) reducing the prevalence of hypertension by 25% between 2010 and 2025. (2) By 2025, at least,

M. Stephen · A. Felix (✉)
Mathematics Division, School of Advanced Sciences, Vellore Institute of Technology, Chennai Campus, Chennai, TN 600127, India
e-mail: felix.a@vit.ac.in

M. Stephen
e-mail: stephen.m2019@vitstudent.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_51

half of all eligible persons should be receiving medication treatment and counseling to avoid heart attack. Cardiovascular disease includes heart disease, stroke, and vascular illness. Cardiovascular diseases are the leading cause of death both globally and in India. Annual CVD fatalities in India have increased from 2.26 million in 1990 to 4.77 million in 2020. Cardiovascular illnesses are abnormalities of the heart and blood vessels. It might start when you are young and progress quickly by the time you reach middle age. The core threats of cardiovascular disease are hypertension, high cholesterol, diabetes, obesity, smoking, diet, exercise, stress, age, gender, family history, ethnic background, and alcohol consumption.

Numerous researchers contributed various methods to detect CVD disease, and the main risk factors of CVD are analyzed by incorporating machine learning techniques like Bayesian classification, neural networks, fuzzy inference systems, etc. Moridani et al. [9] employed an electrocardiogram signal to predict mortality in ICU cardiovascular patients using a fuzzy logic technique. Almustafa [2] employed 14 attributes and some methods to predict heart disease patients, including Naive Bayes, support vector machine, stochastic gradient decent, and decision tables. Kora et al. [8] detected heart arrhythmias using fuzzy logic. Nawaz et al. [10] used the computational modeling heart disease datasets to create a model for CVD detection. Abdar et al. [1] developed a novel N2Genetic optimizer method for CVD, with 93.08% accuracy. Repaka et al. [11] employed Naive Bayesian to model cardiac disease.

Diagnosing diseases is difficult in the medical field due to ambiguity and uncertainty of identifying the risk factors. The fuzzy tool can deal with an uncertain situation to identify significant risk factors of the problem. Zadeh [14] pioneered fuzzy set theory by converting human linguistic terms into mathematical operators. Fuzzy has numerous applications in fields such as medicine, engineering, robotics, social science, and business analysis. Among many decision-making methods, the multicriteria decision-making problem is the most effective. This method was used to identify the problem's most relevant influencing elements and estimates the weights of the criteria. Several MCDM techniques are available, including AHP, TOPSIS [5], ELECTRE, DEMATEL, and others.

The DEMATEL is a valuable instrument among the different decision-making techniques. To ascertain the influencing factors and influenced factors of any complex problem, the DEMATEL is well suited. In this study, the fuzzy DEMATEL is utilized to determine the most important risk factors for cardiovascular disease. DEMATEL is a method for analyzing direct and indirect relationships between attributes developed by Fontela and Gabus [7]. It was based on graph theory and used maps to show the relationship between the attributes for better comprehension. Deva and Felix [3] identified the best mobile networks using DEMATEL and bipolar fuzzy graphs. Felix et al. [6] investigated solid waste management using the DEMATEL technique and a fuzzy cognitive map. Devi et al. [4] employed the intuitionistic fuzzy DEMATEL method for COVID-19 lockdown relaxation protocols.

1.1 Motivation and Contribution

Cardiovascular disease poses significant risks to the worldwide population. CVD is a leading cause of death in low- and middle-income countries, accounting for more than 75% of all fatalities. WHO issued a global action plan to combat non-communicable illnesses, particularly CVD, in 2021. Risk factors play an essential part in every diagnostic system. Finding illness risk factors in decision-making models is difficult because recognizing a disease early and controlling the condition rely on them. The goal of this research is to use a mathematical model to identify modifiable risk factors. CVD illness can be prevented and mortality avoided by identifying and focusing more on modifiable risk factors. The fuzzy DEMATEL algorithm using trapezoidal fuzzy numbers selects influencing, modifiable risk factors from distinct risk factor groupings. The rest of the paper is structured as follows: Sects. 2 and 3 provide the required preliminary and recommended algorithm. Section 4 discusses the illustration of the algorithm, and the conclusion is given in the Sect. 5.

2 Preliminaries

Definition 2.1 [11] Let X be any non-empty universal set of points, then a fuzzy set $\tilde{A}$ in X is defined as the set of ordered pairs of elements and its membership values. It is denoted as $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)), x \in X, 0 \leq \mu_{\tilde{A}}(x) \leq 1\}$, where $\mu_{\tilde{A}}(x)$ is a membership function of x and $\mu_{\tilde{A}}(x) : X \to [0, 1]$.

Definition 2.2 [12] A trapezoidal fuzzy number (TrFN) $\tilde{A}$ is symbolized as (u_1, u_2, u_3, u_4) is shown in Fig. 1, and its membership function is defined as,

$$\mu_{\tilde{A}}(x) = \begin{cases} \left(\frac{x-u_1}{u_2-u_1}\right) & u_1 \leq x \leq u_2 \\ 1 & u_2 \leq x \leq u_3 \\ \left(\frac{u_3-x}{u_4-a_3}\right) & u_3 \leq x \leq u_4 \\ 0 & x \leq u_1 \& x \geq u_4 \end{cases}$$

3 The Proposed Trapezoidal Fuzzy DEMATEL Algorithm

This algorithm attempts to choose the most significant influencing factors of the problem using the fuzzy DEMATEL ranking method, which aids in categorizing the risk factors based on their influence.

Step-1: Planning Process.

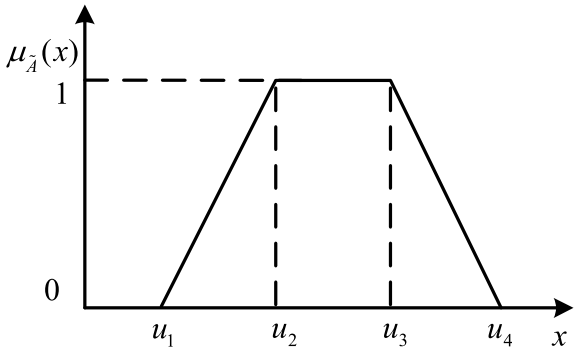


Fig. 1 Trapezoidal fuzzy number

First, choose the most critical problem endangered to the world, experts related to the problem, and choose a mathematical technique to elucidate the problem. Let $D = \{D_1, D_2, ..., D_p\}$ be the corresponding field's experts. Let $R = \{R_1, R_2, ..., R_i\}$ be the attributes of the problem. The related risk factors are chosen based on the literature analysis and professional opinions.

Step-2: Making the direct relation matrix $\left(\widehat{M}_d\right)$ using the linguistic variable.

The first stage is to create a direct relation matrix $\left(\widehat{M}_d\right)$ using linguistic variables like Neither impact (N), Small impact (S), Fair impact (F), Big impact (B), and Extremely high impact (E) to compare attributes to other attributes with the help of a professional's opinion.

$$\widehat{M}_d = [\hat{m}_{ij}^d]_{n\times n} = \begin{array}{c} \\ R_1 \\ R_2 \\ \vdots \\ R_n \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \cdots & R_n \end{array} \\ \begin{bmatrix} m_{11}^d & m_{12}^d & \cdots & m_{1n}^d \\ m_{21}^d & m_{22}^d & \cdots & m_{2n}^d \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1}^d & m_{n2}^d & \cdots & m_{nn}^d \end{bmatrix} \end{array} \tag{1}$$

Step-3: Construct trapezoidal direct relation matrix (TDRM).

In this step, the linguistic DRM $\left(\widehat{M}_d\right)$ is converted into a TDRM ($\widetilde{M}_d$) using trapezoidal fuzzy number. The integer score ranges from 0 to 1, with (0, 0, 0.25, 0.25) indicating N, (0, 0, 0.25, 0.5) indicating L, (0, 0.25, 0.5, 0.75) indicating M, (0.25, 0.5, 0.75, 1) indicating H, and (0.25, 0.75, 1,1) indicating V.

$$\widetilde{M}_d = [\tilde{m}_{ij}^d]_{n\times n} = \begin{array}{c} \\ R_1 \\ R_2 \\ \vdots \\ R_n \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \dots & R_n \end{array} \\ \begin{bmatrix} \tilde{m}_{11}^d & \tilde{m}_{12}^d & \cdots & \tilde{m}_{1n}^d \\ \tilde{m}_{21}^d & \tilde{m}_{22}^d & \cdots & \tilde{m}_{2n}^d \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{m}_{n1}^d & \tilde{m}_{n2}^d & \cdots & \tilde{m}_{nn}^d \end{bmatrix} \end{array} \tag{2}$$

Step-4: Calculate the defuzzified initial TDRM ($\widetilde{M}_d$) through the centroid method.

The TDRM ($\widetilde{M}_d$) is defuzzify from the trapezoidal fuzzy number using the centroid method. The formula is,

$$\widetilde{M}_d = \frac{c^2 + d^2 + \mathrm{cd} - (a^2 + b^2 + \mathrm{ab})}{3[(c + d) - (a + b)]} \tag{3}$$

Step-5: Generate the average TDRM ($\widetilde{M}$).

The defuzzified TDRM is made up of expert opinions on the corresponding field. The average TDRM is generated in this step by taking the average of the medical specialist's views.

$$\widetilde{M} = \frac{1}{n}\sum_{d=1}^{n} \tilde{m}_{ij}^d \text{ where } \tilde{M} = [\tilde{m}_{ij}]_{n\times n} = \begin{array}{c} \\ R_1 \\ R_2 \\ \vdots \\ R_n \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \dots & R_n \end{array} \\ \begin{bmatrix} \tilde{m}_{11} & \tilde{m}_{12} & \cdots & \tilde{m}_{1n} \\ \tilde{m}_{21} & \tilde{m}_{21} & \cdots & \tilde{m}_{21} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{m}_{n1} & \tilde{m}_{n1} & \cdots & \tilde{m}_{nn} \end{bmatrix} \end{array} \tag{4}$$

Step-6: Calculate the normalized DRM ($\widetilde{N}$).

The values of every row are added, and the maximum value is selected among them. Then, each row is divided by the maximum value. The formula for constructing a normalized direct relation matrix is,

$$\widetilde{N} = K.\widetilde{M}, \quad \text{where} \quad K = \frac{1}{\max \sum_{j=1}^{n} \tilde{m}_{ij}}; i, j = 1, 2, ..., n$$

$$\widetilde{N} = [\tilde{n}_{ij}]_{n\times n} = \begin{array}{c} \\ R_1 \\ R_2 \\ \vdots \\ R_n \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \dots & R_n \end{array} \\ \begin{bmatrix} \tilde{n}_{11} & \tilde{n}_{12} & \cdots & \tilde{n}_{1n} \\ \tilde{n}_{21} & \tilde{n}_{21} & \cdots & \tilde{n}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{n}_{n1} & \tilde{n}_{n1} & \cdots & \tilde{n}_{nn} \end{bmatrix} \end{array} \tag{5}$$

Step-7: Generate the total-relation matrix (TRM)

The TRM ($\widetilde{T}$) is generated using Eq. (6) in which I is an identity matrix of $n \times n$.

$$\widetilde{T} = \widetilde{N}(I - \widetilde{N})^{-1} \quad \widetilde{T} = [\tilde{t}_{ij}]_{n\times n} = \begin{array}{c} \\ R_1 \\ R_2 \\ \vdots \\ R_n \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \cdots & R_n \end{array} \\ \begin{bmatrix} \tilde{t}_{11} & \tilde{t}_{12} & \cdots & \tilde{t}_{1n} \\ \tilde{t}_{21} & \tilde{t}_{21} & \cdots & \tilde{t}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{t}_{n1} & \tilde{t}_{n2} & \cdots & \tilde{t}_{nn} \end{bmatrix} \end{array} \tag{6}$$

Step-8: Calculate the values ($\widetilde{R}$) and ($\widetilde{C}$).

$\widetilde{R}$ and $\widetilde{C}$ be $n \times 1$ and $1 \times n$ matrix, it is calculated by sum of rows and sum of columns of the TRM $\left(\widetilde{T}\right)$, respectively. It is estimated by,

$$\widetilde{R} = [\tilde{r}_i]_{n\times 1} = \left[\sum_{j=1}^{n} \tilde{t}_{ij}\right]_{n\times 1} \qquad \widetilde{C} = [\tilde{c}_j]_{1\times n} = \left[\sum_{j=1}^{n} \tilde{t}_{ij}\right]_{1\times n} \tag{7}$$

Then, ($\widetilde{R}+\widetilde{C}$) denotes the effects of the problem; if ($\widetilde{R}-\widetilde{C}$) is positive, it indicates the causes of the problem, and if ($\widetilde{R} - \widetilde{C}$) is negative, it is effect of the problem.

Step-9: Selected cause attributes of the problem.

The cause attributes are selected for the diagnosing system from the positive values of ($\widetilde{R} - \widetilde{C}$). Important influencing attributes can be selected by choosing the attributes of the cause, and the attributes can be minimized by selecting the attributes.

4 Illustration

This section describes selecting the most crucial influencing risk factors of cardiovascular disease. Then, the critical risk factors are categorized into lifestyle factors and controllable factors. The CVD mortality rates are reduced by concentrating more on lifestyle-changing factors and modifiable factors.

Step-1: The most crucial problem (Cardiovascular disease) and mathematical models such as fuzzy DEMATEL were chosen in the planning process. Two medical experts were chosen to deal with this problem related to cardiovascular disease. Selected essential risk factors as R_1—Age, R_2—Blood pressure, R_3—Total cholesterol, R_4—Smoking, R_5—Gender, R_6—Diabetes, R_7—Exercise, R_8—Body mass index, R_9—Family history, R_{10}—Diet, R_{11}—Ethnic background, R_{12}—Stress, R_{13}—Alcohol.

Step-2: The direct relation matrix $\left(\widetilde{M}_d\right)$ is created using linguistic variables to compare attributes to other attributes with the help of a professional's opinion; it is shown in Table 1.

Step-3 to Step-9: The linguistic DRM $\left(\widetilde{M}_d\right)$ is converted into a trapezoidal direct relation matrix $\left(\widetilde{M}_d\right)$ using trapezoidal fuzzy number. The TDRM $\left(\widetilde{M}_d\right)$ is defuzzified using Eq. (3). The average TDRM $(\widetilde{M})$ is generated by using Eq. (4). A normalized TDRM $(\widetilde{N})$ is constructed using Eq. (5). The total relational matrix is calculated using Eq. (6). $\widetilde{R}$ and $\widetilde{C}$ is calculated in sum of rows and sum of columns of the total-relation matrix $\left(\widetilde{T}\right)$ using Eq. (7), which is shown in Table 2.

Table 1 Linguistic DRM

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}
R_1	N	F	F	S	S	B	F	S	S	S	S	S	F
	N	F	S	S	S	F	S	F	S	F	S	F	B
R_2	E	N	B	E	B	E	E	E	B	E	B	E	E
	B	N	B	E	B	E	B	E	B	E	F	E	B
R_3	B	E	N	B	B	E	E	E	F	E	F	B	B
	F	E	N	B	B	B	E	B	B	E	F	E	E
R_4	F	E	B	N	B	B	B	B	B	E	B	E	B
	B	E	E	N	B	E	B	E	B	E	B	E	B
R_5	S	F	S	S	N	S	F	S	S	F	S	S	F
	F	S	S	F	N	S	S	F	S	S	S	F	S
R_6	E	E	B	F	B	N	E	B	E	E	F	F	B
	E	E	E	B	F	N	B	E	B	E	B	B	F
R_7	B	E	B	E	E	E	N	E	B	E	F	E	B
	B	E	E	B	B	E	N	E	F	E	B	E	E
R_8	F	E	E	B	B	E	E	N	F	E	F	B	B
	B	E	E	B	F	E	E	N	B	E	B	E	B
R_9	S	S	F	S	S	F	S	S	N	S	F	S	F
	S	F	S	S	S	B	F	S	N	S	S	F	B
R_{10}	E	B	E	F	F	E	B	E	F	N	B	F	B
	B	E	E	B	F	E	B	E	S	N	F	B	E
R_{11}	S	F	F	B	S	F	S	B	S	S	N	F	B
	S	S	S	F	S	F	S	F	S	F	N	S	F
R_{12}	B	E	E	E	F	B	E	B	E	B	F	N	B
	B	E	B	E	F	F	B	E	B	F	S	N	B
R_{13}	B	E	E	B	F	E	B	E	F	E	F	B	N
	F	E	E	B	S	B	F	B	F	B	S	F	N

Table 2 Total-relational matrix

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	0.063	0.096	0.084	0.070	0.061	0.106	0.080	0.085	0.063	0.085
R_2	0.179	0.150	0.185	0.188	0.153	0.207	0.185	0.204	0.157	0.203
R_3	0.154	0.203	0.133	0.167	0.148	0.192	0.187	0.190	0.140	0.196
R_4	0.155	0.205	0.187	0.123	0.149	0.194	0.173	0.191	0.153	0.197
R_5	0.069	0.078	0.066	0.070	0.047	0.068	0.071	0.075	0.055	0.075
R_6	0.176	0.196	0.179	0.150	0.132	0.134	0.174	0.183	0.155	0.190
R_7	0.171	0.211	0.193	0.181	0.161	0.207	0.133	0.205	0.146	0.203
R_8	0.156	0.205	0.195	0.169	0.138	0.202	0.189	0.139	0.142	0.198
R_9	0.066	0.084	0.079	0.067	0.058	0.101	0.076	0.073	0.053	0.072
R_{10}	0.166	0.187	0.186	0.149	0.120	0.192	0.165	0.190	0.115	0.128
R_{11}	0.072	0.092	0.088	0.101	0.063	0.099	0.076	0.108	0.066	0.089
R_{12}	0.157	0.195	0.177	0.175	0.120	0.166	0.172	0.181	0.154	0.162
R_{13}	0.143	0.190	0.181	0.155	0.108	0.179	0.149	0.177	0.120	0.176
C_i	1.725	2.093	1.932	1.766	1.459	2.048	1.831	2.002	1.518	1.974

	R_{10}	R_{11}	R_{12}	R_{13}	R_i	$R_i + C_i$	$R_i - C_i$	Risk factor
R_1	0.085	0.057	0.079	0.102	1.029	2.754	−0.695	Non-modifiable
R_2	0.203	0.133	0.191	0.191	2.324	4.417	0.232	Modifiable
R_3	0.196	0.117	0.177	0.184	2.190	4.122	0.258	Modifiable
R_4	0.197	0.141	0.186	0.178	2.233	3.999	0.466	Modifiable
R_5	0.075	0.051	0.071	0.073	0.869	2.328	−0.590	Non-modifiable
R_6	0.190	0.125	0.153	0.160	2.107	4.155	0.059	Modifiable
R_7	0.203	0.133	0.192	0.191	2.327	4.158	0.497	Modifiable
R_8	0.198	0.130	0.179	0.178	2.220	4.222	0.218	Modifiable
R_9	0.072	0.062	0.075	0.098	0.965	2.484	−0.553	Non-modifiable
R_{10}	0.128	0.123	0.151	0.176	2.049	4.023	0.075	Modifiable
R_{11}	0.089	0.053	0.083	0.105	1.095	2.423	−0.233	Non-modifiable
R_{12}	0.162	0.104	0.117	0.169	2.049	3.851	0.247	Modifiable
R_{13}	0.176	0.101	0.147	0.118	1.944	3.867	0.021	Modifiable
C_i	1.974	1.328	1.802	1.923				

The efficiency of the result is established by comparing it with other situations. The modifiable and non-modifiable risk factors are initially classified under the fuzzy DEMATEL method. In this process, the classification is compared using the classical DEMATEL method. The stability of the outcome is validated through this comparative analysis process; it is shown in Table 3.

A perfect model is required to address ambiguity in making decisions and uncertainty in problem's information. The multi-criteria decision-making technique is one method for selecting the most important influencing risk factors from a large number

Table 3 Comparative analysis

Models/risk factors	Modifiable	Non-modifiable
Fuzzy DEMATEL	R_2, R_3, R_4, R_6, R_7, R_8, R_{10}, R_{12}, R_{13}	R_1, R_5, R_9, R_{11}
Classical DEMATEL	R_2, R_3, R_4, R_6, R_7, R_8, R_{10}, R_{12}, R_{13}	R_1, R_5, R_9, R_{11}

of risk factors. From the literature review, 13 risk factors are selected for the study and classified as modifiable or non-modifiable using the fuzzy DEMATEL method. Modifiable factors classified by this system include total cholesterol, blood pressure, body mass index, and diabetes. It is influenced by changes in lifestyle factors such as smoking, exercise, diet, stress, and alcohol consumption. Finally, the existing classical DEMATEL method is used to validate the result.

5 Conclusion

The fuzzy DEMATEL was designed using trapezoidal fuzzy number to determine the most influential risk factors in cardiovascular disease. According to the findings, modifiable risk factors like total cholesterol, blood pressure, diabetes, and body mass index are regulated by lifestyle factors like smoking, exercise, nutrition, stress, and alcohol. The mortality rates of cardiovascular disease can be reduced by quitting smoking, doing at least 45 min of exercise daily, eating a balanced diet, managing stress, and quitting drinking. This study compares it to existing techniques, demonstrating that it performs well. In the future, other methods, such as VIKOR and fuzzy AHP, may be used to investigate this work.

References

1. Abdar, M., Książek, W., Acharya, U. R., Tan, R. S., Makarenkov, V., & Pławiak, P. (2019). A new machine learning technique for an accurate diagnosis of coronary artery disease. *Computer Methods and Programs in Biomedicine., 179*, 104992.
2. Almustafa, K. M. (2020). Prediction of heart disease and classifiers' sensitivity analysis. *BMC Bioinformatics, 21*(1), 1–18.
3. Deva, N., & Felix, A. (2021). Designing DEMATEL method under bipolar fuzzy environment. *Journal of Intelligent and Fuzzy Systems, 41*(6), 7257–7273.
4. Devi, S. A., Felix, A., Narayanamoorthy, S., Ahmadian, A., Balaenu, D., & Kang, D. (2022). An intuitionistic fuzzy decision support system for COVID-19 lockdown relaxation protocols in India. *Computers and Electrical Engineering, 102*, 108166.
5. Ezhilarasan, N., & Felix, A. (2022). Fuzzy ELECTRE and TOPSIS method to analyze the risk factors of tuberculosis. *Journal of Physics: Conference Series. IOP Publishing, 2267*(1).
6. Felix, A., & Dash, S. K. (2021). Haar FCM with DEMATEL techniques to analyze the solid waste management. *Advances in Smart Grid Technology, Lecture Notes in Electrical Engineering, 688*, 393–402 (2021). https://doi.org/10.1007/978-981-15-7241-8_28
7. Fontela, E., & Gabus, A. (1976). *The DEMATEL observer*. Battelle Geneva Research Center.

8. Kora, P., Meenakshi, K., Swaraja, K., Rajani, A., & Islam, M. K. (2019). Detection of cardiac arrhythmia using fuzzy logic. *Informatics in Medicine Unlocked, 17*, 100257.
9. Moridani, M. K., Setarehdan, S. K., Nasrabadi, A. M., & Hajinasrollah, E. (2018). A novel approach to mortality prediction of ICU cardiovascular patient based on fuzzy logic method. *Biomedical Signal Processing and Control, 45*, 160–173.
10. Nawaz, M. S., Shoaib, B., & Ashraf, M. A. (2021). Intelligent cardiovascular disease prediction empowered with gradient descent optimization. *Heliyon, 7*(5), 06948.
11. Repaka, A. N., Ravikanti, S. D., & Franklin, R. G. (2019). Design and implementing heart disease prediction using naives Bayesian. In *3rd International Conference on Trends in Electronics and Informatics (ICOEI)* (pp. 292–297).
12. Swethaa, S., & Felix, A. (2021). Various defuzzification methods for trapezoidal dense fuzzy sets. *Advances in Mathematics: Scientific Journal, 10*, 251–258.
13. WHO. (2016). World Health Organization; Geneva: Global Health Estimates 2015: Deaths by cause, Age, Sex, by Country and by Region, 2000–2015.
14. Zadeh, L. A., Klir, G. J., & Yuan, B. (1996). Fuzzy sets, fuzzy logic, and fuzzy systems: Selected papers (vol. 6).

Bipolar Trapezoidal Fuzzy ARAS Method to Identify the Tuberculosis Comorbidities

N. Ezhilarasan and A. Felix

Abstract Tuberculosis causes a high mortality rate worldwide. The World Health Organization (WHO) report shows that TB afflicts over 10.4 million people. It is found that TB comorbidities disease causes a rapid increase in disease level. Therefore, this study aims to analyze the communicable and non-communicable diseases that impact TB levels in patients. This process includes the bipolar trapezoidal fuzzy set to analyze the vagueness or ambiguity in positive and negative perceptions. The entropy technique is used for weighting the influencing criteria in the bipolar view. The top 10 TB-affected Indian states are chosen as criteria. The fuzzy additive ratio assessment (ARAS) technique is applied to determine the influencing comorbidities disease in TB. The obtained result is verified through the extant fuzzy evaluation based on distance from average solution (EDAS) method. Therefore, the proposed and comparative analysis provides the same result, which proves that the proposed method is very effective in the bipolar view.

Keywords Bipolar trapezoidal fuzzy number · Entropy measure · ARAS method · EDAS method tuberculosis · Communicable and non-communicable disease

1 Introduction

Mycobacterium tuberculosis (TB) causes TB. When a person with active TB disease in their lungs coughs or sneezes, TB bacteria are released into the air in the droplets that are expelled, which can then be inhaled by another person. The cough, weight loss, chest pain, trouble breathing, and night sweats are the symptoms of TB. A few risk factors that spread TB are homelessness, shaking hands, sharing a drinking glass, kidney disease, and air pollution. As per the World Health Organization

N. Ezhilarasan · A. Felix (✉)
Mathematics Division, School of Advanced Science, Vellore Institute of Technology, Chennai, India
e-mail: felix.a@vit.ac.in

N. Ezhilarasan
e-mail: ezhilarasan.n2019@vitstudent.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_52

(WHO), nearly, 40% of Indians have latent Mycobacterium tuberculosis infections (Mtb), and a weakened immune system is one of the primary causes of active TB. This deficiency affects active TB, other communicable diseases (CDs), and non-communicable diseases (NCDs). Over the past ten years, risk factors of TB contributing to the rise in NCDs include smoking, alcohol, malnutrition, diabetes, and chronic lung disease. According to the TB India report, TB disease is increasing widely among COVID, HIV patients, smoking, and alcohol consumers.

In 2019, TB-HIV collaborative committee was recommended Ministry of Health and Family Welfare (MoHFW) to form a TB co-morbidity collaborative committee at the national, state, and district level. This collaboration includes both communicable and non-communicable diseases. A few diseases that influence TB are described. (1) Diabetes occurs when the blood glucose level increases in the human body. TB might induce glucose and worsen glycemic control in people with diabetes. (2) Since 2019, COVID disease rules the world. It is a highly transmittable disease, and TB is also easy spreadable disease. TB and COVID have a high chance of increasing in infection rate. (3) HIV is a non-communicable disease. It kills immune system cells that help the body fight infections and diseases. (4) Tobacco or smoking increases the risk for TB, eye disease, cancer, heart disease, stroke, lung disease, and diabetes. It drastically affects the immune system. (5) The high consumption of alcohol affects the nervous system, brain, and liver, low blood sugar. Alcohol can stimulate the TB percentage.

1.1 Literature Review of MCDM Methods

The bipolar fuzzy numbers and their extensions are applied in decision-making problems in medical and various fields. The fuzzy AHP and ARAS methods are utilized for green supplier selection [1] and the equipment selection process [2]. The methodology of ENTROPY-ARAS concepts is used to select better engineering material [3]. A few researchers worked on various MCDM methods for decision-making problems. The fuzzy ELECTREE and TOPSIS methods [4] were utilized to analyze the major risk factors of TB, and various fuzzy MCDM methods are applied to analyze the selection of sustainable recycling partner [5], steel products supplier [6]. The DEMATEL technique was used to analyze solid waste management [7]. An effective choice of laser cutter was studied by TOPSIS [8]. The fuzzy WASPAS, COPRAS and EDAS methods are employed for the site selection problem [9]. Covering-based variable precision using PROMETHEE-EDAS methods [10], Prioritizing autonomous maintenance systems [11], and evaluation of the mobile payment platforms [12]. DEMATEL method was also used to identify the most influencing India's COVID lockdown relaxation protocols [13], and this method also discussed in the bipolar fuzzy environment [14]. Also, the different categories of comorbidities are available for tuberculosis, which is the most risk for TB patients. Therefore, this present study works on the bipolar trapezoidal fuzzy number-based ARAS method. Moreover, the

comparative analysis is carried out through the EDAS method to validate the obtained result.

1.2 Motivation and Contribution

TB is one of the leading causes of death globally. It is a highly contagious disease that spreads quickly from person to person. Due to its easy transmission mode, it affects numerous people worldwide. India is also listed within the top 10 countries that cause death among people. It causes serious illness among TB-comorbidities patients. So, this motivates to work on the impact of TB while the presence of communicable and non-communicable diseases.

This study collected data based on the impact created by TB on other diseases from the WHO portal. The top 10 TB-affected states in India are also selected using WHO 2021 report. The combination of TB and other disease are also chosen. A few diseases that stimulate TB are COVID, HIV, diabetes, alcohol, and tobacco. To scrutinize the data, this study uses the bipolar trapezoidal fuzzy number along with the fuzzy ARAS method. The ARAS technique can handle the various alternatives with conflicting criteria. Through comparative analysis using the EDAS technique, the outcomes are validated.

2 Preliminaries

2.1 Bipolar Fuzzy Set

A bipolar fuzzy set $\tilde{B}$ is defined by $\tilde{B} = \{u, \mu^{+}_{\tilde{B}}(u), \mu^{-}_{\tilde{B}}(u)\}, u \in U$, where $\mu^{+}_{\tilde{B}}(u : u \to [0, 1]$ and $\mu^{-}_{\tilde{B}}(u) : u \to [-1, 0]$ represents the positive and negative degree of the BFS $\tilde{B}$ respectively.

2.2 Bipolar Fuzzy Number

The bipolar fuzzy number $\tilde{B}$ is on the real line R, where the bipolar membership function should be fulfilled the following conditions:

(i) $\tilde{B}$ is normal
(ii) $\mu^{p}_{\tilde{B}}(x), \mu^{n}_{\tilde{B}}(x)$ are piecewise continuous
(iii) $\tilde{B}$ *is* convex $\mu^{+}_{\tilde{B}}(\rho x_1 + (1-\rho)x_2) \geq \min(\mu^{+}_{\tilde{B}}(x_1), \mu^{+}_{\tilde{B}}(x_2)), \forall x \in [x_1, x_2], \rho \in [0, 1]$

(iv) $\tilde{\mathrm{B}}$ *is* convex $\mu_{\tilde{B}}^{-}(\rho x_1 + (1-\rho)x_2) \leq \max(\mu_{\tilde{B}}^{-}(x_1), \mu_{\tilde{B}}^{-}(x_2)),\ \forall x \in [x_1, x_2], \rho \in [0, -1]$

3 Proposed Bipolar Trapezoidal Fuzzy ARAS Method (BTFAM)

The proposed algorithm aids in understanding the conversion of real data into fuzzy values. The entropy measure is used to determine the importance of criteria and also shows the involvement of criteria in $m \times n$ matrix analyzation.

Step 1: Construct the possible alternatives and criteria.

The suitable $A = \{A_1, A_2, A_3, ..., A_m\}$ alternatives and $C = \{C_1, C_2, C_3, ..., C_n\}$ criteria are framed.

Step 2: Construct the linguistic decision matrix.

On the basis of real-time data observation, the decision experts aid in constructing the linguistic decision matrix (LDM).

Step 3: Convert the LDM into the bipolar trapezoidal fuzzy matrices (BTrFM).

The LDM is converted into a bipolar trapezoidal fuzzy matrix using linguistic terms.

Step 4: Frame the defuzzified matrices.

The defuzzified matrix is framed by converting the BTrFM through Eq. (1).

$$\mu_{\tilde{a}} = \frac{2l^{+} + 7m_1^{+} + 7m_2^{+} + 2u^{+}}{18}, \frac{2l^{-} + 7m_1^{-} + 7m_2^{-} + 2u^{-}}{18} \tag{1}$$

then,

$$D = [d_{ij}] = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ d_{m1} & d_{m2} & \cdots & d_{mn} \end{bmatrix} \tag{2}$$

where $d_{ij} = (d_{ij}^{+}, d_{ij}^{-})$, $i = 1, 2, \ldots, m$, and $j = 1, 2, \ldots, n$.

Step 5: Construct the bipolar normalized decision matrices N (BNDM).

The defuzzified matrix D is transformed into BNDM to bring the values into the particular interval $[1, 0]$ and $[-1, 0]$.

$$N = [r_{ij}] = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{3}$$

$$r_{ij}^{*} = \frac{r_{ij}}{\sum_{i=0}^{m} r_{ij}}, \; j = 1, 2, \ldots, n$$

where, $r_{ij} = \left(, r_{ij}^{-} r_{ij}^{+}\right)$, $i = 1, 2, \ldots, m$, and $j = 1, 2, \ldots, n$.

Step 6: Determine the bipolar weight values.

The objective weight for criteria is calculated through bipolar entropy measure.

$$E_j = \left(-c \sum_{p=1}^{m} F_{ij}^{+} \log\left(F_{ij}^{+}\right), -c \sum_{p=1}^{m} F_{ij}^{-} \log(F_{ij}^{-}) \right) \tag{4}$$

where $c = (\log(m))^{-1}$ is a constant, the degree of divergence d_j for each criterion is determined as follows:

$$d_j = \left(1 - E_j^{+}, 1 - E_j^{-}\right), \text{where } d_j = \left(d_j^{+}, d_j^{-}\right), \; j = 1, 2, ..., n \tag{5}$$

The objective weights of each criterion are obtained.

$$W_j = \left(\frac{d_j^{+}}{\sum_{j=1}^{n} d_j^{+}}, \frac{d_j^{-}}{\sum_{j=1}^{n} d_j^{-}} \right) \tag{6}$$

Step 7: Construct the bipolar weighted normalized decision matrices (BWNDMs).

The BWNDM is framed by multiplying the weight vector and normalized matrices.

$$W = [w_{ij}] = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{m1} & w_{m2} & \cdots & w_{mn} \end{bmatrix} \tag{7}$$

where $w_{ij} = \left(w_{ij}^{+}, w_{ij}^{-}\right)$, $i = 1, 2, \ldots, m$, and $j = 1, 2, \ldots, n$.

Step 8: Determine the bipolar optimal values

$$S_i = \left(\sum_{j=1}^{n} w_{ij}^{+}, \sum_{j=1}^{n} w_{ij}^{-} \right) \tag{8}$$

where $S_i = \left(s_{ij}^{+}, s_{ij}^{-}\right)$ is the bipolar optimal value and the w_{ij}^{+} and w_{ij}^{-} are the BWNDM value.

Step 9: Determine the bipolar degree of utility values.

The bipolar optimal value S_i and each alternative's bipolar degree of utility is calculated through Eq. (9).

$$U_i = \frac{S_i}{S_o} \tag{9}$$

$U_i = (u_{ij}^+, u_{ij}^-)$ and $S_i = (s_{ij}^+, s_{ij}^-)$ are the bipolar utility value and bipolar optimal values, respectively. $S_o = \left(s_o^+, s_o^-\right)$ is the bipolar optimality value of the optimal alternative. And the obtained result is validated through comparative analysis using the EDAS method.

4 An Adaption of the Proposed Method for Selecting the TB Comorbidities

The conversion of real data into fuzzy values and the entropy measure are used to determine the importance of alternatives.

Step 1. The set of alternatives $A = \{A_1, A_2, A_3, A_4, A_5\}$ and the criteria $C = \{C_1, C_2, C_3, ..., C_{10}\}$ are framed. The A_1—TB-Covid, A_2—TB-HIV, A_3—TB-Diabetes, A_4—TB-Alcohol, and A_5—TB-Tobacco are the alternatives that indicate the TB with other diseases. The C_1-Andhra Pradesh, C_2-Gujarat, C_3-Karnataka, C_4-Madhya Pradesh, C_5-Maharashtra, C_6-Odisha, C_7-Rajasthan, C_8-Tamil Nadu, C_9-Uttar Pradesh, and C_{10}-West Bengal are the chosen criteria.
Step 2. The linguistic decision matrix is framed by converting the real data into linguistic variables through decision-makers opinions, as represented in Table 1.
Step 3. The LDM is converted into a bipolar trapezoidal fuzzy matrix using linguistic terms in Table 2.
Step 4. The BTrFM is defuzzified using Eq. (1), and the bipolar defuzzified matrix is represented in Table 3.
Step 5. The BNDM is determined through Eq. (3).
Step 6. The bipolar weight values are calculated using the entropy measure in Eq. (8). (Table 4).
Step 7: The BWNDM is calculated. After that, the bipolar optimal values are presented in step 8 (Table 5).
Step 8. Finally, determine the bipolar degree of utility values through Eq. (9). Also, the comparative study result of the EDAS method values is determined in Table 6.

Table 1 Construct the linguistic decision matrix (LDM)

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
A_1	VL	L	VL	VL	M	VL	VL	VL	VH	L
A_2	VH	VH	VH	H	VH	VH	H	H	H	VH
A_3	H	H	H	M	H	VH	H	H	L	H
A_4	H	M	M	VL	L	H	L	M	VL	H
A_5	H	H	H	L	M	H	M	M	VL	M

Table 2 Linguistic terms of BTrFN

Linguistic variable	Bipolar trapezoidal fuzzy number
Very low (VL)	(0.0, 0.1, 0.18, 0.23) (0.72, 0.78, 0.92, 0.97)
Low (L)	(0.17, 0.22, 0.36, 0.42) (0.58, 0.63, 0.80, 0.86)
Medium (M)	(0.32, 0.41, 0.58, 0.65) (0.32, 0.41, 0.58, 0.65)
High (H)	(0.58, 0.63, 0.80, 0.86) (0.17, 0.22, 0.36, 0.42)
Very high (VH)	(0.72, 0.78, 0.92, 0.97) (0.0, 0.1, 0.18, 0.23)

Table 3 Bipolar defuzzifed matrix

A_i	C_1	C_2	C_3	C_4	C_5
	C_6	C_7	C_8	C_9	C_{10}
A_1	(0.1344, 0.8489)	(0.2911, 0.7161)	(0.1344, 0.8489)	(0.1344, 0.8489)	(0.4928, 0.4928)
	(0.1344, 0.8489)	(0.1344, 0.8489)	(0.1344, 0.8489)	(0.8489, 0.1344)	(0.2911, 0.7161)
A_2	(0.8489, 0.1344)	(0.8489, 0.1344)	(0.8489, 0.1344)	(0.7161, 0.2911)	(0.8489, 0.1344)
	(0.8489, 0.1344)	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.8489, 0.1344)
A_3	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.4928, 0.4928)	(0.7161, 0.2911)
	(0.8489, 0.1344)	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.2911, 0.7161)	(0.7161, 0.2911)
A_4	(0.7161, 0.2911)	(0.4928, 0.4928)	(0.4928, 0.4928)	(0.1344, 0.8489)	(0.2911, 0.7161)
	(0.7161, 0.2911)	(0.2911, 0.7161)	(0.4928, 0.4928)	(0.1344, 0.8489)	(0.7161, 0.2911)
A_5	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.7161, 0.2911)	(0.2911, 0.7161)	(0.4928, 0.4928)
	(0.7161, 0.2911)	(0.4928, 0.4928)	(0.4928, 0.4928)	(0.1344, 0.8489)	(0.4928, 0.4928)

Table 4 Bipolar fuzzy entropy weight value

Weigh value	(0.0936, 0.1059)	(0.1004, 0.1090)	(0.0973, 0.1055)	(0.1059, 0.0970)	(0.1041, 0.1086)
	(0.0902, 0.1028)	(0.1049, 0.1045)	(0.1045, 0.1082)	(0.0987, 0.0943)	(0.1004, 0.1090)

Table 5 Bipolar optimal values

S_o	A_1	A_2	A_3	A_4	A_5
(0.2341, 0.2803)	(0.0812, 0.2535)	(0.2297, 0.0646)	0.1890, 0.1110)	(0.1204, 0.1805)	(0.1455, 0.1548)

Table 6 Bipolar optimal values on ARAS and EDAS methods

Alternatives	ARAS method values	Rank	Comparative study values (EDAS method)
A_1	(0.3469, 0.9044)	5	(0.2881, 0.8050)
A_2	(0.9812, 0.2303)	1	(0.7568, 0.2123)
A_3	(0.8072, 0.3960)	2	(0.6107, 0.3698)
A_4	(0.5143, 0.6441)	4	(0.3804, 0.5989)
A_5	(0.6213, 0.5523)	3	(0.4640, 0.5140)

5 Result and Discussion

TB disease is one of the major causes of death worldwide. It is very effective in TB comorbidities patients. So, this work analyzes TB's effectiveness while the presence of other CDs and NCDs. Initially, the alternatives and criteria are selected to analyze the TB comorbidities. The appropriate data are collected from WHO 2021 India report. The various TB comorbidities diseases are chosen as alternatives, and the TB-affected rate in the top 10 Indian states is chosen as criteria. The bipolar trapezoidal fuzzy context is used to measure the vagueness and implemented in the fuzzy ARAS method. The obtained result is $A_2 > A_3 > A_5 > A_4 > A_1$. From the result, the TB-HIV is graded one, where HIV patients have a high possibility of affecting by TB. The fuzzy EDAS method is utilized in comparative analysis to validate the outcomes. The ARAS generates the result through the bipolar degree of utility score, whereas EDAS calculates the positive and negative distance from the average value. The result remains the same in the comparative study, which proves the effectiveness of the proposed method. This study has limitations. According to the result, TB-COVID has attained the fifth rank. As COVID is also a CDs, the TB-COVID has a high possibility of infection rate. Here, the collected data for COVID are limited. If the entire data are collected, the result may change and vary to other countries.

6 Conclusion

TB disease affects people of all ages and is also the leading cause of death worldwide. TB comorbidities are also a major issue that the world faces. Even the other disease can hugely stimulate the TB to reach the alarm stage. Therefore, the work analyzed a few diseases that hugely impact TB. The data were collected based on India's TB comorbidities and the top 10 TB comorbidities states. The work progressed in the bipolar context to view the positive and negative views, which aid in producing the disease that highly influences TB in two ways. The ARAS method is utilized to rank the alternatives using the optimal value. The effectiveness of the proposed method is proved by comparing the acquired result with the extant fuzzy method. This analysis found that HIV highly impacts TB, and TB-HIV patients are high in number in India. This result also helps the Indian government to reduce the spread

of TB by monitoring HIV patients. Further, the work can be extended to a bipolar intuitionistic context.

References

1. Mavi, R. K. (2015). Green supplier selection: A fuzzy AHP and fuzzy ARAS approach. *International Journal of Services and Operations Management., 22*(2), 165–188.
2. Nguyen, H. T. et al. (2016). An integrated MCDM model for conveyor equipment evaluation and selection in an FMC based on a Fuzzy AHP and Fuzzy ARAS in the presence of vagueness.
3. Goswami, S. S., & Behera, D. K. (2020). Implementation of ENTROPY-ARAS decision making methodology in the selection of best engineering materials. *Materials Today: Proceedings, 38*, 2256–2262.
4. Ezhilarasan, N., & Felix, A. (2022). Fuzzy ELECTRE and TOPSIS method to analyze the risk factors of tuberculosis. *Journal of Physics: Conference Series, 2267*(1), 012109.
5. Mishra, A. R., & Rani, P. (2021). A q-rung orthopair fuzzy ARAS method based on entropy and discrimination measures: An application of sustainable recycling partner selection. *Journal of Ambient Intelligence and Humanized Computing* 0123456789.
6. Brahmi, H. et al. (2022). A new group decision making approach with fuzzy SWARA and ARAS-H for selecting steel products suppliers : A Case Study,*& 7*(3), 33–43.
7. Felix, A., & Dash, S. K. (2021). Hear FCM with DEMATEL techniques to analyze the solid waste management. *Advances in Smart Grid Technology, Lecture Notes in Electrical Engineering, 688*, 393–402.
8. Stephen, M., et al. (2022). *Numerical modelling and optimation in advanced manufacturing process*. Springer.
9. Schitea, D., et al. (2019). Hydrogen mobility roll-up site selection using intuitionistic fuzzy sets based WASPAS, COPRAS and EDAS. *International Journal of Hydrogen Energy, 44*(16), 8585–8600.
10. Zhan, J., et al. (2020). Covering-based variable precision fuzzy rough sets with PROMETHEE-EDAS methods. *Information Sciences, 538*, 314–336.
11. Srivastava, P., et al. (2020). Prioritizing autonomous maintenance system attributes using fuzzy EDAS approach. *Procedia Computer Science, 167*(2019), 1941–1949.
12. Darko, A. P., & Liang, D. (2020). Some q-rung orthopair fuzzy hamacher aggregation operators and their application to multiple attribute group decision making with modified EDAS method. *Engineering Applications of Artificial Intelligence, 87*, 103259.
13. Devi, S. A. et al. (2022). An intuitionistic fuzzy decision support system for COVID-19 lockdown relaxation protocols in India. *Computers and Electrical Engineering, 102*.
14. Deva, N., & Felix, A. (2021). Designing DEMATEL method under bipolar fuzzy environment. *Journal of Intelligent and Fuzzy Systems, 41*(6), 7257–7273.

Intuitionistic Fuzzy PROMETHEE Method for Medical Ventilator Selection

S. Aicevarya Devi and A. Felix

Abstract Knowledge about medical ventilators is paramount as it acts as a life-saver for COVID patients. Due to the availability of unrelated health conditions, the medical market manufactured numerous ventilators with unique features. This evaluation process aids in selecting the suitable ventilator for critical stage COVID patients. Multi-criteria decision-making processes are used to manage this selection. The pentagonal intuitionistic fuzzy set (PIFS) is utilized to deal with uncertain information because it incorporates both belongingness and non-belongingness grades, making it more precise than traditional fuzzy sets. This work combines the preference ranking organization method for enrichment evaluation (PROMETHEE) and PIFS for deciding the medical ventilator. The criteria are weighted through entropy technique. A new defuzzification approach is introduced for PIFS, and a case study involving ventilator assessment under a PIFS context is used to demonstrate the robustness of the proposed method. The attained result is validated by comparing with the extant fuzzy MCDM method. Therefore, this work aids medical professionals in selecting the best life-saving ventilators for COVID patients in the critical stage.

Keywords COVID-19 · Medical ventilators · Intuitionistic fuzzy sets · Pentagonal intuitionistic fuzzy sets · CPIFCS algorithm · PROMETHEE · VIKOR

1 Introduction

COVID-19 is caused by a new coronavirus that has not been seen in humans before. In December 2019, this virus was born in Wuhan, China and spread worldwide in a short period. The 2019 novel coronavirus (2019 nCoV) [1] was identified by the World

S. Aicevarya Devi (✉) · A. Felix
Mathematics Division, School of Advanced Sciences, Vellore Institute of Technology, Chennai 606127, India
e-mail: aicevaryadevi.s2019@vitstudent.ac.in

A. Felix
e-mail: felix.a@vit.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_53

Health Organization (WHO) on January 12, 2020, and declared a global pandemic on March 11, 2020. Coughing or sneezing, close contact with infected patients, and respiratory difficulty are the most frequent and rapid transmission modes [2]. The respiratory issue is considered to be a serious symptom. These difficulty can be overcome by fitting the ventilators for each individual.

Ventilators are the device that supports or recreate the process of breathing by pumping air into the lungs. It plays a vital role in saving lives in both hospitals and ambulances. It is used when a person cannot breathe on their own. Two types of ventilators [3] are (i) Invasive ventilators that deliver the oxygen into the lungs through a tube inserted into the windpipe or trachea of the patient. (ii) Non-invasive ventilators deliver oxygen through a tight-fitting mask positioned above the nose region of the patient. Doctors use different types of ventilators at varying stages based on a patient condition. This work analyzes the eight ventilators. (1) Nasal cannulas consist of a flexible tube. It delivers a low amount of oxygen, sited beneath the nose. (2) Simple face mask, also called a simple Hudson mask, is a disposable mask made of plastic. It delivers higher flow than nasal cannulas [4] (3) O_2 mask with reservoir, it contains high oxygen concentration with a face mask connected to a reservoir bag. (4) O_2 blenders with nebulizer, one or two of a blender's output ports are low flow, and one is high flow. (5) Venturi mask delivers a high oxygen level with a risk of hypercapnic respiratory failure. (6) Anesthesia masks are silicone or rubber material covering the nose and mouth. (7) Mechanical ventilator aids to breathe during surgery, and illnesses occur in the own breathing system. It is connected to the hollow tube (artificial airway). (8) When the natural breathing passage is blocked or becomes smaller, a tracheostomy provides a breathing passage. A few research on ventilators that address in fuzzy perception are listed. In order to maintain the ventilator's saturation level, the Mamdani fuzzy controller was utilized in [5] to observe the oxygen flow in the ventilator. The selection of green suppliers was carried out using the fuzzy PROMETHEE method [6], while the management of the solid waste problem [7] was addressed using the fuzzy DEMATEL method. The DEMATEL method used in the bipolar and intuitionistic environment [8, 9]. This technique paved the way to obtaining the best lifesaver ventilators by identifying the cause and effect relationship between ventilators. The methodology of various fuzzy MCDM and defuzzification techniques are indicated in [10–12].

1.1 Motivation and Contribution

During the COVID pandemic, the shortage of ventilators occurred worldwide, and people died due to the non-availability of ventilators. This motivates to fetch awareness among the common public about ventilators and the availability of various ventilator that suits for all health conditions. Therefore, the different ventilators are analyzed through PROMETHEE II by incorporating the proposed defuzzification method. The Obricovic [13] converting fuzzy into crisp score (CFCS) algorithm is extended to the converting pentagonal intuitionistic fuzzy into crisp score (CPIFCS)

algorithm as a defuzzification method for pentagonal intuitionistic fuzzy context, which is a novelty of the work.

This paper is arranged into seven sections. Section 2 encompasses the fundamentals of PIFS. Section 3 presents the proposed defuzzification method for the PIFN called CPIFCS algorithm. Section 4 provides the proposed method and the illustration of the proposed method in given in Sect. 5. The result and discussion is in Sect. 6. Section 7 holds the conclusion.

2 Preliminaries

2.1 Fuzzy Number

A fuzzy number is a fuzzy set $\tilde{A}$ on the real line R, whose membership function $\mu_{\tilde{A}}(c)$ satisfies the following conditions:

(1) Normality, i.e., there exists an element c_0 such that $\mu_{\tilde{A}}(c_0) = 1$.
(2) Piece-wise continuity, i.e., $\forall \varepsilon > 0, \exists \delta > 0$ such that $\left|\mu_{\tilde{A}}(c) - \mu_{\tilde{A}}(c_0)\right| < \varepsilon$ whenever $|c - c_0| < \delta$.
(3) Convexity, i.e., $\mu_{\tilde{A}}(\lambda c_1 - (1-\lambda)c_2) \geq \min\left(\mu_{\tilde{A}}(c_1) - \mu_{\tilde{A}}(c_2)\right) \forall c_1, c_2 \in R, \lambda \in [0, 1]$.

2.2 Intuitionistic Fuzzy Number

An intuitionistic fuzzy number is an intuitionistic fuzzy set $\tilde{A}_I$ on the real line R, satisfying the following condition in addition to the above three conditions in Definition 2.1.

(1) Concavity, i.e., $\nu_{\tilde{A}}(\lambda c_1 - (1-\lambda)c_2) \geq \max\left(\nu_{\tilde{A}}(c_1) - \nu_{\tilde{A}}(c_2)\right) \forall c_1, x_2 \in R, \lambda \in [0, 1]$.

2.3 Pentagonal Intuitionistic Fuzzy Number

Let $\tilde{A}_p(x) = \left(a_1, a_2, a_3, a_4, a_5, a_1', a_2', a_3, a_4', a_5'\right)$ be the pentagonal intuitionistic fuzzy number. Its membership and non-membership functions are represented below.

$$\mu_{\tilde{A}_p}(x) = \begin{cases} m\left(\frac{x-a_1}{a_2-a_1}\right) & \text{if } a_1 \le x \le a_2 \\ m + (1-m)\left(\frac{x-a_2}{a_3-a_2}\right) & \text{if } a_2 \le x \le a_3 \\ 1 & \text{if } x = a_3 \\ m + (1-m)\left(\frac{a_4-x}{a_4-a_3}\right) & \text{if } a_3 \le x \le a_4 \\ m\left(\frac{a_5-x}{a_5-a_4}\right) & \text{if } a_4 \le x \le a_5 \end{cases}$$

$$v_{\tilde{A}_p}(x) = \begin{cases} m + (1-m)\left(\frac{x-a_1'}{a_2'-a_1'}\right) & \text{if } a_1' \le x \le a_2' \\ m\left(\frac{x-a_2'}{a_3'-a_2'}\right) & \text{if } a_2' \le x \le a_3' \\ 0 & \text{if } x = a_3' \\ m\left(\frac{a_4'-x}{a_4'-a_3'}\right) & \text{if } a_3 \le x \le a_4 \\ m + (1-m)\left(\frac{a_5'-x}{a_5'-a_4'}\right) & \text{if } a_4 \le x \le a_5 \end{cases}$$

3 Proposed CPIFCS Algorithm

The process of converting fuzzy value into crisp value is called defuzzification. This work provides the defuzzification technique for the pentagonal intuitionistic fuzzy number and is presented as CPIFCS algorithm. Let $\left(a_1, a_2, a_3, a_4, a_5, a_1', a_2', a_3, a_4', a_5'\right)$ are the parameters of PIFN. The following steps help in converting PIFN into crisp score.

Step 1: Normalize each term of PIFN

$$\left(\begin{array}{l} a_{ij}^n = \frac{a_{ij}^n - \min\left(a_{ij}^n\right)}{\Delta_{\min}^{\max}}, b_{ij}^n = \frac{b_{ij}^n - \min\left(a_{ij}^n\right)}{\Delta_{\min}^{\max}}, c_{ij}^n = \frac{c_{ij}^n - \min\left(a_{ij}^n\right)}{\Delta_{\min}^{\max}}, d_{ij}^n = \frac{d_{ij}^n - \min\left(a_{ij}^n\right)}{\Delta_{\min}^{\max}}, \\ e_{ij}^n = \frac{e_{ij}^n - \min\left(a_{ij}^n\right)}{\Delta_{\min}^{\max}}, a_{ij}^{n'} = \frac{\max\left(e_{ij}^{n'}\right) - a_{ij}^{n'}}{\nabla_{\min}^{\max}}, b_{ij}^{n'} = \frac{\max\left(e_{ij}^{n'}\right) - b_{ij}^{n'}}{\nabla_{\min}^{\max}}, c_{ij}^{n'} = \frac{\max\left(e_{ij}^{n'}\right) - c_{ij}^{n'}}{\nabla_{\min}^{\max}}, \\ d_{ij}^{n'} = \frac{\max\left(e_{ij}^{n'}\right) - d_{ij}^{n'}}{\nabla_{\min}^{\max}}, e_{ij}^{n'} = \frac{\max\left(e_{ij}^{n'}\right) - e_{ij}^{n'}}{\nabla_{\min}^{\max}} \end{array}\right)$$

where $\Delta_{\min}^{\max} = \max\left(e_{ij}^n\right) - \min\left(a_{ij}^n\right)$; $\nabla_{\min}^{\max} = \max\left(e_{ij}^{n'}\right) - \min\left(a_{ij}^{n'}\right)$

Step 2: Normalizing the left and right scores

$$\left(\begin{array}{l} l_1 s_{ij}^n = \frac{b_{ij}^n}{1 + b_{ij}^n - a_{ij}^n}, l_2 s_{ij}^n = \frac{c_{ij}^n}{1 + c_{ij}^n - b_{ij}^n}, r_1 s_{ij}^n = \frac{d_{ij}^n}{1 + d_{ij}^n - c_{ij}^n}, r_2 s_{ij}^n = \frac{e_{ij}^n}{1 + e_{ij}^n - d_{ij}^n}, \\ l_1 s_{ij}^{n'} = \frac{a_{ij}^{n'}}{1 + a_{ij}^{n'} - b_{ij}^{n'}}, l_2 s_{ij}^{n'} = \frac{b_{ij}^{n'}}{1 + b_{ij}^{n'} - c_{ij}^{n'}}, r_1 s_{ij}^{n'} = \frac{c_{ij}^{n'}}{1 + c_{ij}^{n'} - d_{ij}^{n'}}, r_2 s_{ij}^{n'} = \frac{d_{ij}^{n'}}{1 + d_{ij}^{n'} - e_{ij}^{n'}} \end{array}\right)$$

Step 3(a): Total normalization scores

$$\left(\begin{array}{l} x_{ij1}^{n}=\frac{l_1 s_{ij}^{n}\left(1-l_1 s_{ij}^{n}\right)+\left(l_2 s_{ij}^{n}\right)^{2}}{1-l_1 s_{ij}^{n}+l_2 s_{ij}^{n}}, x_{ij2}^{n}=\frac{l_2 s_{ij}^{n}\left(1-l_2 s_{ij}^{n}\right)+\left(r_1 s_{ij}^{n}\right)^{2}}{1-l_2 s_{ij}^{n}+r_1 s_{ij}^{n}}, \\ x_{ij3}^{n}=\frac{r_1 s_{ij}^{n}\left(1-r_1 s_{ij}^{n}\right)+\left(r_2 s_{ij}^{n}\right)^{2}}{1-r_1 s_{ij}^{n}+r_2 s_{ij}^{n}}, x_{ij1}^{n'}=\frac{l_2 s_{ij}^{n'}\left(1-l_2 s_{ij}^{n'}\right)+\left(l_1 s_{ij}^{n'}\right)^{2}}{1-r_1 s_{ij}^{n'}+r_2 s_{ij}^{n'}}, \\ x_{ij2}^{n'}=\frac{r_1 s_{ij}^{n'}\left(1-r_1 s_{ij}^{n'}\right)+\left(l_2 s_{ij}^{n'}\right)^{2}}{1-r_1 s_{ij}^{n'}+l_2 s_{ij}^{n'}}, x_{ij3}^{n'}=\frac{r_2 s_{ij}^{n'}\left(1-r_2 s_{ij}^{n'}\right)+\left(r_1 s_{ij}^{n'}\right)^{2}}{1-r_2 s_{ij}^{n'}+r_2 s_{ij}^{n'}} \end{array}\right)$$

Step 3(b): Total normalization scores

$$\left(\begin{array}{l} x_{ij1*}^{n}=\frac{x_{ij1}^{n}\left(1-x_{ij1}^{n}\right)+\left(x_{ij1}^{n}\right)^{2}}{1-x_{ij1}^{n}+x_{ij2}^{n}}, x_{ij2*}^{n}=\frac{x_{ij2}^{n}\left(1-x_{ij2}^{n}\right)+\left(x_{ij3}^{n}\right)^{2}}{1-x_{ij2}^{n}+x_{ij3}^{n}}, \\ x_{ij1*}^{n'}=\frac{x_{ij2}^{n'}\left(1-x_{ij2}^{n'}\right)+\left(x_{ij1}^{n'}\right)^{2}}{1-x_{ij2}^{n'}+x_{ij1}^{n'}}, x_{ij2*}^{n'}=\frac{x_{ij3}^{n'}\left(1-x_{ij3}^{n'}\right)+\left(x_{ij2}^{n'}\right)^{2}}{1-x_{ij3}^{n'}+x_{ij2}^{n'}} \end{array}\right)$$

Step 3(c): Total normalization scores

$$\left(x_{ij}^{n}=\frac{x_{ij2*}^{n}\left(1-x_{ij2*}^{n}\right)+\left(x_{ij1*}^{n}\right)^{2}}{1-x_{ij2*}^{n}+x_{ij1*}^{n}}, x_{ij}^{n'}=\frac{x_{ij1*}^{n'}\left(1-x_{ij1*}^{n'}\right)+\left(x_{ij2*}^{n'}\right)^{2}}{1-x_{ij2*}^{n'}+x_{ij1*}^{n'}}\right)$$

Step 4: Evaluating the separated values

$$\left(z_{ij}^{n}=\min a_{ij}^{n}+x_{ij}^{n} * \Delta_{\min}^{\max}, z_{ij}^{n'}=\frac{x_{ij}^{n} * \Delta_{\min}^{\max}}{\Delta_{\min}^{\max}}\right)$$

4 The Proposed PROMETHEE-Entropy Method

The algorithm determines the grading methodology when analyzing the application in the $m \times n$ matrix using PROMETHEE II, and the objective weighting has been determined through the entropy measure for criteria.

Step 1: Set up the possible alternatives and criteria

The feasible u alternatives and v criteria are framed along with appropriate k decision-makers and its representations are $A = \{A_1, A_2, \ldots, A_u\}, C = \{C_1, C_2, \ldots, C_v\}, T = \{T_1, T_2, \ldots, T_k\}$.

Step 2: Construct the linguistic decision matrices

The linguistic decision matrices are framed through the opinions collected from the k decision-makers.

Step 3: Transform the linguistic decision matrices

The linguistic decision matrices are converted into pentagonal intuitionistic fuzzy matrices (PIFMs).

$$\tilde{P}_l = \left[\tilde{P}_{ij}\right] = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_u \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_v \end{array} \\ \begin{bmatrix} \tilde{P}_{11} & \tilde{P}_{12} & \ldots & \tilde{P}_{1v} \\ \tilde{P}_{21} & \tilde{P}_{22} & \ldots & \tilde{P}_{2v} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{P}_{u1} & \tilde{P}_{u2} & \ldots & \tilde{P}_{uv} \end{bmatrix} \end{array} \tag{1}$$

where $\tilde{P}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}, d_{ij}, e_{ij}, a'_{ij}, b'_{ij}, c_{ij}, d'_{ij}, e'_{ij}\right)$, $i = 1, 2, \ldots, u$; $j = 1, 2, \ldots, v$ and $l = 1, 2, \ldots, k$.

Step 4: Aggregate all the linguistic decision matrices

All the linguistic decision matrices $\tilde{P}_l, l = 1, 2, \ldots, k$ are aggregated using the following formula:

$$a_{ij} = a'_{ij} = \min\left(a_{ij}\right), b_{ij} = b'_{ij} = \frac{1}{k}\sum b_{ij}, c_{ij} = c'_{ij} = \frac{1}{k}\sum c_{ij},$$
$$d_{ij} = d'_{ij} = \frac{1}{k}\sum d_{ij}, e_{ij} = e'_{ij} = \max\left(e_{ij}\right) \tag{2}$$

Step 5: Calculate the defuzzified matrix

From the aggregated matrix, the defuzzified matrix is calculated using the proposed CPIFCS algorithm will generate the intuitionistic fuzzy matrix (IFM).

Step 6: Defuzzify the intuitionistic fuzzy matrix

The scoring function aids in defuzzifying the belongingness and non-belongingness elements of IFS. The defuzzified matrix is expressed as *D*.

$$\frac{1}{2}(1 - \mu(x) + \nu(x)) \tag{3}$$

Step 7: Determine the weights for criteria

The criteria are assigned objective weights through entropy.

$$E_j = -\frac{1}{c}\left(\sum_{j=1}^{v} r_{ij} \log r_{ij}\right), \text{where } c = \log(u) \tag{4}$$

$$W_j^o = \frac{1 - E_j}{\sum 1 - E_j} \tag{5}$$

After weighting, split the *D* matrix criteria into beneficiary and non-beneficiary category.

Step 8: Evaluate the normalized matrix

Normalization is a process of converting the obtained defuzzified matrix into a particular interval [0, 1]. Then, each alternative is compared with other alternatives to check the alternative individual performance.

$$N_{ij} = \frac{r_{ij}}{\sum r_{ij}} \quad \text{where } i = 1, 2, \ldots, u \text{ and } j = 1, 2, \ldots, v \tag{6}$$

Step 9: Select the preference index

The preference function $R_j = (a, b)$. After preference index selection, calculate the weighted preference matrix.

$$\begin{aligned} R_j = (a, b) &= 0 \text{ if } D(A_1 - A_2) \leq 0 \\ R_j = (a, b) &= x_{uv} \text{ if } D(A_1 - A_2) > 0 \end{aligned} \tag{7}$$

Step 10: Calculate the aggregated weighted preference matrix

The weighted preference matrix is aggregated using Eq. (8).

$$A_i = \frac{\sum_{j=1}^{v} w_j P_j}{\sum_{j=1}^{v} w_j} \tag{8}$$

Step 11: Evaluate the final ranking for alternatives

$$\varphi(r) = \varphi^{+}(r) - \varphi^{-}(r) \tag{9}$$

The grade for each alternative is calculated through the entering (positive) and leaving (negative) flow. Thus, ranking is obtained by Eq. (9).

Step 12: Comparative analysis

The obtained result are validated by comparing with the fuzzy VIKOR method.

5 Assessing the Suitable Ventilator for COVID-19 Patients Through Proposed Method

The proposed model intends to solve the preference of medial ventilators that are used at a critical stage of COVID patients based on the suggestions of health professionals.

Step 1: Initially, $A = \{A_1, A_2, \ldots, A_8\}$ and $C = \{C_1, C_2, \ldots, C_5\}$ be the set of alternatives and criteria are framed, respectively. The different types of ventilators are chosen as alternatives are nasal cannula (A_1), simple Hudson mask (A_2), O_2 mask with reservoir bags (A_3), O_2 blenders with Nebulizers (A_4), venturi mask (A_5), anesthesia face mask (A_6), mechanical ventilators (A_7), and tracheostomy ventilator (A_8). The features of ventilators are chosen as criteria are cost (C_1), airflow , maintenance (C_2), handling (C_3) and portability (C_5).

Step 2: The three linguistic matrices are evaluated by the opinions of three decision-makers $T = \{T_1, T_2, T_3\}$. The experts are from the medical field.

Step 3: The three decision matrices are converted to PIFM using linguistic values.

Table 1 Linguistic terms of pentagonal intuitionistic fuzzy number

Linguistic variables	Pentagonal intuitionistic fuzzy number
Extremely small	(0.000, 0.350, 0.700, 0.105, 0.140) (0.000, 0.300, 0.700, 0.110, 0.190)
Very small	(0.122, 0.175, 0.210, 0.245, 0.280) (0.970, 0.170, 0.210, 0.250, 0.330)
Small	(0.262, 0.315, 0.350, 0.385, 0.420) (0.257, 0.310, 0.350, 0.390, 0.470)
Moderate	(0.402, 0.455, 0.490, 0.525, 0.560) (0.397, 0.450, 0.490, 0.530, 0.610)
Large	(0.542, 0.595, 0.630, 0.665, 0700) (0.492, 0.590, 0.630, 0.670, 0.750)
Very large	(0.682, 0.735, 0.770, 0.805, 0.840) (0.650, 0.730, 0.770, 0.810, 0.890)
Extremely large	(0.822, 0.875, 0.910, 0.945, 1.000) (0.790, 0.870, 0.910, 0.950, 1.000)

The linguistic values are represented as the pentagonal intuitionistic fuzzy number in Table 1.

Step 4: Using Eq. (2), the linguistic decision matrices are aggregated.

Step 5: The CPIFCS algorithm is used to defuzzify the aggregated matrix to transform the pentagonal intuitionistic fuzzy score into ordinary intuitionistic fuzzy score, which contains belongingness and non-belongingness of an element in a set.

Step 6: Again the ordinary intuitionistic fuzzy score is converted into a crisp score through a scoring function in Eq. (3).

Step 7: The objective weights of criteria are computed using the entropy technique in Eqs. (4) and (5). The attained objective weight vector for criteria is $W_{ij}^{o} = [0.197, 0.174, 0.380, 0.217, 0.033]$.

Step 8: Categorize the criteria into beneficiary and non-beneficiary group and by using Eq. (6) calculate the normalized matrix N_{ij} from the defuzzified matrix.

Step 9: Each alternative performance level is computed with neighborhood alternative. Then, the preference index is chosen by Eq. (7) and then calculate the weighted preference matrix.

Step 10: The aggregated weighted preference matrix is evaluated using Eq. (8).

Step 11: The entering and leaving flow of alternatives is evaluated. It reveals the degree of alternative that dominates other alternatives through negative and positive flow.

Step 12: The final ranking for alternatives is given in Table 2. The comparative analysis is carried out to validate the outcomes. This analysis was done through fuzzy VIKOR method. The result remains the same when it is compared with VIKOR method. So, through the comparative study, the strength of proposed method is acquired.

Table 2 Final ranks of the alternatives

Alternatives	$\varphi^+(r)$	$\varphi^-(r)$	$\varphi(r)$	Proposed method rank	Q_i	Comparative rank with VIKOR
A_1	0.084	0.301	−0.217	7	0.595	7
A_2	0.099	0.366	−0.267	8	0.748	8
A_3	0.140	0.219	−0.079	6	0.379	6
A_4	0.179	0.189	−0.010	3	0.144	3
A_5	0.135	0.175	−0.040	5	0.347	5
A_6	0.135	0.148	−0.015	4	0.245	4
A_7	0.406	0.130	0.276	2	−0.028	2
A_8	0.445	0.093	0.352	1	−0.252	1

6 Results and Discussion

The suitable ventilators for serious illness COVID patients are scrutinized by comparing eight different types of ventilators and their specifications. The PROMETHEE approach is executed to rank the ventilators based on influencing criteria. The significance level of the criteria is calculated using an entropy measure. According to the proposed method and the opinions of the health professionals, the most suitable ventilators for critical stage COVID patients are listed as $A_8 > A_7 > A_4 > A_6 > A_5 > A_3 > A_1 > A_2$. The acquired result is compared with the VIKOR method. The comparative study also resulted same as the proposed method. From the ranking list, a tracheostomy ventilator (A_8) is ranked one as it chooses the airflow through the throat when a usual breathing system fails. The mechanical ventilator (A_7) is graded two. It has a maximum airflow by comparing other ventilators. It pumps the oxygen on its own, and these ventilators are utilized at a critical stage for the patient and also during surgery. So, medical ventilators are useful machine that recovers from respiratory illness.

7 Conclusion

Due to the increase in COVID cases, the availability of ventilators decreases. The use of ventilators based on the patient's condition will reduce the shortage of ventilators. This work selected the medical ventilators for critical stage COVID patients based on the ventilator's features. The PIFS is executed to tackle the uncertainty, which navigates to develop the MCDM model to assess the ventilators for critical stage COVID patients. The proposed model incorporates the PROMETHEE to grade the alternatives and the entropy to estimate the weights for criteria under the PIFS context. Further, this study can be extended to a picture fuzzy set to include the hesitation

element of the problem, and the proposed PROMETHEE-entropy model can be applied to solve various real-world selection problems.

References

1. Shereen, M. A., Khan, S., Kazmi, A., Bashir, N., & Siddique, R. (2020). Covid-19 infection: Emergency, transmission, and characteristics of human coronaviruses. *Journal of Advanced Research, 24*, 91–98.
2. Liu, Y. C., Kuo, R. L., & Shih, S. R. (2020). Covid-19: The first documented coronavirus pandemic in history. *Biomedical Journal, 43*(4), 328–333.
3. Popat, B., & Jones, A. T. (2012). Invasive and non-invasive mechanical ventilation. *Medicine, 40*(6), 298–304.
4. Nicholson, K., Henke-Adams, A., Henke, D. M., Kravitz, A. V., & Gay, H. A. (2021). Modified full-face snorked mask as covid-19 personal protective equipment: Quantitative results. *Hardware, 9*, 00185.
5. Radhakrishna, S., Nair, S. G., & Isaac, J. (2019). Analysis of parameters affecting blood oxygen saturation and modeling of fuzzy logic system for inspired oxygen prediction. *Computer Methods and Programs in Biomedicine, 176*, 43–49.
6. Abdullah, L., Chan, W., & Afshari, A. (2019). Application of PROMETHEE method for green supplier selection: A comparative result based on preference functions. *Journal of Industrial Engineering International, 15*(2), 271–285.
7. Felix, A., & Dash, S. K. (2021). Haar fem with DEMATEL technique to analyze the solid waste management (pp. 393–402).
8. Deva, N., & Felix, A. (2021). Designing DEMATEL method under bipolar fuzzy environment. *Journal of Intelligent and Fuzzy Systems*, 1–17.
9. Devi, S. A., Felix, A., Narayanamoorthy, S., Ahmadian, A., Balaenu, D., & Kang, D. (2022). An intuitionistic fuzzy decision support system for COVID-19 lockdown relaxation protocols in India. *Computers and Electrical Engineering, 102*, 108166.
10. Ezhilarasan, N., & Felix, A. (2022). Fuzzy ELECTRE and TOPSIS method to analyze the risk factors of Tuberculosis. *Journal of Physics: Conference Series*, *2267*, 012109. IOP Publishing.
11. Swethaa, S., & Felix, A. (2022). Haar and Yager's ranking methods for intuitionistic dense fuzzy set. *Journal of Physics: Conference Series*, *2267*, 012065. IOP Publishing.
12. Stephen, M., Felix, A., & Parthiban, A. (2022). *Numerical modelling and optimization in advanced manufacturing process.* Springer.
13. Opricovic, S., & Tzeng, G. H. (2003). Defuzzification within a multicriteria decision model. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 11*(05), 635–652.

Dynamic Bandwidth Allocation Using Linear Regression Model in IOT with Machine Learning Techniques

Shekhar, Gaurav Bhandari, and Sudhanshu Tyagi

Abstract An improved dynamic bandwidth allocation (IDBA) technique is presented for optimal bandwidth management provisioning in IoT devices. Although there are several application areas in IoT, however, smart home-based IoT devices dataset used as input, *K*-means clustering algorithm grouped the IoT devices into three categories based on bandwidth usage pattern. It may be used for cluster the devices. The linear regression method would be applied over cluster-based IoT devices to get on-demand bandwidth for each cluster category. On-demand prediction value obtained through the linear regression method used in artificial intelligence-enabled bandwidth allocation technique. Finally, an artificial intelligence-enabled IDBA method allocates the bandwidth dynamically with a high degree of precision and improves the quality of service in IoT devices.

Keywords IDBA · Dynamic bandwidth allocation · Clustering · Linear regression and machine learning

1 Introduction

With an estimated 7 billion devices by 2020, there are already over 130 million IoT devices available in India. The nation's IoT market is anticipated to increase fivefold by 2022, from $1.2 billion to $7 billion. The Internet of Things (IoT) is efficiently providing the connectivity between people and machines in the modern world. A service provider can greatly increase network efficiency by increasing the percentage of appropriate oversubscription, which allows for flexibly tailoring responsiveness networks and producing more profits from their networks without increasing raw bandwidth. Several studies suggest that by the year 2050, the number of connected

Shekhar (✉) · G. Bhandari
ICFAI Tech School, The ICFAI University, Dehradun, India
e-mail: shekharpundir@gmail.com

S. Tyagi
Thapar Institute of Engineering and Technology, Patiala, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_54

devices will have risen to 50 billion. Limitations in processing power and available bandwidth can cause a number of problems in the Internet of Things. Security, heterogeneity, low power, and other similar problems are just a few examples. It will be challenging to allocate bandwidth to billions of IoT devices using the current network infrastructure. To solve this problem, we introduce the improved dynamic bandwidth allocation (IDBA) method, which guarantees a constant flow of bandwidth while also boosting the quality of service in IoT gadgets. The IoT market is expanding significantly year after year due to a wide range of applications, ranging from tiny sensors to large industrial devices. With the billions of connected devices opening up unique commercial options, IoT applications also help to enhance the economy. The IoT market has been expanding quickly, but it still faces a number of obstacles, including security, heterogeneity, and a lack of standardized protocols, communication topology, and bandwidth choice. The purpose of this research is to better understand how to give IoT devices consistent bandwidth for improved connectivity. The explanation of mechanisms linked to enhanced and improved dynamic bandwidth selection, common protocols, and network topologies is the main contribution of this article. Some of author discussed as in [1] *K*-pattern clustering has been shown to be effective in categorizing and characterizing user activity patterns using artificial neural networks. A pattern-based clustering algorithm extracts the potential load in a predetermined amount of time. This method is used to obtain statistical information about the consumer domain. In large IoT devices, computational bandwidth utilization is not possible. However, this method has the disadvantage of producing subpar results due to the similarity of related activities in IoT nodes. In paper [2], author proposed DUP-TRMA methods were proposed, which work by allocating bandwidth based on user priority using lower bound logic and the throughput maximum resource allocation (TRMA) scheme. DUP-TRMA outperforms traditional RPA methods by 4% by authors Torres et al. A dynamic resource allocation method that is based on bandwidth allocation and supports new trends in IoT systems. The authors proposed the BAMSDN model, which is a system for dynamic bandwidth allocation using a software-defined network. The experimental results show that BAM with SDN is effective and flexible in [3]. HOWSN energy consumption and end-to-end packet delay are proposed to be reduced by implementing a delay and energy-efficient DBA system. When comparing the DEE DBA scheme to the ALDBA and ALDBM schemes at the highest offered load of 1.0, the DEE DBA scheme consumes 30% and 37% less TE, respectively. However, because safeguard time is required to protect packets from threats, it increases overhead and bandwidth consumption [4]. ANN calculates network latency for various applications. It is difficult to measure bandwidth in homogeneous devices. Dynamic frequency and bandwidth assignments (DFBAs) are used in the deployment of small cell networks. The DFBA technique is not suitable for heterogeneously linked IoT devices [5]. Unsupervised learning method: An artificial neural network based on Allen's temporal relations is used in the smart home environment to recognize and anticipate user activities in personal space. This technique may produce irrelevant qualities in the presence of more sensitive sensors in [1]. In [6], author proposed deep learning-based solutions for dynamic bandwidth allocation in future access networks. To improve bandwidth allocation,

the authors proposed a next-generation passive optical network to control message exchange between terminal and network unit. They concentrated on reducing the overheads caused by the request-response procedure in the proposed method. As IoT devices increasing from millions to billions, the amount of data IoT devices collect and transmit can increase which in turn adds to need for more bandwidth. For example, bandwidth need in smartphone increased when it able to transmit images and stream videos. Such that when all the things in the world like automobiles to agriculture plants connected with Internet will produce zettabytes of data over the Internet. Handling mass data with existing infrastructure will be challenging factor. It requires highly enhanced bandwidth management techniques to providing quality of service to the entire connected IoT devices. The many elements may have an impact on the functionality of IoT applications are displayed in this section.

1.1 Security

A significant possibility for corporate development is offered by the Internet of Things. The current organizational framework is helpless against the targeted threats, such as ransomware for smart cars or smart homes, actual damage, information integrity, and new types of Botnets; to avoid this, IoT applications should be developed with security features built in. At the same time, it allows programmers to take protected devices, compromise client data, and disregard their protection.

1.2 Scalability

Due to the IoT's rapid growth, managing scalability is becoming increasingly crucial. As a result, IoT applications must now support an increasing number of connected devices, users, application features, and analytics capabilities without sacrificing the effectiveness of their operation. Flexible IoT applications will be needed to monitor, safeguard, and manage an ever-increasing number of devices through a proportionate rise in the resource (Fig. 1).

1.3 Energy Efficiency

Due to the network connections and always-on nature of IoT devices, energy efficiency is one of the major problems for IoT applications. The majority of Internet of Things (IoT) devices have self-powered or battery-powered sensors although some devices, like gateways and home appliances, are powered by an AC line. Due to the device's numerous sensor interfaces, Internet connection, and embedded processing capabilities, it must be regularly recharged or hooked into a power source. Many

Fig. 1 Challenging factors in IoT

devices are expected to be recharged using solar energy or self-charging batteries in the near future, leading to a significant decrease in overall energy usage in IoT applications.

1.4 Interoperability

The Internet of Things infrastructure is made up of a variety of sensors and communication protocols to handle varied environments like the automotive and agricultural industries. Different communication standards and sensors, like RFID, ZigBee, Infrared, Bluetooth, 6LowPAN, Lora, and Arduino, Raspberry Pi, SMARTEC, and XSens, are used for sensing that may overcome the heterogeneous environment by changing their communication technology. To handle the diverse devices and protocol standards, an effective IoT networking architecture is necessary.

1.5 Data Storage

IoT tools are now employed by business professionals to collect data and make wiser decisions that will increase client satisfaction. Companies must upgrade their information storage infrastructure in order to store the data generated by the Internet of Things, which is growing exponentially and necessitating the adaptation of cloud

storage by the IoT for data storage. Data collected must be stored and delivered to the storage system in an appropriate format.

1.6 Data Analytics

IoT data analytics will undoubtedly assist many businesses by lowering costs, preventing equipment failure, enhancing the customer experience, and boosting employee productivity. Although data of IoT devices have been shown to be helpful. Many companies fail to value-add their own data. The IoT device data analytics methods are displayed in Fig. 2 purely because they are uninformed about technology. A machine or person may get overloaded with data if sensor data are received every 30 s.

2 Improved Dynamic Bandwidth Allocation (IDBA)

The amount of data that IoT devices collect and transmit may expand as the number of IoT devices rises from millions to billions, which will increase the demand for additional bandwidth. For instance, a smartphone's bandwidth requirements grew

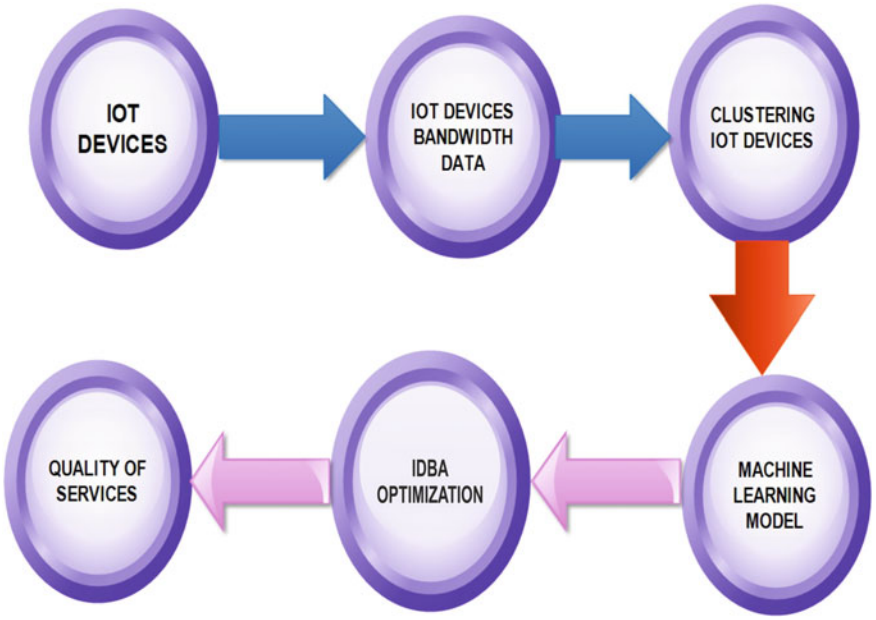


Fig. 2 System architecture

when it could stream videos and send photographs. Such that zettabytes of data will be transmitted over the Internet when everything in the planet, from automobiles to agricultural plants, is connected to the Internet. The challenge will be managing large amounts of data with the current infrastructure. To provide quality of service to all connected IoT devices, more advanced bandwidth management strategies are needed. Dynamic bandwidth allocation is a method for distributing traffic bandwidth equally and on-demand among various users of a shared telecommunications channel. Before the Internet of Things is fully implemented, there will be 300 zettabytes of data transmitted by connected devices. IPv6 addresses make it possible to connect almost any device to the Internet, but in a large-scale IoT setting, managing bandwidth and ensuring quality of service become significant challenges. The on-demand bandwidth and QoS is managed by DBA techniques, but not by bandwidth management. Most dynamic bandwidth allocation algorithms are not well suited to IoT devices, and there are no techniques available to accommodate both wired and wireless devices. The proposed method (IDBA) effectively manages bandwidth by employing machine learning methods. This method guarantees low latency, high reliability, and throughput increases of up to 97% in IoT devices, despite their limited bandwidth. Clustering methods are used to observe and classify data on bandwidth consumption from IoT devices as they transmit and receive data over the Internet via a gateway. Regression analysis of the collected data is then used to make predictions about the bandwidth needs of the connected devices, and the resulting rule is then applied to the IDBA optimization process to enhance the quality of service in the IoT. In our model, system architecture, Fig. 2, consist of six phases: IoT devices, IoT devices bandwidth data, clustering IoT devices, machine learning, IDBA optimization, quality of service. The IDBA technique efficiently manages bandwidth using traffic rules derived from machine learning models. Process, optimization, validation, and deployment are the four pillars of the IDBA methodology. Data processed by the IDBA method are clustered according to predefined categories. Throughput, on-demand prediction, and input optimization are all performed.

2.1 Clustering IOT Devices

The Internet of Things (IoT) is the hub of a system that seamlessly links together physical and digital objects with minimal overhead costs. There is an automated system in the IoT gateway that detects and monitors the daily usage pattern of bandwidth in various IoT devices over a smart home environment. Regular IoT node operation generates bandwidth usage patterns that are significant in IoT device clustering. Using these motifs, we can give preference to IoT clustering that optimizes bandwidth utilization and service quality through dynamic resource allocation. Figure 3 visualizes the actions of smart home users by keeping tabs on their behavior in a monitored setting and feeding that information into a machine learning system. The clustering process can be broken down into two distinct phases: Finding and defining the recurring patterns across multiple activities is the first step; second, the threshold

Fig. 3 Smart home user activity

value determined by the trend is an essential metric. To accommodate the unique qualities of the IoT and the smart home, the authors of this paper suggest combining pattern clustering with *K*-means clustering. *K*-means clustering is used because it provides the best results in terms of time complexity and cluster consistency even for extremely large amounts of data in the context of an IoT smart home. The second step involves defining the rules of a smart environment in order to foresee and recognize the actions of a device within its own private sphere, thus reducing the issue of bandwidth overload. The daily routine of a device can be distinguished in large part by observing how it is used.

2.2 Future-Oriented Clustering Approach

The method's goal is to improve smart home systems with a more refined pattern clustering and activity decision model. IoT Devices (with different functionality), despite performing the same function. The baby, for instance, can be monitored from a dashboard and a mobile device simultaneously. The system's bandwidth usage format reveals some deviations from the average daily pattern. It is crucial to identify the related behavior of an individual device, as opposed to the behavior of multiple devices, at an early stage in the behavior detection process. During operation, the *K*-means algorithm makes better use of the bandwidth available by managing the devices in the same cluster that are similar to one another. After the clusters have

been established, the ANN systems decide which subsequent steps should be taken. We obtained dataset (bandwidth with time variations) from different IoT devices in smart home. The proposed architecture for the dynamic bandwidth allocation strategy in an IoT network is depicted in Fig. 4. Bandwidth information collected from a smart home router for Internet of Things devices. Extraction of bandwidth patterns the procedure for gathering raw data from numerous nodes in the IoT network infrastructure (e.g., smart home system). To estimate the predicted load in the IoT network, we must first process the bandwidth model, which is the process by which data processing and analysis steps are implemented and translated into statistical details on user consumption by time slots. The following steps in the smart home system are involved in the data extraction and analysis process for each device in order to collect the distribution of the device on the cluster within a specified period and feed the pattern into wireless router in order to change the bandwidth allocation to meet the planned load. The cluster approach provides an advantageous solution that can address many of the issues associated with the Internet of Things.

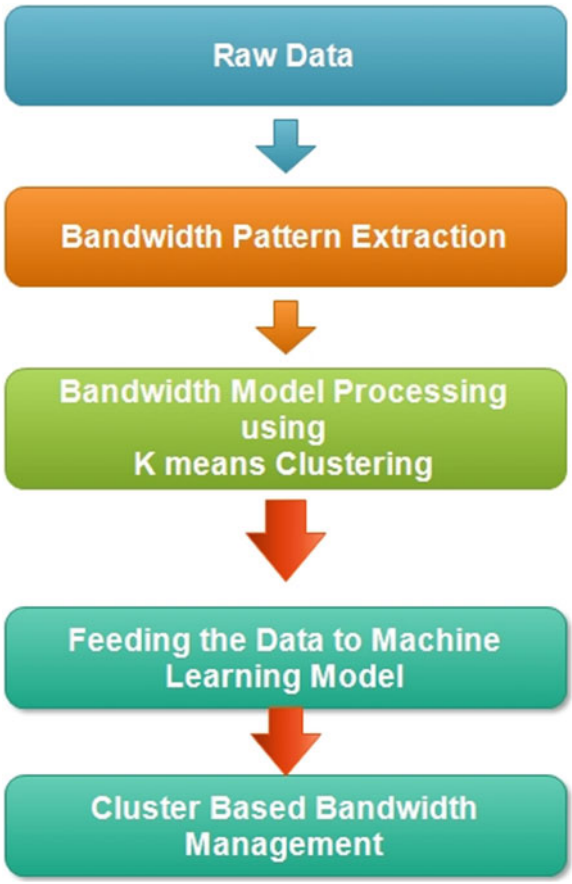


Fig. 4 Framework for IoT network clustering strategy

2.3 K-Means Algorithm

K-series clustering schemes frequently employ random clustering centers, which can lead to incongruous outcomes. Many different scales exist, but the most common ones are distance, diversity, and similarity. Data entropy, density, and correlation form the backbone of the clustering function. Different methods, each with their own set of advantages and disadvantages, can be used on various types of datasets. The clustering method is used to classify Internet of Things gadgets by their bandwidth consumption habits. In an effort to identify the optimal clustering algorithm, many different approaches were evaluated. When applied to unlabeled data, *K*-means is an unsupervised learning technique. Unlabeled or uncategorized information is one example. The number of groups (here denoted by "*K*") that can be found in the data is one of the primary goals of this method. The algorithm sorts the data according to similarity into *K* groups based on the attributes you provide. Assuming that all points within a cluster are most similar to one another, we find that there is minimal dissimilarity between groups. *N* is the number of IoT nodes used in each cluster category, allocate initial bandwidth to nearest nodes based on bandwidth usage pattern, Euclidean process finding the nearest average bandwidth range. Figure 5 shows the bandwidth usages based on clustering [7]. Figure 6 demonstrated the cluster category on the basis of bandwidth usage and throughput [8].

3 Linear Regression Methods

By applying a linear equation to the observed data, linear regression attempts to predict the relationship between two variables. A variable is viewed as a dependent

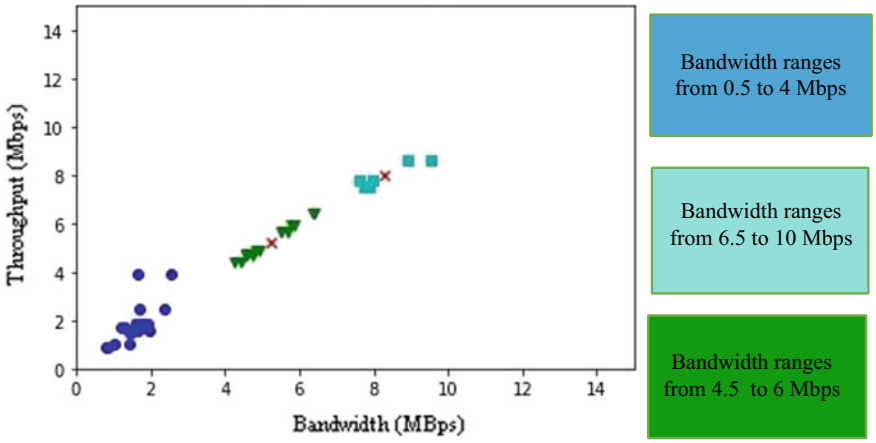


Fig. 5 Clustering based on bandwidth usage

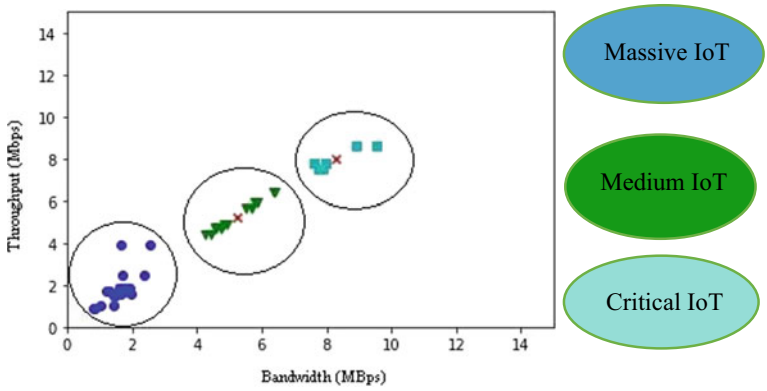


Fig. 6 Cluster category

variable whereas another is handled as an independent variable. For instance, in the dynamic bandwidth allocation method, the bandwidth controller wants to use a linear regression model to relate the bandwidth consumption of each device to its cluster category. A scatterplot can be a helpful tool for figuring out how closely two variables are related. A linear regression line has the function equation $Y = a + bx$, where X is the independent variable, Y is the dependent variable, and b and a stand for the slope and intercept of the line, respectively. Simple linear regression and multiple linear regression are the two different forms of linear regression techniques. While multiple linear regression involves many independent variables, simple linear regression simply requires one.

3.1 Regression Analysis

Consider a situation in which two congestible links occur along network path. Cluster 1 link has total bandwidth supply of 10 Mpbs, the lowest and highest bandwidth usage range falls as 2, 5 Mbps. Thus, surplus bandwidth for this range is 3 Mbps. Cluster 2 link has total bandwidth supply of 15 Mpbs; the lowest and highest bandwidth usage range falls as 4, 7 Mbps. Thus, surplus bandwidth for this range is 4 Mbps. Cluster 3 link has total bandwidth supply of 25 Mpbs; the lowest and highest bandwidth usage range falls as 5, 15 Mbps. Thus, surplus bandwidth for this range is 5 Mbps. In the topology, surplus bandwidth shares with cluster on request. There are other cross-traffic links in addition to these congestible links. Results indicate average connection and surplus bandwidth for on-demand nodes in the network and show how surplus bandwidth automatically allocated to on-demand nodes in the critical cluster category.

Machine learning—is a branch of artificial intelligence that creates software that can learn from its previous experiences. ML algorithms and methods are typically

data driven, inductive and generic, different from expert systems. Predictions or decisions for a general class of tasks are identified and implemented, like activity detection or bandwidth pattern identification. There are three main types of ML problem:

Classification—it consists of group of clusters, interaction with one of a set of possible groups as device state goes to idle or not. Therefore, classification has secure n-array output.

Regression—described as an estimate of the dependent variable relationship of one or more independent variables, like predicting the on-demand bandwidth of cluster considering its minimum, maximum, and idle state. Generally, regression inputs and output can differ in continuous value ranges.

Clustering—splits the set of devices into clusters based on bandwidth utilization pattern, maximizes the similarity in each group, and shows the variation in different groups. Many problems in pattern recognition located on clustering. ML includes two major phases: training and testing. In the training process, the adopted ML algorithms induce training data to construct a model of the particular problem. The algorithm then produces the results based on the model that would probably fit the real inputs in the testing stage that is carried out during the program testing to validate the training system fitness. In fact, classification of success measurement based on the positive class and description of one of the production classes. The number of nodes correctly placed in the positive clusters (true positive). False positive (FP)—the number of nodes in the positive cluster that are incorrectly positioned. True Negative (TN)—the number of nodes that are correctly placed in the negative cluster but not in the positive cluster. False Negative (FN)—the number of nodes in the not in the positive cluster that are correctly put. The following rating efficiency measures often included for the above definitions:

$$\text{Accuracy (positive forecasting value) defined as } A = \frac{\text{TP}}{\text{TP} + \text{FP}} \tag{1}$$

$$\text{Sensitivity (awareness) defined as } S = \frac{\text{TP}}{\text{TP} + \text{FN}} \tag{2}$$

$$G \text{ labeled as the harmonic tool of precision and alert } G = \frac{2\text{AS}}{A + S} \tag{3}$$

$$\text{Exactness defines as } E = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{FP} + \text{TN} + \text{FN}} \tag{4}$$

A model training set and a validation test set were created from all accessible data. There are numerous approaches for selecting appropriate training and evaluation components. In the k-fold cross-validation, the dataset was separated into k equal-sized subsets, one for testing and the rest for preparation. Each time a different subset used to check the entire cycle. In fact, the resulting models are only suitable for the particular situation on which built for, as the circumstances change, not reusable and portable.

4 Conclusion

In this model, wide range of household types and customer Internet usage patterns. Low processing power and bandwidth availability can lead to a number of IoT problems. Security, heterogeneity, low power, and other challenges are a few of them. One of the most important challenges for the infrastructure providers, however, is allocating and managing the bandwidth for billions of IoT devices. This problem is addressed by the improved dynamic bandwidth allocation (IDBA) technology, which offers a constant bandwidth supply and enhances the quality of service in IoT devices. An IoT bandwidth dataset from smart home-based devices is given to the IDBA algorithm. Datasets from various IoT devices will be gathered based on the level of utilization. The IoT device can be clustered using a variety of clustering algorithms.

5 Future Scope

The future Internet bandwidth projections in this research are informative. In terms of how they will affect future home demand, it contrasts the Internet of Things with other major bandwidth drivers. A prerequisite for effective bandwidth management is optimization techniques, applying machine learning approaches to study automatically detect the usage pattern and group them to cluster. Existing dynamic bandwidth allocation strategies are unable to handle enormous IoT devices. This problem is addressed by the suggested enhanced dynamic bandwidth allocation (IDBA) technique, which offers a constant bandwidth supply and raises the quality of service in IoT devices.

6 Summary

Different clustering algorithms are used to group IoT devices, including *K*-means, mean-shift, hierarchical, DBSCAN, and EM using Gaussian mixture models (Expectation–maximization clustering using Gaussian mixture models) with machine learning techniques. *K*-means performed the best in terms of achieving the best results.

References

1. Joshi, M., Gupta, B., Belwal, R., & Agarwal, A. K. (2020). An innovative cloud based approach of image segmentation for noisy images using DBSCAN scheme. *EAI Endorsed Transactions on Cloud Systems, 6*(19), 166768.

2. Pratap, A., Gupta, R., Nadendla, V. S. S., & Das, S. K. (2019). On maximizing task throughput in IoT-enabled 5G networks under latency and bandwidth constraints. In *2019 IEEE International Conference on Smart Computing (SMARTCOMP)* (pp. 217–224).
3. Torres, E. S., Reale, R. F., Sampaio, L. N., Martins, J. S. B. (2021). *A SDN/OpenFlow Framework for Dynamic Resource Allocation based on Bandwidth Allocation Model*. arXiv. https://doi.org/10.48550/ARXIV.2102.00460
4. Hossen, M., & Hanawa, M. (2020). Delay and energy efficient dynamic bandwidth allocation algorithm for hybrid optical and wireless sensor networks. *Optical Fiber Technology, 55*, 102159.
5. Cai, H., Xu, B., Jiang, L., & Vasilakos, A. V. (2016). IoT-based big data storage systems in cloud computing: perspectives and challenges. *IEEE Internet of Things Journal, 4*(1), 75–87.
6. Hatem, J. A., Dhaini, A. R., & Elbassuoni, S. (2019). Deep learning-based dynamic bandwidth allocation for future optical access networks. *IEEE Access., 7*, 97307–97318.
7. Mohandas, R., Aravindhar, J., & Praveenkumar, D. (2020). *An enhanced dynamic bandwidth allocation method to improve quality of service in internet of things*. http://hdl.handle.net/10603/316761
8. Mohandas, R., Aravindhar, J., & Praveenkumar, D. (2018). Enhanced dynamic bandwidth allocation for improve QoS in Internet of Things. *Journal of Advanced Research and Dynamical Control System, 2018*, 594–600.
9. Sudharma, I. P., Yoga, G. S., & L. (2021). Dynamic bandwidth allocation for internet of things system using elastic wireless local area network. *Jurnal Rekayasa Elektrika, 17*(3). https://doi.org/10.17529/jre.v17i3.21087

An Open CV-Based Social Distance Violation Identification Using a Deep Learning Technique

Syam Sundar Pillalamarri, K. Saikumar, Sarah A. Al-Ameedee, Sahar R. Abdul Kadeem, and Mohammed J. Hussein

Abstract Due to the Covid-19 epidemic, there is now a high need for social seclusion. As several studies have shown, it is possible to limit the transmission of Covid-19 by keeping appropriate social distances. Open CV with deep learning is used to detect the distance between individuals to lessen the effect of the coronavirus epidemic, as we describe in this paper. Individuals should be warned to stay a safe distance from one other using a video broadcast, it was suggested. To put the model to the test, we use CCTV camera footage to gather video clips, which we then feed into CNN models that have already been trained. We are attempting to use YOLOv3 algorithm to recognize pedestrians on the road. Video file now transformed top-down perspective distance measurement from the 2D plane once pedestrian recognition is complete. Social distance violation is the visible distance between any two persons less than the intended length. For every person, the distance between them is highlighted in blue or green if it seems to be more than the predicted distance. Our current model is being tested with prerecorded videos of people strolling the street to verify its correctness. According to the finding, the suggested system is capable of detecting various degrees of social distance between different characters given

S. S. Pillalamarri (✉) · K. Saikumar
Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India
e-mail: syamsundarp@kluniversity.in

K. Saikumar
e-mail: saikumarkayam4@ieee.org

S. A. Al-Ameedee
Department of Computer Technical, Al-Mustaqbal University College, Hillah, Iraq
e-mail: sarah.abdulridha@uomus.edu.iq

S. R. Abdul Kadeem
National University of Science and Technology, Nasiriyah, Iraq
e-mail: sahar@nust.edu.iq

M. J. Hussein
Al-Esraa University College, Baghdad, Iraq
e-mail: mohamed.jabar@esraa.edu.iq

K. Saikumar
School of Engineering, Department of CSE, Malla Reddy University, Hyderabad 500043, India

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_55

movie. The same approach may be used future to identify social distance violations in real-time applications.

Keywords Learning · YOLOv3 · Video sequences · Pedestrians · Object detection · Social distancing detection

1 Introduction

In December of 2019, the new Covid was released in Wuhan, China, and was formally recognized by the World Health Organization (W.H.O.) on December 31, 2019. A global threat was created by this Covid illness, which the World Health Organization designated as Covid-19 on February 11th, 2020 [1]. SARS, ARDS, and a slew of other illnesses go into its composition. The WHO has officially declared this virus to be a global health issue [2], and the most common way it spreads is via direct contact with an infected person's exhaled breath. Different methods the illness may spread or communicate among humans are yet unknown. There is absence of social distance between people crucial factor in spread by Covid-19 [3]. Government is taking a lot of effort in communicating individuals about importance of wearing mask [4] and maintains social distance in public places. For example, if one person is contaminated with Covid-19 virus, the infected person shows indications inside 2–14 days, contingent upon the brooding time of infected person. For some infected persons, this can be found in very early stage, and for some immune persons, it will be identified somewhat late. Hence, taking proper precautions from one another will help the individual to avoid this spread of Covid-19 [5]. Figure 1 clearly identifies there are several persons present all are identified with black color icon. If any person enters into the group with covid infection, then it will spread to other people easily, if the users are not maintaining any social distance from each other without any safety measurements.

Then, we can see the other users who are very close and nearer to the infected user get affected, and they will also suffer from this Covid-19 infection. Hence, this is one of the main reasons why social distance violation leads to a serious situation in present days. This motivated me to design the current application in which social distancing takes very important step in preventing the spread of coronavirus.

2 Literature Survey

There is an important phase in the software development process literature review. Before beginning the development, new application or model, the time factor, economy, and corporate strength are considered. The available applications are outdated and face high complexity of operations issues. A literature review focused on work done by various users and the merits and drawbacks of those earlier models.

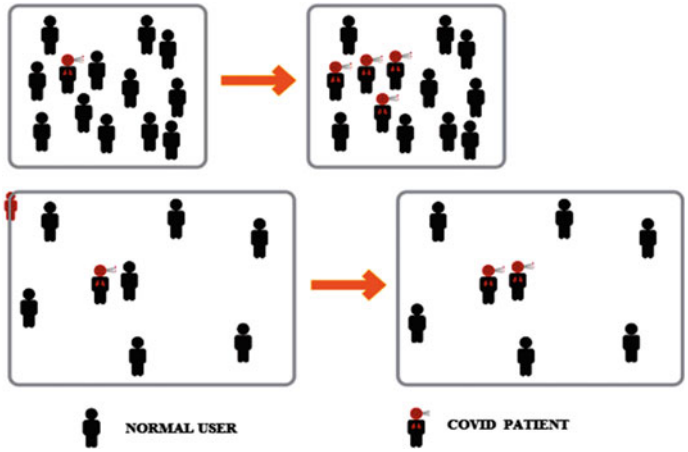


Fig. 1 Represent the spread of Covid-19 due to social distance violation

Primary of this literature review is to determine the resources needed to build the application. The author used deep learning algorithm to identify social distance in this article. Deep learning can be used to identify the distance between a pair of extremely near individuals, and then, it can be used to determine how many of those people are adhering to social distancing and how many are not [6]. A framework for tracking individuals and monitoring social distance is the goal of this study, which was written by the author. A social distance monitoring technique based on object detection was devised by the author to demonstrate this claim. In this case, we are attempting to use a human detection approach based on CNNs. It is determined by how far apart two people are from each other. In this paper, the author aims to develop a framework to prevent global disasters from their deadly spreading. As we all know, there are no effective remedies present in the real world for stopping the spread of Covid disease; a very great loss is occurred due to many viruses. To prevent the transmission of the virus, social distancing [7–10] is considered an acceptable precaution (norm) in the present scenario since there is no comprehensive treatment or therapy. Careful care and avoiding physical touch with one another may help prevent the spread of Covid illness. An overhead view on social distance monitoring will consequently be used in this project to create a deep learning platform. If we use a deep learning platform, we can able to apply object detection methods and can find out the best way to identify social distancing.

3 Current System

In the existing system, there was no proper method to identify the person who is following social distancing with a minimum 3 to 6 feet distance. All the existing

approaches are manual approaches, and hence, there is no proper method that can guarantee the prevention of social distance violation. The following are the main limitations of the existing system. Limitations of the existing system are the following.

- Generally, all the existing methods use a manual approach for identifying social distancing.
- All existing methods try to use either machine learning classification models to identify following social distancing.
- All existing approaches failed in identifying the distance between either two static or dynamic objects accurately and efficiently.
- Existing methods are not effective and efficient.
- All the existing methods are almost operated by using the manual method with the help of a lot of manpower. There is no single method that can give accurate results by avoiding manual efforts.

4 Proposed System

To test the model, we try to collect video sequences collected from CCTV cameras and then try to apply some pre-trained CNN models on that input video. Here, we try to apply the YOLOv3 algorithm for identifying the persons who are walking on the road. Once pedestrian detection is completed, now video file is converted into a top-down view for distance measurement 2D plane. Distance between any pair of people is less than the expected length then it marked in the red color frame and identified as a social distance violation is seen. If the distance between any pair of people seems more than the expected distance, then those pairs of pedestrians are marked with blue or green color.

4.1 Advantages of the Proposed System

Some of the benefits of implementing the suggested approach include the following (Fig. 2).

- By using the proposed deep learning model, we can identify the objects easily and can find out the distance between two or multiple objects accurately.
- In this proposed model, we can able to check the social distance between static objects and dynamic objects.
- This is very efficient and effective.
- Here, we used YOLOv3 algorithm.

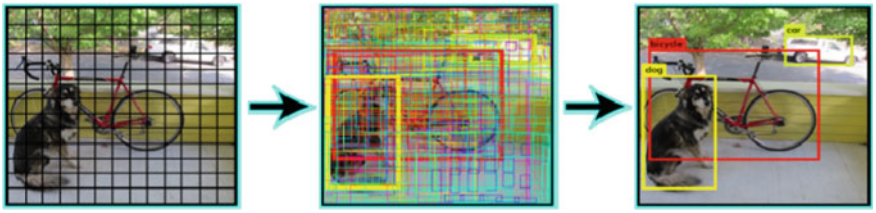


Fig. 2 Represent the proposed YOLOv3 model for object detection

4.2 Proposed Deep Learning Model

The proposed deep learning CNN model YOLO V3 is developed to object detection and to find out whether the distance between two or multiple objects follows social distance or not.

Figure 3 clearly identifies object detection by using a pre-trained CNN model such as YOLOv3 [11–14]. Best pre-trained models used object detection and classification. Initially, we try to load the video sequence as input, and from that video sequence, we will collect some sort of frames/images captured from that video file. Once frames are gathered now, we try to apply those frames as input for the YOLO v3 model and then check the detection result. Here, we try to find out the box coordinates and object confidence of that detected object. Based on these values, probability is calculated, and we try to identify how many pedestrians are present within the frame.

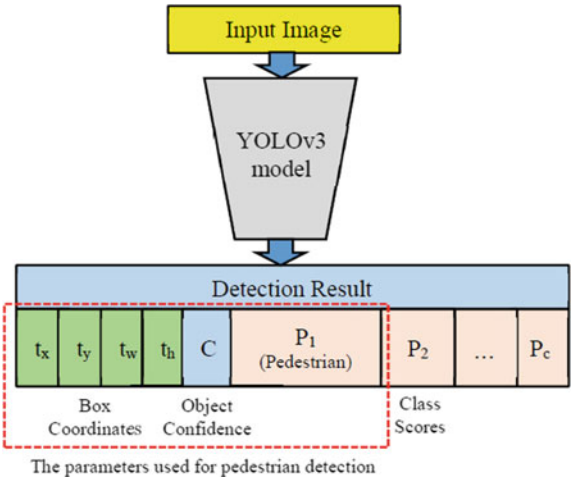


Fig. 3 Represent the architecture flow of YOLOv3 model for object detection in social distance violation

4.3 Box Co-ordinates Distance

- $d = \sqrt{(x_2 - x_1)^2} + (y_2 - y_1)^2$.

The above equation identifies the distance between two pedestrians either static or dynamic. The value is assigned or labeled with variable 'd'.

The boundary box is labeled with two distinct colors such as red for social distance violations and a green box for normal users who are far away from each other.

- $c = \begin{cases} \text{red} & d < t \\ \text{green} & d \geq t \end{cases}$

These are labeled with variable 'c' and of distance is less than the expected threshold value. Then, those persons are marked with a red color box and distanced' is greater than or equal to threshold value they marked green color box in boundary detection [15].

4.4 Box Co-ordinates Distance

The process of turning a conceptual design into a working programmer is known as implementation. Once the application has been broken down into modules, it will be programmed for deployment. Object identification and boundary classification algorithms from the UCI machine learning repository are loaded into Google Collaborator as the application's back-end database. Here, we are using Python as programming language to implement the current application. Application divided mainly into the following 5 modules. They are as follows:

- Import Necessary Libraries
- Load Dataset Module
- Data Preprocessing
- Train Model Using Yolo V3 Algorithm
- Detect Social Distance Violation.

4.5 Import Necessary Libraries

In order to begin developing model, first import essential libraries into this module. All of libraries that needed to transform data into meaningful form used this example. Because data broken down into numerical values system can recognize, we attempt to import NumPy module and CNN packages to load category data and install neural networks [16].

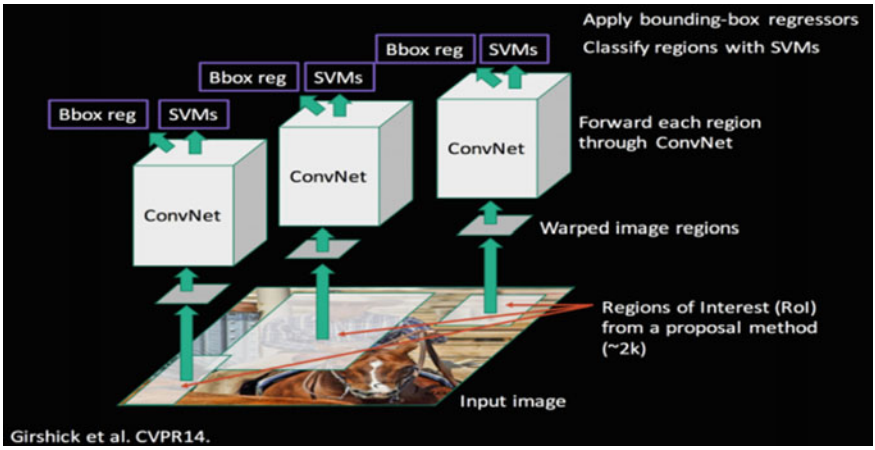


Fig. 4 Represent the architecture flow of data preprocessing

4.6 Load Dataset Module

Data obtained or gathered from UCI's repository loaded in this module. The images in the dataset have been categorized with quality levels as well as determined by the frames. The detailed dataset contains social distance samples information, spreading details, and patients' recovery data.

4.7 Data Preprocessing Module

A sample CCTV video sequence used to gather input pictures or frames for preprocessing purposes in this example. For face recognition, obtaining the face area and converting the pictures to a format suitable with the CNN architecture is part of the preprocessing step. For each CNN, the size of the input data is varied (Fig. 4).

4.8 Train the Model Using Yolo V2 Model

On supplied dataset, we attempt to train current model using CNN model before attempting to recognize or categorize items in a short video clip. When Webcam captures item, it is compared to pre-defined photos in Yolo V2 dataset and best one tried to classified.

4.9 Detect Social Distance Violation Module

In this session, we will use prerecorded footage of people strolling down the street to see how accurate our existing model is. The proposed work tries to define the distance between the multiple people who are walking on that road. The proposed model in future can be used for deploying some more applications. This same model can be deployed as a tool in future for real-time applications to detect the social distance violations.

5 Experimental Results

In order to demonstrate performance of planned application, there are attempts to install existing application in Python. To begin, we trained deep learning CNN model using dataset shown below.

In the above window shown by Fig. 5, we can see there are almost 5 pedestrians who walk on the road, and we can see our proposed model identified all the 5 are very close each other, and hence, everyone is marked red color boxes and the corresponding distance between each other marked separately beside of that sample input. In the above window, see there are almost 4 pedestrians who walk on the road, and we can see our proposed model identified that two are close to each other and two are far away from each other. Hence, our proposed model tries to mark the closely associated users with green color and far away users with red color.

From the two above graphs shown by Figs. 6 and 7, we can able to identify the training loss as well as training accuracy of input data by using YOLOv2 model.

Fig. 5 Represent the proposed system identification in red color

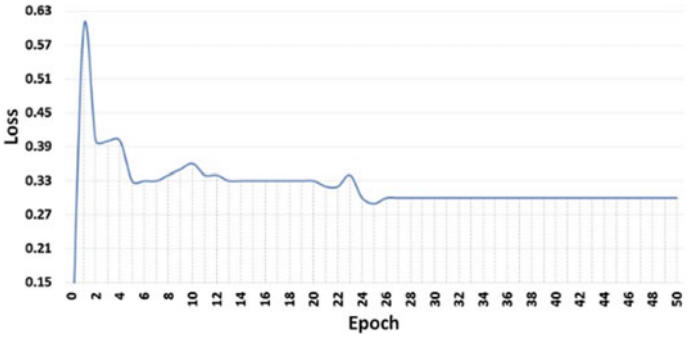


Fig. 6 Representation of training loss with overhead

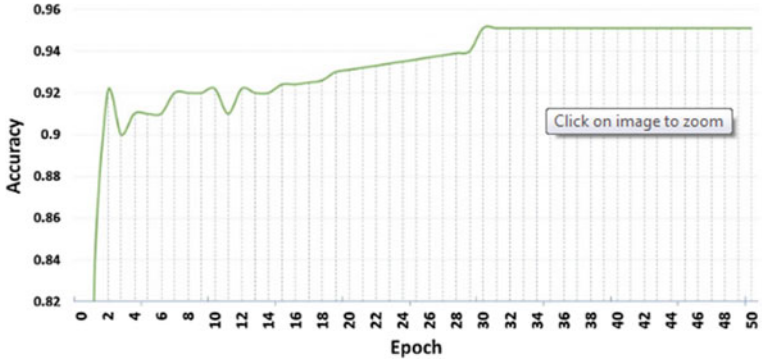


Fig. 7 Representation of training accuracy with overhead

6 Conclusion

In this research work a computer vision-based Social Distance Violation Identification model has been implemented with Deep learning technology. It is an Open CV application for future-level. monitorization with DL. It is simple to recognize and measure the distance between two or more items in a picture using CV. Tests were conducted using video as a training stimulus. To do this, we will need merely a video sequence captured by surveillance camera showing a group of people going down street. Finally, after running multiple trials on our suggested model, we have concluded that our proposed technique is highly effective in spotting social distance violations. The same model can be applied on some other working environments such as offices, schools, hospitals, and so on. In the future, implemented Social Distance Violation Identification application has to be imported into the cloud platform then it can access easily from remote areas.

References

1. Yadav, S. (2020). Deep learning based safe social distancing and face mask detection in public areas for covid-19 safety guidelines adherence. *International Journal Resource Applied Science Engineering Technology, 8*(7), 1368–1375.
2. Sharma, M. (2020). Open-CV social distancing intelligent system. In *2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN)* (pp. 972–975). IEEE.
3. Ahamad, A. H., Zaini, N., & Latip, M. F. A. (2020). Person detection for social distancing and safety violation alert based on segmented ROI. In *2020 10th IEEE international conference on control system, computing and engineering (ICCSCE)* (pp. 113–118). IEEE.
4. Hou, Y. C., Baharuddin, M. Z., Yussof, S., & Dzulkifly, S. (2020). Social distancing detection with deep learning model. In *2020 8th International Conference on Information Technology and Multimedia (ICIMU)* (pp. 334–338). IEEE.
5. Militante, S. V., & Dionisio, N. V. (2020). Deep learning implementation of facemask and physical distancing detection with alarm systems. In *2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE)* (pp. 1–5). IEEE.
6. Melenli, S., & Topkaya, A. (2020). Real-time maintaining of social distance in covid-19 environment using image processing and big data. In *The International Conference on Artificial Intelligence and Applied Mathematics in Engineering* (pp. 578–589). Cham: Springer.
7. Petrović, N., & Kocić, Đ. (2020). Iot-based system for covid-19 indoor safety monitoring. preprint). *IcETRAN, 2020*, 1–6.
8. Abdulbaqi, A. S., Obaid, A. J., & Mohammed, A. H. (2021). ECG signals recruitment to implement a new technique for medical image encryption. *Journal of Discrete Mathematical Sciences and Cryptography, 24*(6), 1663–1673. https://doi.org/10.1080/09720529.2021.1884378
9. Akila, D., et al. (2021). *Journal of Physics: Conference Series, 1963*, 012144.
10. Agarwal, P., Idrees, S. M., & Obaid, A. J. (2021). Blockchain and IoT technology in transformation of education sector. *International Journal of Online and Biomedical Engineering (iJOE), 17*(12), 4–18. https://doi.org/10.3991/ijoe.v17i12.25015
11. Punn, N. S., Sonbhadra, S. K., Agarwal, S., & Rai, G. (2020). Monitoring COVID-19 social distancing with person detection and tracking via fine-tuned YOLO v3 and Deepsort techniques. arXiv preprint arXiv:2005.01385.
12. Khandelwal, P., Khandelwal, A., Agarwal, S., Thomas, D., Xavier, N., & Raghuraman, A. (2020). Using computer vision to enhance safety of workforce in manufacturing in a post covid world. arXiv preprint arXiv:2005.05287.
13. Verma, S., & Jain, P. K. (2022). COVID-19: Automatic social distancing rule voilation detection using PP-Yolo and Tensorflow in OpenCV. In *2022 International Conference for Advancement in Technology (ICONAT)* (pp. 1–6). IEEE.
14. Vedraj, M., Kumar, M. Y., Krishna, M. H., & Gowtham, M. N. (2021). Person detection for social distancing and safety violation. *Annals of the Romanian Society for Cell Biology*, 16395–16401.
15. Balamurugan, S. S., Santhanam, S., Billa, A., Aggarwal, R., & Alluri, N. V. (2021). Model proposal for a yolo objection detection algorithm based social distancing detection system. In *2021 International Conference on Computational Intelligence and Computing Applications (ICCICA)* (pp. 1–4). IEEE.
16. Ahmed, I., Ahmad, M., & Jeon, G. (2021). Social distance monitoring framework using deep learning architecture to control infection transmission of COVID-19 pandemic. *Sustainable cities and society, 69*, 102777.

Fuzzy Net for Image Processing Applications: Image Segmentation

Huda A. Alameen, Noor Riyadh Kareem, and Sundus Q. Habeeb

Abstract Since the invention of computers, image processing methods have been utilized in a variety of applications, where their significance has grown. An important topic and the main emphasis of image processing methods are image segmentation, which is also a classic topic in the area. In order to segment images, a number of general-purpose algorithms and methods have been created. Since the image segmentation problem does not have a generic solution, these strategies frequently need to be paired with domain expertise to successfully solve an image segmentation problem for a problem domain. In this paper, we present a comparative study of basic two types of fuzzy convergence with a midpoint as image segmentation techniques.

Keywords Fuzzy set · Fuzzy point · Fuzzy topological space · Fuzzy net · Convergence of fuzzy net

1 Introduction

In 1965, Zadeh [1] invented the idea of a fuzzy set. Since then, scholars from other fields have utilized this key set. The fuzzy set has shown to be highly promising and effective in modeling human involvement in human-based intelligence to achieve modernism in various sectors like data analysis, data mining, picture coding and explanation, as well as in intelligence systems [2].

H. A. Alameen (✉) · N. R. Kareem
Department of Computer Science, Faculty of Computer Science and Mathematics, University of Kufa, Najaf, Iraq
e-mail: hudaa.alameen@uokufa.edu.iq

N. R. Kareem
e-mail: noorr.almusawi@uokufa.edu.iq

S. Q. Habeeb
Faculty of Medicine, Jabir Ibn Hayyan Medical University, Najaf, Iraq
e-mail: sundus.qahtan@jmu.edu.iq

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_56

The fuzzy set has also established itself as a legitimate area of study in both pure and practical statistics and mathematics, demonstrating this theory's broad applicability and usefulness. Despite being a hot topic for many years, fuzzy sets continue to draw academics because they offer solutions to pressing problems with particular qualities that these notions call into question.

Through cooperative problem solving, the fuzzy set may solve a variety of physical world issues that may be beyond the scope of traditional methods. This suggests that the fuzzy set would be able to handle a variety of issues, including decision-making, intelligent data analysis, information processing, pattern identification, and optimization [3, 4].

The main goal of this paper is to dive deeper into present a comparative study of basic two types of fuzzy convergence with midpoint as image segmentation techniques.

2 Image Segmentation

Image processing and pattern recognition depend basically on image segmentation. Image segmentation becomes a very important challenge in various fields such as political, medical, and others [5]. Image segmentation is playing an essential role in the medical sector because it makes it easier or automatically delineates anatomical structures and other regions of interest [6]. Image segmentation techniques play a major and important role in the investigation of political fields and can provide evidence for the trial and litigation of the case [7].

There are three classes into which the segmentation methods can be classified: (1) characteristic feature thresholding or clustering, (2) edge detection, and (3) region extraction [8–10]. The first type will be employed in this paper [11, 12].

3 Related Works

Cheng et al. [5] used a mixing of several approaches such as histogram thresholding, region-based approaches, fuzzy approaches, and edge detection methods that were applied together for color image segmentation [13].

Shi [7] discussed the notion of image processing techniques in regard to a criminal investigation, using different processes of fuzzy image technology and taking into his consideration the enhancement of the contrast ratio analyses [14].

Dass et al. [15] investigated and combined some of the image segmentation technologies. Also, a survey of several image segmentation techniques is discussed, and finally, general tendencies in image segmentation are presented [16].

Sharma and Aggarwal [17] explained the details of image segmentation techniques mostly in the situation of CT and MR images. The aim of this study to solve the

problem faced by the segmentation method of CT and MR images and explains the available limitations for medical image segmentation [18].

4 Fuzzy Concepts

Definition 4.1 Reference [1] Let $\mathfrak{U}$ be a non-empty set, then a function from a non-empty set $\mathfrak{U}$ into a closed unit interval $\mathfrak{I}$, where $\mathfrak{I} = [0, 1]$ is said to be a fuzzy set $\mathfrak{N}$ of a set $\mathfrak{U}$, , i.e., ($\mathfrak{N} : \mathfrak{U} \to \mathfrak{I}$ be a function). For all $\mathfrak{u} \in \mathfrak{U}$, $\mathfrak{N}(\mathfrak{u})$ is an interpretation of the degree of membership of element $\mathfrak{u}$ in a fuzzy set $\mathfrak{N}$.

One manner in which a fuzzy subset $\mathfrak{N}$ of $\mathfrak{U}$ can be expressed as the pairs $\mathfrak{N} = \{(\mathfrak{u}, \mathfrak{N}(\mathfrak{u}) : \mathfrak{u} \in \mathfrak{U})\}$. The symbol $\mathfrak{I}^{\mathfrak{U}}$ symbolizes to the class of all fuzzy subsets of a set $\mathfrak{U}$.

Definition 4.2 Reference [1] For any fuzzy subsets $\mathfrak{N}$ and $\mathfrak{M}$ of a set $\mathfrak{U}$, we can say that $\mathfrak{N}$ is a fuzzy subset of a fuzzy set $\mathfrak{M}$ symbolized by $\mathfrak{N} \leq \mathfrak{M}$ if and only if $\mathfrak{N}(\mathfrak{u}) \leq \mathfrak{M}(\mathfrak{u})$, for all $\mathfrak{u} \in \mathfrak{U}$.

Definition 4.3 Reference [19] A function from $\mathfrak{U}$ into the unit closed interval $\mathfrak{I}$ is said to be a fuzzy (singleton) point in $\mathfrak{U}$ which is a fuzzy subset of $\mathfrak{U}$ and symbolized by $\mathfrak{u}_{\mathfrak{r}}$. In other words, a fuzzy point in $\mathfrak{U}$ is, $\mathfrak{u}_{\mathfrak{r}} : \mathfrak{U} \to \mathfrak{I}$ be a function defined by:

$$\mathfrak{u}_{\mathfrak{r}}(\mathfrak{y}) = \begin{cases} \mathfrak{r}, & \text{if } \mathfrak{u} = \mathfrak{y} \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

The single point $\mathfrak{u}$ is said to be the support of $\mathfrak{u}_{\mathfrak{r}}$ whenever $\mathfrak{u} \in \mathfrak{U}$ and $\mathfrak{r} \in (0, 1]$ is called value of $\mathfrak{u}_{\mathfrak{r}}$. $\mathcal{FP}(\mathfrak{U})$ denoted to the class of all fuzzy points in $\mathfrak{U}$. A fuzzy point $\mathfrak{u}_{\mathfrak{r}}$ is said to be belongs to a fuzzy set $\mathfrak{N}$ or contained in a fuzzy set $\mathfrak{N}$, i.e., $\mathfrak{u}_{\mathfrak{r}} \in \mathfrak{N}$ if and only if $\mathfrak{r} \leq \mathfrak{N}(\mathfrak{u})$.

Definition 4.4 Reference [20] A set $\mathfrak{D}$ with a relation $\succcurlyeq$ is said to be a directed set and symbolized by $(\mathfrak{D}, \succcurlyeq)$, if the following conditions hold:

(1) $\mathfrak{n} \succcurlyeq \mathfrak{n}$, for each $\mathfrak{n} \in \mathfrak{D}$.
(2) For each $\mathfrak{n}_1$, $\mathfrak{n}_2$, and $\mathfrak{n}_3 \in \mathfrak{D}$, if $\mathfrak{n}_1 \succcurlyeq \mathfrak{n}_2$ and $\mathfrak{n}_2 \succcurlyeq \mathfrak{n}_3$, then $\mathfrak{n}_1 \succcurlyeq \mathfrak{n}_3$.
(3) If $\mathfrak{n}_1$ and $\mathfrak{n}_2 \in \mathfrak{D}$, then there is some $\mathfrak{n}_3 \in \mathfrak{D}$ with $\mathfrak{n}_3 \succcurlyeq \mathfrak{n}_1$ and $\mathfrak{n}_3 \succcurlyeq \mathfrak{n}_2$.

Definition 4.5 Reference [21, 22] A pair $(\mathfrak{U}, \mathfrak{T})$ is said to be fuzzy topological space on a set $\mathfrak{U}$ (in short fts), and defined as a family $\mathfrak{T}$ of fuzzy subsets of $\mathfrak{U}$, which is satisfies the following conditions:

(1) $0_{\mathfrak{U}}, 1_{\mathfrak{U}} \in \mathfrak{T}$.
(2) If $\mathfrak{N}, \mathfrak{M} \in \mathfrak{T}$, then $\mathfrak{N} \wedge \mathfrak{M} \in \mathfrak{T}$.
(3) If $\mathfrak{N}_{\mathfrak{j}} \in \mathfrak{T}$ for each $\mathfrak{j} \in \mathfrak{L}$, then $V_{\mathfrak{j} \in \mathfrak{L}} \mathfrak{N}_{\mathfrak{j}} \in \mathfrak{T}$.

$\mathfrak{T}$ is said to be a fuzzy topology for $\mathfrak{U}$ and $\mathfrak{U}$ is called a fuzzy space.

Definition 4.6 Reference [23] A fuzzy net of a set $\mathfrak{U}$ is denoted by $\{\mathfrak{S}(\mathfrak{n}) : \mathfrak{n} \in \mathfrak{Q}\}$ and defined as the function $\mathfrak{F} : \mathfrak{Q} \to \mathcal{FP}(\mathfrak{U})$, where $\mathfrak{Q}$ is a directed set. If $\mathfrak{S}(\mathfrak{n}) = \mathfrak{u}^{\mathfrak{n}}_{\mathfrak{r}\mathfrak{n}}$ for each $\mathfrak{n} \in \mathfrak{Q}$, whenever $\mathfrak{u} \in \mathfrak{U}$, $\mathfrak{n} \in \mathfrak{Q}$ and $\mathfrak{r}_{\mathfrak{n}} \in (0, 1]$, then the fuzzy net $\mathfrak{F}$ is symbolized by $\left\{\mathfrak{u}^{\mathfrak{n}}_{\mathfrak{r}\mathfrak{n}} : \mathfrak{n} \in \mathfrak{Q}\right\}$ or simply $\left\{\mathfrak{u}^{\mathfrak{n}}_{\mathfrak{r}\mathfrak{n}}\right\}$.

Definition 4.7 Reference [23] If $\mathfrak{F} = \left\{\mathfrak{u}^{\mathfrak{n}}_{\mathfrak{r}\mathfrak{n}} : \mathfrak{n} \in \mathfrak{D}\right\}$ is a fuzzy net in $\mathfrak{U}$, and let $(\mathfrak{U}, \mathfrak{T})$ be an fts. Then $\mathfrak{F}$ is said to be:

(1) Eventually with a fuzzy subset $\mathfrak{N}$ of $\mathfrak{U}$ if and only if $\exists \mathfrak{m} \in \mathfrak{Q}$, such that $\forall \mathfrak{n} \in \mathfrak{Q}$ and $\mathfrak{n} \geq \mathfrak{m}$, $\mathfrak{u}^{\mathfrak{n}}_{\mathfrak{r}\mathfrak{n}} \leq \mathfrak{N}$.
(2) Frequently with a fuzzy subset $\mathfrak{N}$ of $\mathfrak{U}$ if and only if $\forall \mathfrak{m} \in \mathfrak{Q}$, $\exists \mathfrak{n} \in \mathfrak{Q}$, with $\mathfrak{n} \geq \mathfrak{m}$, such that $\mathfrak{u}^{\mathfrak{n}}_{\mathfrak{r}\mathfrak{n}} \leq \mathfrak{N}$.

5 Proposed Segmentation Methodology

The steps algorithm for using convergence of fuzzy nets is given as follows:

Algorithm 1 Algorithm for eventually convergence

Step 1: Read an image and converting it within the closed unit interval [0, 1].
Step 2: Choose a midpoint in the matrix with the smallest image value.
Step 3: Calculate the convergence of the image for each point after midpoint of the image.
Step 4: Print image.
Step 5: Apply performance criteria to determine the best method such as mean and peak signal-to-noise ratio.

Algorithm 2 Algorithm for frequently convergence

Step 1: Read an image and converting it within the closed unit interval [0, 1].
Step 2: Choose a random midpoint in the matrix.
Step 3: Calculate the convergence of the image for each point after midpoint of the image, the stop else go to step 2.
Step 4: Print image.
Step 5: Apply performance criteria to determine the best method such as mean and peak signal-to-noise ratio.

6 Results and Discussion

Reading the color images and converting them within the closed period [0, 1] and then applying the Algorithms 1 and 2, respectively (Figs. 1, 2 and 3; Table 1).

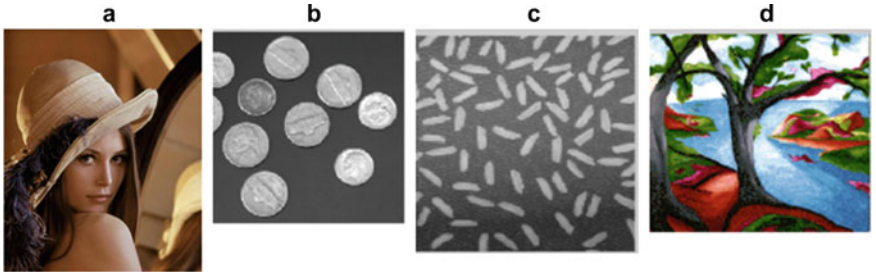


Fig. 1 Sample of different types of images, **a** and **d**: Color images, **b** and **c**: Grayscale images

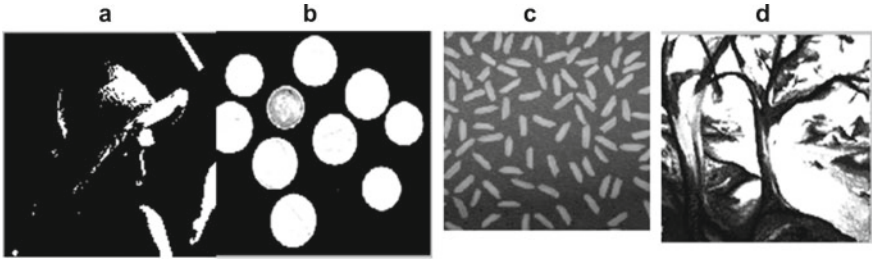


Fig. 2 Applying Algorithm 1 on samples images

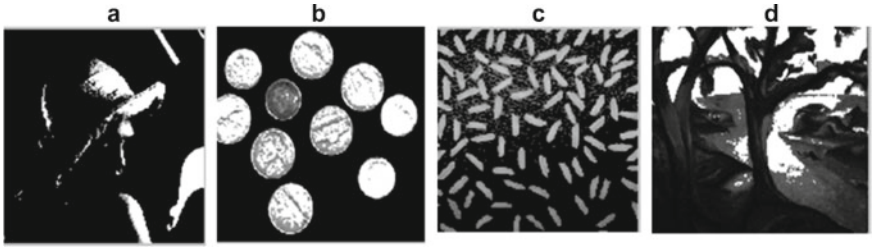


Fig. 3 Applying Algorithm 2 on samples images

Table 1 Statistical features (mean and peak signal-to-noise ratio)

Images	Statistical features			
	First algorithm		Second algorithm	
	Mean	Peak signal-to-noise ratio	Mean	Peak signal-to-noise ratio
ImageA	0.0742	0.0742	0.0626	20.0275
ImageB	0.2249	12.7513	0.1566	16.73
imagesC	0.4360	11.3952	0.2356	15.374
ImageD	0.1923	17.5294	0.0863	22.55

7 Conclusion

In this paper, we used the basic two types of fuzzy convergence with midpoints to segment images into two regions. The light region represents the convergence points, but the dark regions represent the points that do not achieve convergence. Our two algorithms can be applied to any type of image (color, indexes, grayscale, and others) and any format.

According to the above results and when applying the mean on the resulting images, we conclude that the values of grayscale images are highest than the values of color images as well as the values of grayscale images when used the second algorithm highest than the values of those images when applying the first algorithms.

As well as when applying the peak-to-signal noise ratio on images, the results show that the color images have the highest values of noise.

In general, the results showed that using the frequent convergence algorithm achieved better results in image segmentation than the eventual convergence algorithm.

Acknowledgements The researchers thankfully acknowledge the reviewers for the beneficial comments.

References

1. Zadeh, L. A. (1965). Fuzzy sets. *Information Control, 8*, 338–353.
2. Vo, M. T., Vo, A. H., Nguyen, T., Sharma, R., & Le, T. (2021). Dealing with the class imbalance problem in the detection of fake job descriptions. *Computers, Materials and Continua, 68*(1), 521–535.
3. Sachan, S., Sharma, R., & Sehgal, A. (2021). Energy efficient scheme for better connectivity in sustainable mobile wireless sensor networks. *Sustainable Computing: Informatics and Systems, 30*, 100504.
4. Priyadarshini, I., Kumar, R., Tuan, L. M. et al. (2021). A new enhanced cyber security framework for medical cyber physical systems. *SICS Software-Intensive Cyber-Physics System*. https://doi.org/10.1007/s00450-021-00427-3
5. Cheng, H.-D., et al. (2001). Color image segmentation: Advances and prospects. *Pattern Recognition, 34*(12), 2259–2281.
6. Pham, D. L., Xu, C., & Prince, J. L. (2000). A survey of current methods in medical image segmentation. *Annual Review of Biomedical Engineering, 2*(3), 315–337.
7. Shi, W. (2017). The application of image processing in the criminal investigation. In *2016 4th International Conference on Machinery, Materials and Information Technology Applications*. Atlantis Press.
8. Fu, K.-S., & Mui, J. K. (1981). A survey on image segmentation. *Pattern Recognition, 13*(1), 3–16.
9. Al-Asadi, T. A., & Obaid, A. J. (2016). Object-based image retrieval using enhanced SURF. *Asian Journal of Information Technology*, *15*: 2756–2762. https://doi.org/10.36478/ajit.2016.2756.2762
10. Alasadi, T. A., & Obaid, A. J. (2016). Object detection and recognition by using enhanced speeded up robust feature. *International Journal of Computer Science and Network Security (IJCSNS), 16*(4), 66–71.

11. Ghanem, S., Kanungo, P., Panda, G., et al. (2021). Lane detection under artificial colored light in tunnels and on highways: An IoT-based framework for smart city infrastructure. *Complex Intelligent System*. https://doi.org/10.1007/s40747-021-00381-2
12. Priyadarshini, I., Kumar, R., Sharma, R., Singh, P. K., & Satapathy, S. C. (2021). Identifying cyber insecurities in trustworthy space and energy sector for smart grids. *Computers and Electrical Engineering, 93*, 107204.
13. Sahu, L., Sharma, R., Sahu, I., Das, M., Sahu, B., & Kumar, R. (2021). Efficient detection of Parkinson's disease using deep learning techniques over medical data. *Expert Systems*, e12787. https://doi.org/10.1111/exsy.12787
14. Sachan, S., Sharma, R., & Sehgal, A. (2021). SINR based energy optimization schemes for 5G vehicular sensor networks. *Wireless Personal Communications*. https://doi.org/10.1007/s11277-021-08561-6
15. Dass, R., & Devi, S. (2012). Image segmentation techniques 1.
16. Azad, C., Bhushan, B., Sharma, R., et al. (2021). Prediction model using SMOTE, genetic algorithm and decision tree (PMSGD) for classification of diabetes mellitus. *Multimedia Systems*. https://doi.org/10.1007/s00530-021-00817-2
17. Sharma, N., & Aggarwal, L. M. (2010). Automated medical image segmentation techniques. *Journal of Medical Physics/Association of Medical Physicists of India, 35*(1), 3.
18. Priyadarshini, I., Mohanty, P., Kumar, R., et al. (2021). A study on the sentiments and psychology of twitter users during COVID-19 lockdown period. *Multimed Tools Appl*. https://doi.org/10.1007/s11042-021-11004-w
19. Wong, C. K. (1974). Fuzzy points and local properties of fuzzy topology. *Journal of Mathematical Analysis and Applications, 46*(2), 316–328.
20. Pao-Ming, P., & Liu, Y.-M. (1980). Fuzzy topology I Neighborhood structure of a fuzzy point and Moore-Smith convergence. *Journal of Mathematical Analysis and Applications, 76*(2), 571–599.
21. Chang, C. L. (1968). Fuzzy topological spaces. *Journal of Mathematical Analysis and Applications, 24*(1), 182–190.
22. Singh, R., Sharma, R., Akram, S. V., Gehlot, A., Buddhi, D., Malik, P. K., & Arya, R. (2021). Highway 4.0: Digitalization of highways for vulnerable road safety development with intelligent IoT sensors and machine learning. *Safety Science, 143*, 105407. ISSN 0925-7535.
23. Nouh, A. A. (2005). On convergence theory in fuzzy topological spaces and its applications. *Czechoslovak Mathematical Journal, 55*(2), 295–316.

A Reliable Transmission and Extraction of Textual Information Using Keyless Encryption, Steganography, and Deep Algorithm with Cuckoo Optimization

Binay Kumar Pandey, Digvijay Pandey, Mohammed Ayad Alkhafaji, Muhammet Tahir Güneşer, and Cihat Şeker

Abstract The entire work postulates a fusion of an innovative keyless image encoding approach based on a chaotic map and steganography. Nearly every single picture element has been encrypted by rearranging pixel values that are then assessed by such an adapted cat map as well as steganography has been used in the suggested methodology to transmit keyless encoded textual information utilizing a cover image, with encoded textual image information inserted into cover images. But on the other hand, retrieving textual images embedded in the receiver has indeed been regarded as the most challenging process. Furthermore, a sender will indeed transfer reasoning rather than a key to the recipient, ignoring the fact that acquiring engrained textual information hidden inside the cover image to enhance efficiency would have been challenging. Steganography was easily accomplished by placing data bits of secret textual image information into the cover image's least significant bit of picture elements. The image quality, on the other hand, suffers greatly from the inclusion of an encrypted message. Images could indeed cause some disturbances from time to time. As a consequence, non-smooth areas of the image have been regarded as smooth. Therefore, the weighted Naive Bayes algorithm (NBA) method is being used in the illustration to retrieve the appropriate textual image information from complicated deteriorated images. Normally, images comprise a small amount of noise, so

B. K. Pandey (✉)
Department of Information Technology, College of Technology, Govind Ballabh Pant University of Agriculture and Technology Pantnagar, Pantnagar, Uttarakhand, India
e-mail: binaydece@gmail.com

D. Pandey
Department of Technical Education, IET, Dr. A.P.J. Abdul Kalam Technical University, Lucknow, Uttar Pradesh, India

M. A. Alkhafaji
National University of Science and Technology, Dhi Qar, Iraq
e-mail: mohammed.alkhafaji@nust.edu.iq

M. T. Güneşer · C. Şeker
Karabuk University, Karabuk, Turkey
e-mail: mtguneser@karabuk.edu.tr

C. Şeker
e-mail: cihatseker@karabuk.edu.tr

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_57

the introduction of the guided filter (GF) during the initial preprocessing phase is required. A very important feature in the textual image information extraction procedure was obtained utilizing a variety of techniques, including Gabor transform (GT), weighted Naive Bayes algorithms (WNBA), and a high-quality learning procedure for standard procedure. Eventually, textual content identification and recognition are performed using a combination of DNN and cuckoo algorithms. Again, for the proposed system, the set of data IIIT5K is being used, as well as high performance has been gained with parameters such as mean square error and peak signal-to-noise ratio.

Keywords Keyless encryption · Hybrid convolution neural network · Security · Steganography · Data transmission

1 Introduction

The World Wide Web is now the center of the universe. The Internet redefined this concept as data transmission from one person to another. The Internet will have a huge impact on people all over the world. Chronology, space, and distance would have all changed. Data is now easily accessible at all times and virtually anywhere. People nowadays are technologically sophisticated, as evidenced by the internet and smartphones. The World Wide Web, awash in new technology, has been steadily rising. Documents, like digital photos, can now be easily shared via the Internet. While cipher information is frequently used to provide security, textual content consumes a large portion of possible cryptography computation. Data protection, along with storage capacity, has become an increasingly important issue in image transmission as multimedia content grows. So, to protect images, "cryptographic algorithms" are used. This one will use cryptographic techniques to transform a difficult to understand image into another image, allowing multiple people to share the image secrets. Two steps are suggested in terms of spatial integration. As such, keyless based on chaos encryption is used to construct encrypted textual information by applying suitable logical operations in a manner that prevents data from being deciphered by an invader. This can be used to encode data from various sources. These tactics can be symmetrical or asymmetrical. The same reasoning methods are used for encryption and decryption in symmetrical keyless techniques. The asymmetrical keyless method's sender and receiver encode and decode data differently. The secret data is first encoded using a revolutionary keyless image encryption method, then embedded in a cover image and transmitted. A hybrid convolution integrated network with cuckoo optimization is used to identify [1] the character from textual images, and then the cipher text is recovered just at the receiver end using reverse steganography.

2 Literature Review

Many approaches to cryptography and steganography have been presented in various carrier media. These techniques use keyless chaos [2] driven encryption and steganography to hide encrypted textual information in a cover image. According to, this new method encodes images by rearranging pixels in plaintext. The diffusing key was created by scrambling the image pixels using a cat map and Lorenz system. The hash function value of a plaintext message is used as a permutations key, determined by cat map's control factors. Unstable images are generated by hashing. The proposed mechanism achieves good diffusing characteristics in one or two rotations, whereas the conventional method required two or more rotations. The new approach satisfies all security screening requirements and is more accurate. Reference [3] describes the entire study, which examines several computational strategies for reducing visual distortion and improving advanced degraded image equalization. The complex deteriorating imagery included impulse interference, Brownian Noise (Fractal Noise), Rayleigh Noise, Gamma Noise, and Structured Noise [4]. This research will examine recent extraction methods and denoise complex deteriorated images. Many filters have been used to repair damaged photos. Two-stage approach is suggested to convert binary digits to a grayscale. The main goal of cyber security is to protect sensitive data. Using the suggested technique, a pattern [5, 6] was first subdivided into more equal subsequences. To scramble the binary bits, one logistic matrix was used per series. The second phase divides scrambled patterns into smaller areas that are then implanted into the appropriate pixels within the grayscale images. An area of a gray current value pixel has been rearranged using the least significant bits. The results show that the proposed technique can safely implant data into a gray image without significantly altering its content, allowing for secure image-based data concealment. According to, cryptography is the primary method for data security, while image steganography is used in some cases. Obfuscation techniques are a scientific method of preventing the detection of secret two-way communication. This causes statistically significant changes in the cover carrier's qualities, especially as the textual payload increases. We present a revolutionary transformation domain JPEG steganographic technique that improves implantation performance while requiring minimal cover image changes. Modulus 3 difference between two DCT coefficients is used to combine 2 bits of a dense shape concealed code. They discuss steganography using generative adversarial networks (GANs) based on cover alteration, cover choice, and cover synthesizing. They describe three GAN-based obfuscation techniques and evaluate them. On analyzed and summarized several existing image obfuscations with GAN issues, this [6] proposed a novel cost-assigning method based on the picture palette and interface correlations of dynamic GIF images. They also provide payload allocation for various blocks. They first reorganize the GIF palette to minimize changes in picture element values when the indexes change. Because index changes affect picture element values differently, the items with the least impact on image pixels should have the lowest insertion charges. Minor embedded costs are assigned to items where inter-frame variations are significant. During implantation,

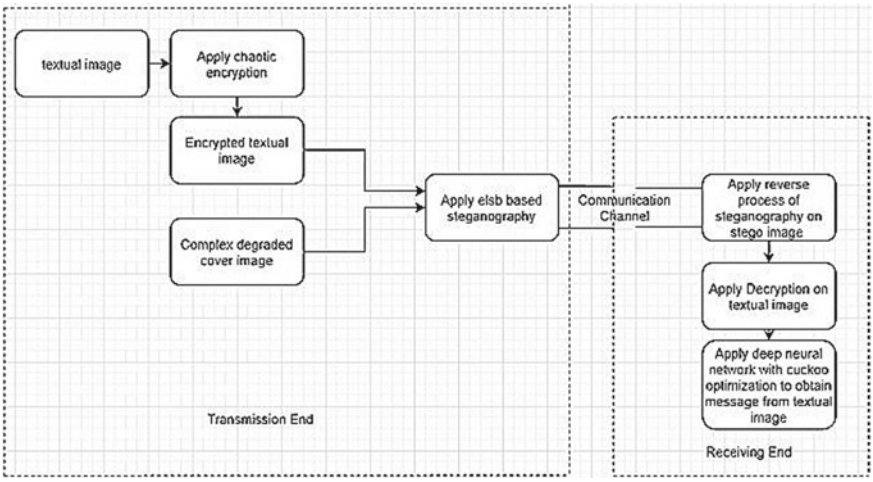


Fig. 1 Suggested methodology used

the picture element values are transformed. This approach's effectiveness is evaluated statistically and subjectively using a variety of input data. The results show that the proposed method ensures undetectable aberrations at the lowest computing cost in terms of PSNR factor.

3 Methodology Used

An image transmission mechanism was created, as shown in Fig. 1. Initially, the image's element intensities and location were changed. Since then, the encoded images have been sent over the Internet as stegoimages.

To protect text information from cover images, the suggested approaches did the following: Then used obfuscation techniques, deep learning, and cuckoo optimization to decrypt textual images.

4 Results and Analysis

The suggested image encryption and steganography based method's effectiveness is measured by PSNR and MSE (MSE). Corrupted disturbances affecting visual representational consistency seem to have a peak signal-to-noise ratio. Even when the PSNR is low, one reconstruction may appear more genuine than another. Better reconstructive performance is associated with higher PSNR (Dey et al., 2011). The peak signal-to-noise ratio was calculated using the mean square error for two-dimensional

$m * n$ monochromatic images I and K.

$$\mathrm{MSE} = \frac{1}{\mathrm{MN}} \sum_{y=1}^{M} \sum_{x=1}^{N} \left[I(x, y) - I^{'}(x, y) \right]^2 \tag{1}$$

where one of the images is well thought out as a noisy image of the other original image.

Equation (1) is used to calculate the peak signal-to-noise ratio as shown in Eq. 2:

$$\mathrm{PSNR} = 10 \log_{10} \left(\frac{\mathrm{MAX}}{\sqrt{\mathrm{MSE}}} \right)_{\mathrm{db}} \tag{2}$$

MAX appears to be the image's maximum element value. The MAX value for pixels with eight bits per sample is 255. This is a great way to test the decryption process's efficiency. The peak signal-to-noise ratio of an image is the proportion of an MSE of an element for two images to a maximum mean square difference between images. The better the image quality, the higher the peak signal-to-noise value. A general-purpose dataset was used to run a set of tests on the suggested technique. Figure 2 shows a few images from the dataset.

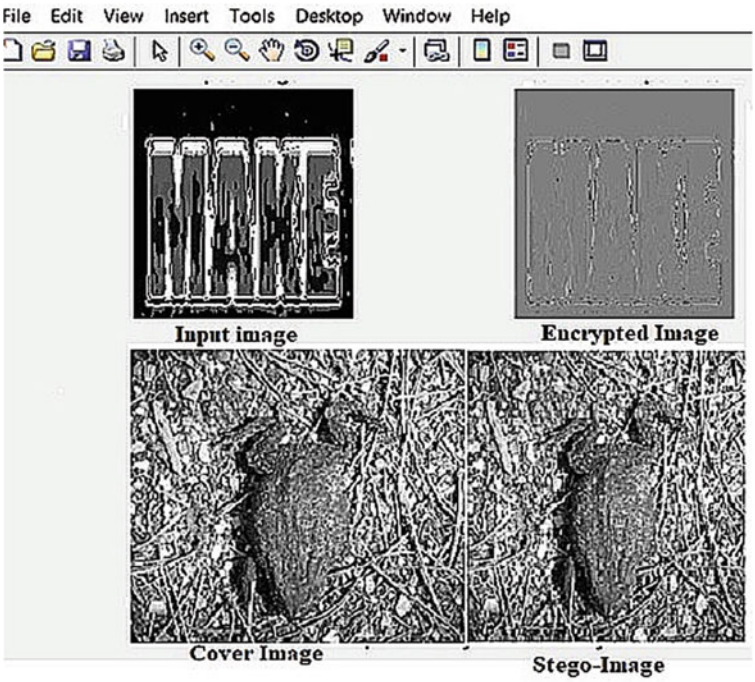


Fig. 2 Processing of proposed method on image dataset

Table 1 gives the suggested methodology's PSNR and MSE estimates for various images. The MSE between the actual and decoded images was found to be just 0.086, while the PSNR was found to be 94.9282, indicating near recovery. A high peak signal-to-noise ratio of a stegoimage represented difficulties in obtaining the actual image without understanding a suggested technique, and a low mean square error between the actual image and the stegoimage represented similarity between the two. Unauthorized people could also distinguish between the stegoimage and the actual images (Fig. 3).

Table 1 PSNR and MSE measurements for multiple images

Images	Measurement of MSE for the suggested method	Measurements of PSNR for the suggested method in the decibel
Image1	0.0741	89.96
Image2	0.0880	90.89
Image3	0.0888	92.75
Image4	0.0887	91.99
Image5	0.0892	93.76
Image6	0.0893	93.89
Image7	0.0954	93.99
Image8	0.0949	94.93
Image9	0.9578	95.22
Image10	0.0972	95.10

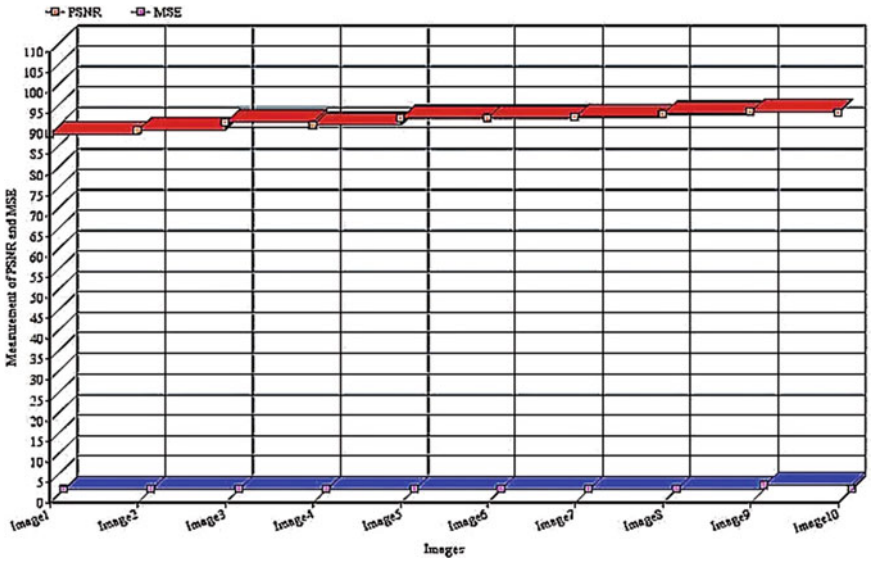


Fig. 3 PSNR and MSE estimates for several images were computed

5 Discussion and Conclusion

In today's world, where most important communications are wireless and rely on the network infrastructure to transfer data, the biggest concerns seem to be the security of personal or national security data. Hence, chaotic encryption improved LSB steganography, a deep learning-based weighted Naive Bayes classifier, and cuckoo optimization which are used to secure textual image data transfer, retrieval, and recognition on a global computer network. On a public web data transfer channel, chaotic encryption, obfuscation, and deep learning were used in three stages to protect data communication. The protected data is first encoded using a chaotic-based picture cryptosystem and then embedded within the cover image using an upgraded LSB steganography process. The receiver uses an information retrieval algorithm to recover the content, and the inserted text is detected using a weighted naive Bayes classifier. Moreover, cuckoo optimization can improve a weighted classification algorithm's efficiency. Due to the high peak signal-to-noise ratio of the suggested technique, reconstructing the actual image is difficult.

References

1. Pandey, D., Pandey, B. K., et al. (2020). Analysis of text detection, extraction and recognition from complex degraded images and videos. *Journal of Critical Reviews, 7*(18), 427–433.
2. Chong, F., Bian, O., Jiang, H.-Y., Ge, L-H., & M, H.-F. (2016). *A New Chaos-Based Image Cipher Using a Hash Function IEEE/ACIS 15th International Conference on Computer and Information Science(ICIS).*
3. Pandey, D., Pandey, B. K., & Wariya, S. (2020). An approach to text extraction from complex degraded scene. *IJCBS, 1*(2), 4–10.
4. Pandey, D., Pandey, B. K., & Wariya, S. (2019). Study of various types noise and text extraction algorithms for degraded complex image. *Journal of Emerging Technologies and Innovative Research, 6*(6), 234–247.
5. Pandey, B. K., Pandey, D., & Pandey, S. (2011). Survey of bioinformatics applications on parallel architectures. *International Journal of Computer Applications, 23*(4), 21–25.
6. Obaid, A. J., Chatterjee, T., & Bhattacharya, A. (2020). Semantic web and web page clustering algorithms: A landscape view. *EAI Endorsed Transactions on Energy Web*, 8(33).
7. Kumar Pandey, B., Pandey, D., Nassa, V. K., Ahmad, T., Singh, C., George, A. S., & Wakchaure, M. A. (2022). Encryption and steganography-based text extraction in IoT using the EWCTS optimizer. *The Imaging Science Journal,* 1–19.
8. Pandey, B. K., Pandey, D., Wairya, S., Agarwal, G., Dadeech, P., Dogiwal, S. R., & Pramanik, S. (2022). Application of integrated steganography and image compressing techniques for confidential information transmission. *Cyber Security and Network Security,* 169–191.
9. Pandey, B. K., Pandey, D., & Agarwal, A. (2022). Encrypted information transmission by enhanced steganography and image transformation. *International Journal of Distributed Artificial Intelligence (IJDAI), 14*(1), 1–14.

10. Pandey, B. K., Pandey, D., Gupta, A., Nassa, V. K., Dadheech, P., & George, A. S. (2023). Secret data transmission using advanced morphological component analysis and steganography. In Role of Data-Intensive Distributed Computing Systems in Designing Data Solutions (pp. 21–44). Cham: Springer International Publishing.
11. Pandey, D., & Pandey, B. K. (2022). An efficient deep neural network with adaptive galactic swarm optimization for complex image text extraction. In Process Mining Techniques for Pattern Recognition (pp. 121–137). CRC Press.

Smart Autonomous Breaking System for Vehicles to Improve Road Safety in India

Praveen Kumar Malik, Abdul Rahim, and Dac-Nhuong Le

Abstract This paper provides the smart autonomous breaking system for vehicles, especially on Indian roads. Major transportation in India is done through road ways, and the major concern is the safety of the vehicles as well as the human life. The automobile industry is evolving with various ideas and technologies to prevent the accidents yet a lot of various techniques can be added for the safety concern in India. The idea in this paper is to implement an autonomous breaking/directing system which can detect the vehicles/objects approaching and to provide breaking or to change the direction depending on the situation and to avoid the road accidents.

Keywords Autonomous vehicles · Breaking system · Doppler shift · CRF Fusion algorithm

1 Introduction

In India, the major concern on roads is to avoid accidents, and according to the survey report, number of accident occur on highways in India is around 3.5% of the total incidents occur, and every year the count is compounded [1]. Safety measures are improved year by year, but still the accident rate is not declined. Autonomous industry is working hard towards the safety of the vehicles, and so many precautionary measures were devolved with the help of the technology. One of the predominant idea is to introduce vehicular communications on to the vehicles [2]. The main objective of the vehicular communications is to ensure road safety, reduce fuel consumption

P. K. Malik
Lovely Professional University, Punjab, India

A. Rahim (✉)
Malla Reddy Engineering College for Women, Hyderabed, India
e-mail: rahim.mrecw@gmail.com

D.-N. Le
Haiphong University, Haiphong, Vietnam
e-mail: nhuongld@dhhp.edu.vn

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_58

and to avoid road accidents [3]. To provide the necessary objectives, the information is needed to transfer between the vehicles. Vehicular communication uses various technologies such as long-term evaluation (LTE), dedicated short-range communications (DSRCs) and cellular communication such as 3G and 4G. The communication is referred as vehicle to everything communications which includes vehicle to vehicle, vehicle to infrastructure, vehicle to road side unit and vehicle to pedestrian communications[4]. The communication between the vehicles can be either one to one communication or multi-hop communication. At present, worldwide research is carried out under vehicular communications with the help of milli-metre wave communication and 5G wireless technology [5]. The mentioned modes are carried out using 4th generation technology in addition to dedicated short-range communication (DSRC), Long-term Evolution 2600, wireless local area network, Wi-max, wireless access under vehicular environments and Bluetooth as shown in Table 1.

2 Related Work

In this section, we present various existing technologies or the research carried out either for autonomous vehicles or for the communication established under vehicular communication for the safety on roads. Reference [6] provides intelligent breaking system while the vehicle is taking an incline on the highway, where there is a possibility of vehicle moving backward while shifting the leg from break to clutch under manual transmission. The intelligent breaking system detects the incline and automatically adjusts the breaking system when the transition takes place and avoids the reverse movement in the vehicle. This technology provides safety of the vehicle as well as the vehicle which is behind it [7].

Reference [8] provides a possible solution for the small vehicles to overtake a cargo or slow-moving heavy vehicles under narrow road configuration. It is very difficult to overtake, especially in nights on the narrow roads, with a fear of colliding with the opposite flow of vehicles. The author provides an intelligent communication unit which can directly communicate with the vehicle in front in order to overtake or not [9]. This technology provides safety of the vehicle while overtaking under narrow roads configuration which is highly recommended, especially for Indian roads.

Reference [10] provides a possible solution for identifying vehicles at the blind spot which is not visible with the side mirrors. For vehicles with the help of side mirrors, the driver can identify the vehicles which are behind, but it is near to impossible to detect the vehicle which is beside it, and it is very dangerous, especially on highways. The electronic unit consisting of sensors which detects the vehicle in blind spots and informs the driver regarding the situation, which in turn provides the safety of both vehicles. Reference [11] provides milli-metre technology-based transmission system where the frequency of operation is 8 to 12 GHz for feasibility and effectiveness evaluation for vehicles on road and highways. For fast and accurate handovers and for better quality of service, two-step timing advance approach is followed [12].

Table 1 Radio access technologies for vehicular communications [1]

S.No.	Features	DSRC	Wi-Fi	VLC	LTE	LTE-A	5G envisage
1	Standard	IEEE802.1 1p	IEEE802.1 1	IEEE802.15 0.7	3GPPRel-10/11/12	3GPPRe l- 10/11/12	3GPPRel −15/16
2	Frequency (bands)	5.86–5.92	2.4, 5.2 GHz	380-800THz	700–2690 MHz	450 MHz–4.99 GHz	700 MHz–100 GHz
3	Channel width	10 MHz	20 MHz	Not Applicable	1.4, 3, 5, 10, 15, 20 MHz	Up to 100 MHz –	Not applicable
4	Bit-rate	3–27 Mbps	6–54 Mbps	11.67 kilo bits to 96Mbps	Up to 300 Mbps	Up to 1 Gbps	Up to 20 Gbps
5	Transfer capacity	Up to 1 km	100–500 m	< 100 m	10 m to 30 km	10 m to 30 km	Ubiquito us
6	Mobility support	Up to 60 km	Low	Low	350 km/h	350 km/ h	Up to 500 km/h
7	Support for V2V	Yes Ad-hoc	Yes, Ad-hoc	Yes	No	Yes: D2D	Yes
8	Support for V2I	Yes	Yes	Yes	Yes	Yes	Yes
9	Distribution	RSU	Hot spot, access point	Available roadside LED's	Modes	Available modes B	NSA and SA mode

Reference [13] provides NOMA schemes, "to reduce latency rates and also to achieve high data rates optimal scheduled algorithm and priority assignment schemes are initiated. This proposal provided better improvements in terms of performance analysis parameters like reducing bit error rates and improved signal to noise interference ratio which enhances the quality of service."

These are few existing technologies which provide better safety and security of the vehicles under the vehicular communication, and lot of research is carried out worldwide to provide more-safer and comfort transportation yet always there is a negligence of human involvement in majority of accidents.

3 Proposed Idea

One of the major threat on the highways is the heavy vehicles parked on the roads, and the highway road authority has described the threat as life threatening, and a survey states that 15% of accidents is due to vehicles parked and moving vehicle collides with it, and 99% death rate is registered under these category of accidents [14].

The main objective is to provide an autonomous breaking system which detects the objects nearby and automatically applies the brakes in order to avoid the accidents. The idea is to instal automotive graded camera on the front side of the vehicle, which captures the images and process in order to detect the object/vehicle on the path. A radar unit is mounted which by using Doppler shit technique measures the distance between the object and the vehicle, and it also detects if the object/vehicle is approaching or at a halt situation [15]. If the object is approaching, then the distance is calculated with the speed at which the vehicle is travelling, and then, automatically, the braking system gets accessed.

The proposed idea is designed under these three test cases, and in the first case, the object/vehicle is approaching. Consider that the vehicle is at stationary and a moving vehicle is heading towards it, and there is a possibility of an accident. The first step is the vehicle draws a pre-defined perimeter around it, detects the object approaching and calculates the distance and speed of approach and automatically get started and moves towards the direction in which it can avoid the accident as shown in Fig. 1.

In the second case, the vehicle under test is heading towards a stationary vehicle/object which commonly happens on highways, and in the first step, a pre-defined perimeter is drawn around the vehicle, and if the vehicle is moving towards a stationary object, the autonomous vehicle system gets active and precautionary measures such as applying breaks or moving to safer directions depending on the speed of the vehicle and distance as shown in Fig. 2.

In the third case, both the autonomous vehicle and the object/vehicle are in motion as shown in Fig. 3. In this scenario, an object enters the pre-defined perimeter of the autonomous vehicle; the camera fixed on the autonomous vehicle will take the pictures and send them to the image processing unit. The radar unit of the autonomous

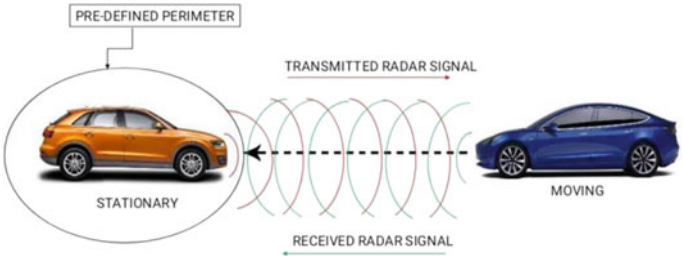


Fig. 1 Moving vehicle heading towards stationary autonomous vehicle

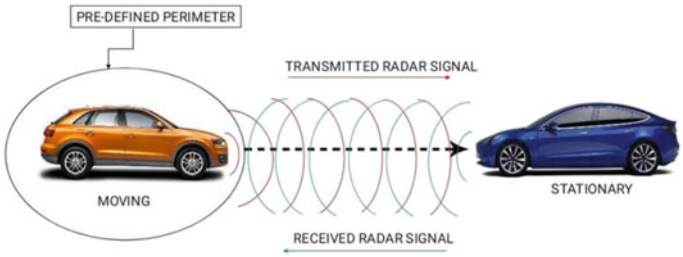


Fig. 2 Autonomous vehicle moving towards stationary vehicle/object

vehicle will calculate the exact distance from the moving object. With the help of the Doppler shift mechanism, if any rapid change in the moving object is detected, the braking system is accessed. Based on the time difference between the transmitted radar signal and the received radar signal and the speed of the objects, the distance between the two objects is measured. CRF fusion algorithms are used with the help of Python programming language to understand the scenario and to present the best approach to avoid the road accidents.

To instal the camera on the autonomous vehicle, AUTO-VOX camera with a resolution of full HD 1080P, with a front view range of 165° and rear view of 170°, can be mounted along with Honeywell IntuVue RDR-84 K Band Radar System. The algorithm can be implemented using Python programming with search algorithms

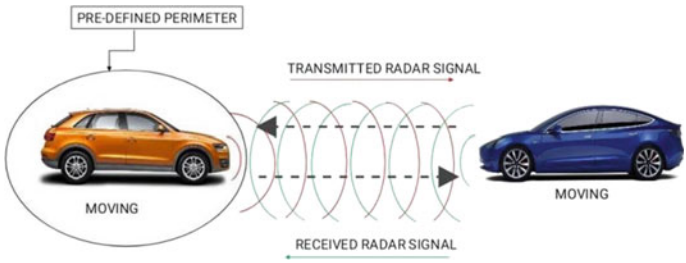


Fig. 3 Autonomous vehicle and object/vehicle are heading towards each other

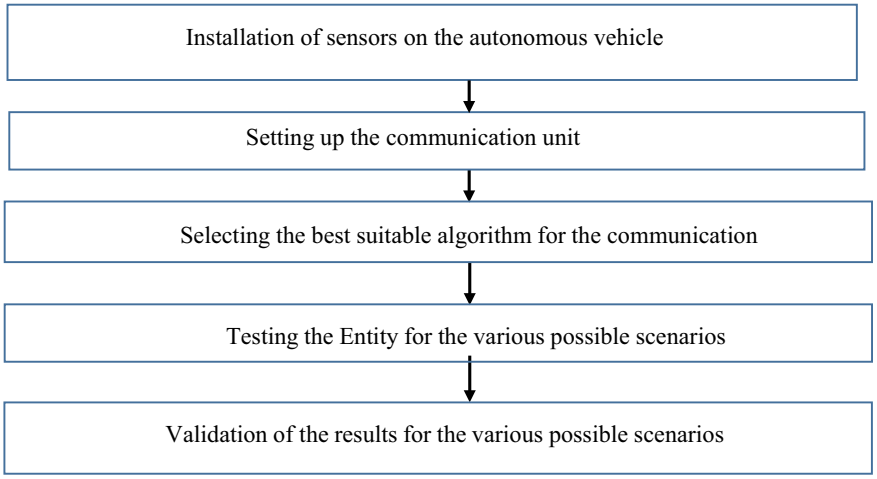


Fig. 4 Implementation flowchart of the idea

which can provide pre-define instructions depending on the test conditions provided. The implementation can be carried out as shown in Fig. 4 which is a flowchart of the idea.

4 Conclusion

This paper provides an idea to avoid accidents on Indian roads with the help of smart autonomous breaking system. Three scenarios are discussed in this paper which can be implemented for the safe journey on the roads with the help of camera and radar system. CRF fusion algorithm can be used to detect the approach of vehicle/object and provides the best alternate to avoid the accidents. This idea can be easily implemented by the automobile industry for the safety of vehicles on roads.

References

1. The Global status report on road safety. (2021). https://www.un.org/en/roadsafety/pdf/roadsafety2021_eng.pdf
2. Singh, P. K., Nandi, S. K., & Nandi, S. (2019). A tutorial survey on vehicular communication state of the art, and future research directions.*Vehicular Communications, 18*, 100164. ISSN 2214- 2096. https://doi.org/10.1016/j.vehcom.2019.100164
3. Rahim, A., Malik, P. K., & Sankar Ponnapalli, V. A.: Fractal antenna design for overtaking on highways in 5g vehicular communication ad-hoc networks environment. *International Journal Engineering Advanced Technology (IJEAT)*, *9*(1S6), 157–160. ISSN: 2249-8958.

4. Zhao, J., Dong, P., Ma, X., Sun, X., & Zou, D. (2020). Mobile-aware and relay-assisted partial offloading scheme based on parked vehicles in B5G vehicular networks. *Physical Communication, 42*, 101163. ISSN 1874-4907, https://doi.org/10.1016/j.phycom.2020.101163
5. Aliyu, A., Abdullah, A. H., Kaiwartya, O., Cao, Y., Lloret, J., Aslam, N., & Joda, U. M. (2018). Towards video streaming in IoT environments: vehicular communication perspective. *Computer Communications, 118*, 93–119. ISSN 0140-3664, 1https://doi.org/10.1016/j.comcom.2017.10.003
6. Rahim, A., & Malik, P. K. (2021). Analysis and design of fractal antenna for efficient communication network in vehicular model. *Sustainable Computing: Informatics and Systems*, *31*, 100586. ISSN 2210-5379, https://doi.org/10.1016/j.suscom.2021.100586
7. Memedi, A., & Dressler, F. (2021). Vehicular visible light communications: a survey. *IEEE Communications Surveys & Tutorials*, *23*(1), 161–181, Firstquarter 2021. https://doi.org/10.1109/COMST.2020.3034224
8. Raghavendra, K., & Kakkar, F. (2022). 14—reliability of 5G in human health monitoring using blockchain technology. In Tanwar, S. (Ed.), *Blockchain Applications for Healthcare Informatics* (pp. 313–326). Academic Press. ISBN 9780323906159, https://doi.org/10.1016/B978-0-323-90615-9.00012-8
9. Madhav, B. T. P., Anilkumar, T., & Kotamraju, S. K. (2018). Transparent and conformal wheel-shaped fractal antenna for vehicular communication applications. *AEU—International Journal Electronic Communication, 91*, 1–10.
10. Rahim, A., Malik, P. K., & Sankar Ponnapalli, V. A. (2020). State of the art: a review on vehicular communications, impact of 5G, fractal antennas for future communication. In P. Singh, W. Pawłowski, S. Tanwar, N. Kumar, J. Rodrigues, & M. Obaidat (Eds.), *Proceedings of First International Conference on Computing, Communications, and Cyber-Security (IC4S 2019). Lecture Notes in Networks and Systems* (Vol. 121). Singapore: Springer. https://doi.org/10.1007/978-981-15-3369-3_1
11. Jameel, F., Wyne, S., Nawaz, S. J., & Chang, Z. (2019). Propagation channels for mmWave vehicular communications: State-of-the-art and future research directions. *IEEE Wireless Communications, 26*(1), 144–150.
12. Malik, P. K., & Singh, M. (2019). Multiple bandwidth design of micro strip antenna for future wireless communication. *International Journal Recent Technology Engineering*, *8*(2). ISSN: 2277-3878.
13. Rahim, A., & Mali, P. K. (2022). Ultra-wide band microstrip patch with dual U-resonating slot and T-shape design for vehicular communication applications. *Mukt Shabd Journal*, *11*(1), 91–100.
14. Shaik, N., & Malik, P. K. (2021). A comprehensive survey 5G wireless communication systems: Open issues, research challenges, channel estimation, multi carrier modulation and 5G applications. *Multimed Tools Appl, 80*, 28789–28827. https://doi.org/10.1007/s11042-021-11128-z
15. Jabbar, A., Abbasi, Q.H., Anjum, N., Kalsoom, T., Ramzan, N., Ahmed, S., Rafi-ul-Shan, P.M., Falade, O.P., Imran, M.A., & Ur Rehman, M. (2022). Millimeter-wave smart antenna solutions for URLLC in industry 4.0 and beyond. *Sensors*, *22*, 2688. https://doi.org/10.3390/s22072688

An Intelligent Framework for Movie Recommendation Through Online Social Media

Gaurav Agarwal, Shail Kumar Dinkar, and Ajay Agarwal

Abstract The production, promotion, and distribution of content in the electronic media and entertainment sector must adapt to new strategies. The reason for this is that current customers can search for and access content on any device, at any time, from anywhere. The world has entered a media-rich information period due to the proliferation of online services and flexible innovations. An efficient recommender system always makes sure to record the users' actual preferences and only makes recommendations for items that the user genuinely wants. Recommender systems have been used for two decades to recommend goods, contents, and services to online users in a variety of applications. Although recommender systems have been successful in many application domains, there are still a number of problems that limit their effectiveness. This paper suggests a hybridized algorithm for a movie recommendation system that uses a particle swarm optimization-based crow search algorithm. The suggested model considered both the most recent and previous user ratings and conducted statistical analysis on a real dataset. Additionally, when performing particle swarm optimization, the items' contents are taken into consideration. As a result, the recommender system's data sparsity issue is greatly diminished. More individualized movie track recommendations are made possible by the concept of hybridization.

Keywords Recommendation system · Filtering · Statistical analysis · Sparsity · Personalization

G. Agarwal (✉)
Department of Computer Science and Engineering, Veer Madho Singh Bhandari Uttarakhand Technical University, Dehradun, Uttarakhand 248007, India
e-mail: gaurav.agarwalvi@gmail.com

S. K. Dinkar
Department of Computer Science and Applications, Govind Ballabh Pant Institute of Engineering and Technology, Pauri, Garhwal, Uttarakhand 246194, India
e-mail: shailkdinkar@gmail.com

A. Agarwal
Department of Information Technology, Krishna Institute of Engineering and Technology, Muradnagar, Ghaziabad, U.P. 201206, India
e-mail: ajay.agarwal@kiet.edu

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_59

1 Introduction

Since the dawn of time, movies have been regarded as the most popular form of entertainment. It has also gotten much simpler to listen to one's favourite movie thanks to the accessibility of several online platforms. Online movie streaming services have amassed a vast amount of data in order to provide each user with the movie of their choice whenever and wherever they choose. Human nature dictates that when making any decision in life, big or small, one or more options will be taken into consideration. Additionally, given how frequently human behaviour and emotions change, different options may be available. Therefore, it becomes crucial for any movie system to adapt to its user's changing nature. On your smartphones, you can easily and quickly find your movies at anytime, anywhere. But because there are two sides to every coin, as the number of options increases, so does information fatigue, which reduces the precision and accuracy of the entire recommendation system. To address this problem, a research model was developed that suggests movie to each user based on the similarity of audio signals [1, 2]. The required data was extracted using a convolutional recurrent neural network (CRNN), and similarity features were created using similarity distance. A new research model was put forth that made use of collaborative filtering to comprehend users' daily routines in order to produce the desired results [3, 4]. A model that helped with movie recommendations by comprehending real-time data like heart rate, time, weather, and so on was proposed. It was made by fusing together two different movie recommendation components: one for figuring out the best fit for the user and the other for figuring out the best fit for all features [5, 6]. The crow search algorithm and particle swarm optimization (PSO) are the foundations for the intelligent recommendation framework proposed in this study (CSA). To begin with, statistical analysis is carried out to comprehend user ratings as feedback for a specific movie component. An important concern for online social recommendation is security and privacy. Sharing of thoughts, opinions, and images poses a serious risk to the security features of social networks. Users' behaviour would be managed to maintain security and privacy [7] and an optimal choice was made to manage users' behaviour [8]. The two most efficient bio-inspired techniques are hybridized in this paper by a smart algorithm. The recommendation system's "data sparsity problem" is significantly reduced by the hybrid model. An item is referred to as sparse if it has very few user ratings. As a result of the low ratings, it becomes challenging to recommend an item.

The remainder of this essay is divided into the following sections. The description of related works is in Sect. 2. The concept of a recommender system is presented in Sect. 3. Section 4 discusses the proposed model, and Sect. 5 contains the results and discussion. Section 6 concludes by outlining the recommendations for further study.

2 Related Works

There are a huge number of different recommendation systems available online, so they need to be modified and improved in a number of different ways. A new model was created and put forth in order to make it better for understanding of the user's emotional behaviour and to make movie recommendations. To improve the quality of predicted output, Geetha et al. [9] describe using deep learning techniques in recommendation systems. E-commerce sells a wide variety of goods, making decision-making extremely difficult. Based on how previous customers have interacted with the product, users are given the option to select the best. Understanding the hierarchy of the model presented requires an explanation of the data acquisition phase, learning phase, and feedback phase. The research that follows also focuses on a thorough investigation of data and how recommendation systems work well to fulfil a customer's future preferences. Datta et al. [10] focus was on an important method for appropriately filtering and accessing online information. It is important to understand terms like utility matrix and long tail in order to comprehend the recommender system's methodology. Additionally, there have been discussions about various hybrid approaches, and an attempt in this direction was successful. The goal of the research is to deliver a thorough understanding of recommendation systems based on content and various hybrid techniques.

According to Batmaz et al. [11], content-based filtering has to do with the information that is available regarding customer and product service. This is the most important issue when creating a standard methodology for the recommender system. A user can be persuaded by text messages, images, videos, and audio to indicate his interest in the product marketing model. To observe how consumers behave and respond to a service, various surveys are carried out. For the users, an intelligent movie recommendation system is suggested by the Sarkar et al. [12]. The particle swarm optimization-based crow search algorithm was proposed as a hybridized algorithm. Resolution strategy in the area of digital applications was noticed by Zhang et al. [13]. This was accomplished using cooperative filtering. Here, predictions were made based on the evaluation of a user-item relational matrix. The opinions of the neighbours were combined with user reviews to produce a favourable outcome. This method involved normalizing the user-provided ratings and calculating a collective prediction.

3 Concept of Recommender System

Users now have a vast array of options to choose from, which frequently results in more difficult decision-making, as a result of the World Wide Web's explosive growth in information and the rapid expansion of e-services. In order to help people who lack experience or knowledge navigate the vast array of options available to them, recommender systems were primarily developed [14]. To forecast users' preferences

for items of interest, recommender systems use a variety of information sources [15]. The potential financial gain that recommender systems could produce for companies like Amazon has been a major source of concern for this field of research for the past 20 years in both academia and industry [16]. Recommender systems were initially employed in e-commerce to address the problem of information overload brought on by Web 2.0. They were quickly expanded to include e-business, e-learning, and e-tourism personalization [17]. These days, recommender systems are a necessary component of websites like Meetup, Facebook, Netflix, YouTube, Amazon.com, and Yahoo. In a nutshell, recommender systems are created to determine whether an item is worthwhile of being recommended and to estimate its utility [18] (Fig. 1).

Figure 2 shows the basic classification of the recommender system. Recommender system is classified into three different categories like content-based filtering, collaborative-based filtering, and hybrid filtering.

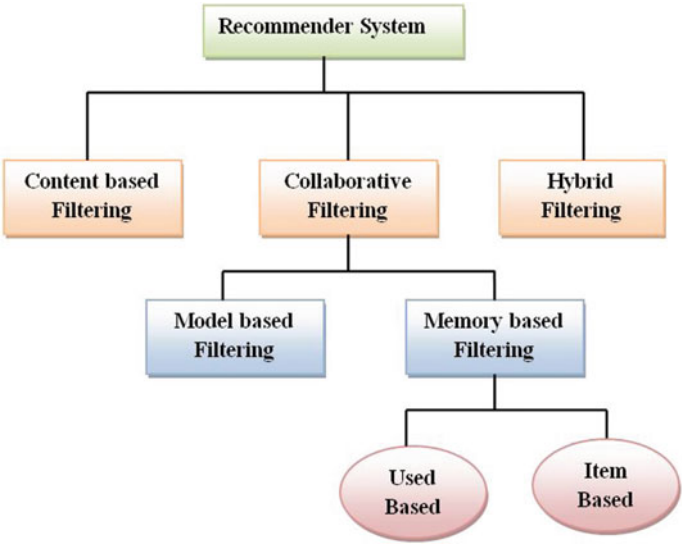


Fig. 1 Classification of recommender system

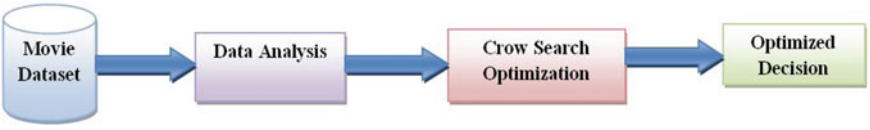


Fig. 2 Intelligent proposed model

4 Proposed Model

This research proposes an intelligent model for optimized prediction. A real dataset is used as a test-bed to verify the proposed model. The best solution to the data sparsity problem is the main objective of this paper. Businesses will not have enough rating points to promote a new song to users if they add it to their database for an online movie subscription service. On the other hand, the movie's rating point won't increase if viewers don't give it a rating. To achieve this, an intelligent recommender system based on crow search and particle swam optimization is proposed.

4.1 Proposed Algorithm

The proposed algorithm is defined based on the CSA algorithm. A swarm intelligence algorithm called the crow search algorithm has many uses. The optimization technique known as the metaheuristic algorithm makes use of a particular randomization and local search trade-off. There are many metaheuristic algorithms that draw inspiration from nature, including the crow search algorithm (CSA). The capability of independently compiling responses from various sources and then calculating all responses collectively to determine the best answer to given challenge. This approach leads to the discovery of a better optimal solution for a particular problem, which is why CSA is used. To resolve a specific problem, the idea of collective behaviour that is decentralized and self-organizing is used.

The problem of this paper is optimized using the computational technique known as particle swarm optimization (PSO) [19] by iteratively attempting to improve a candidate solution in relation to a specified quality metric. By using a population of potential solutions, here referred to as particles, and moving them around the search space in accordance with a straightforward mathematical formula over the particle's position and velocity, it solves problems. In addition to being guided towards the best known positions in the search space, which are updated as other particles find better positions, each particle's movement is also influenced by its local best known position. This is expected to move the swarm towards the best solutions. An optimization is the process of determining the best values for the specific parameters of a given system in order to meet all design requirements while spending the least amount of money.

The social behaviour is incorporated by using the best found solution in the swarm globally (or locally) for the velocity update. Aside from social behaviour, the cognitive behaviour of the swarm is determined by the particle's personal best solution found. To ensure that the algorithm performs well on a wide range of optimization problems, the cognitive and social components must be well balanced.

This concept is applied in this research to get the global optimized solution for users. In this paper, metaheuristic-based CSA optimization algorithms [20] for recommendation is describe in Algorithm 1. The CSA algorithm determines which

choice is best for customers whose selection is similar to that of their community, while the PSO algorithm transforms implicit feedback into explicit feedback [21].

Algorithm 1: Intelligent Algorithm for Optimized Recommendation

Begin	
Step 1:	Initialization of the movie dataset.
Step 2:	Identify Local Best Solutions by computing similarity (sparse item, non- sparse item).
Step 3:	Determine the Global Best Solutions by computing Similarity (sparse item, non-sparse item).
Step 4:	Take into account all users of the best global solutions aside from those who have rated that sparse item.
Step 5:	Utilizing the PSO velocity update rule.
Step 6:	Predicts user ratings on unrated items.
Step 7:	Create a group of users with comparable ratings.
Step 8:	Calculate total fitness in relation to each user who used CSA to rate the sparse item.
Step 9:	Use the CSA's position update rule to predict a user's rating.
Step 10:	Using the position update rule of PSO, predict a user's implicit feedback.
Step 11:	Calculate the average rating variance for the sparse item.
Step 12:	Calculate the standard deviation of each implicit comment on the sparse item.
Step 13:	If the following conditions are met: (Standard deviation of implicit feedbacks% standard deviation of all ratings |top-n recommendation set|) then recommend; rank = remainder − recommendation threshold.
Step 14:	Don't advocate the limited item.
End	

5 Results and Discussions

To validate the model, a live dataset named MovieLens [22] is used as a test-bed. At first, the dataset is analysed to determine the users' activity patterns. According to their preferences, users rate different songs. The same movie can be listened to repeatedly by users. It is obvious that a user likes a song and has given it a high rating if they listen to it more than once. The proposed model is implemented in Python for validation. In the dataset, there are more than ten thousands records and 15 different features are presented. In this research, only four thousands records and 8 features are considered. The main motive of this research is to determine the trending of the recommendation in social media. To achieve the goal, users' activity mainly rating is the important feature. The rating of the users' based on a particular movie is visualized in Fig. 3.

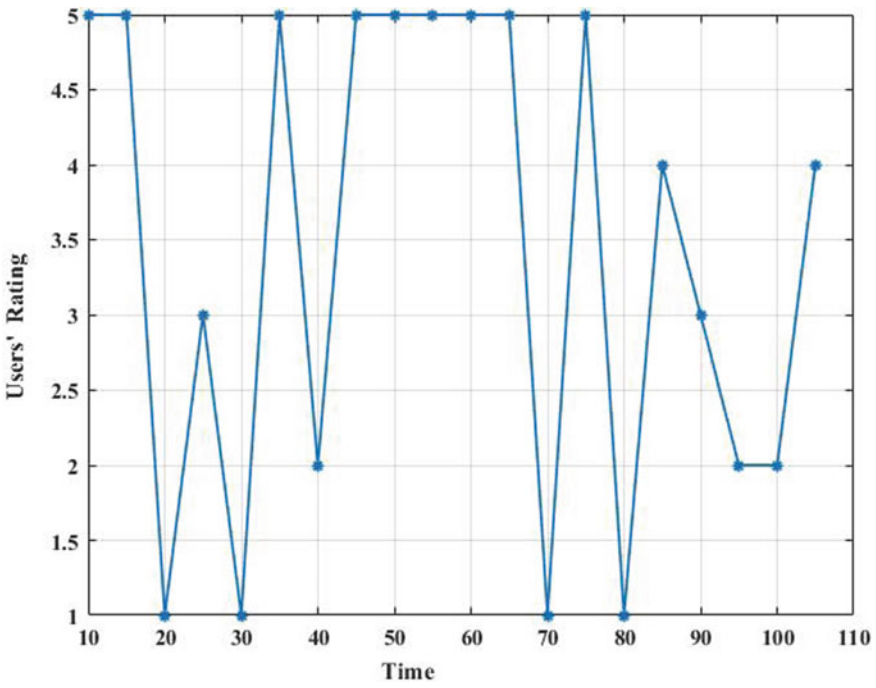


Fig. 3 Users' rating at a regular time interval

Figure 3 shows the users' rating with respect of the time interval. Time stamp is required because of the determination of the propagation rate of the recommendation through social media. The rating scale is 1–5 and time stamp is 10 s. A crow search optimization technique is applied to get the optimized decision. There are lot of asymmetric data are presented in the dataset. On the other hand, the users' behaviour and rating are also uncertain. Optimization decision is graphically shown by the surface graph in Fig. 4.

Figure 4 shows the optimization plane in 3D surface.

To validate the proposed model, fourfold cross validation is applied. Four different strategies are applied for the dataset. The precision and recall value of the proposed model at 4 different strategies are given in Table 1.

In 4 different strategies, the dataset is split into 2 different part training set and testing set with various ratios. The value of the precision and recall is changed based on the ratio of the training and testing dataset. The precision and recall value at 4 different strategies are visualized in Fig. 5.

In Fig. 5, the precision and recall value vary with respect to the strategy. To evaluate the performance of the proposed model, average is calculated for the precision and recall.

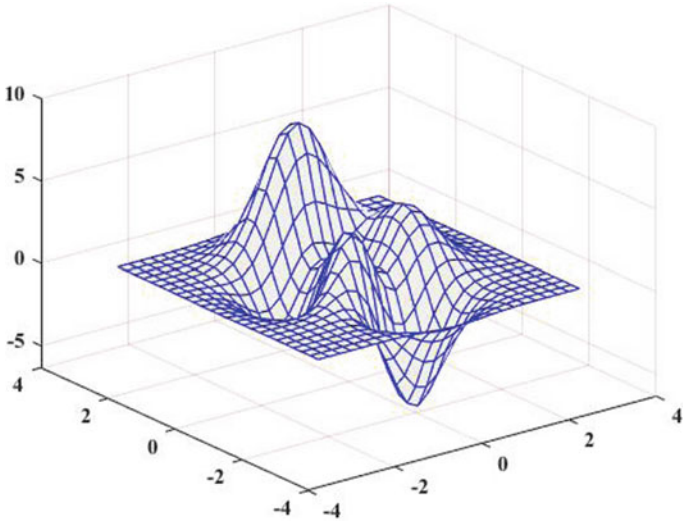


Fig. 4 Optimized decision for the movie recommendation

Table 1 Value of the precision and recall at 4 different strategies

Training and testing strategy	Strategy 1 (50–50%)	Strategy 2 (60–40%)	Strategy 3 (70–30%)	Strategy 4 (80–20%)	Average
Precision	94.6	91.8	94.6	95.7	94.175
Recall	95.8	94.7	92.8	97.6	95.225

Fig. 5 Value of performance metrics for the proposed model at different strategy

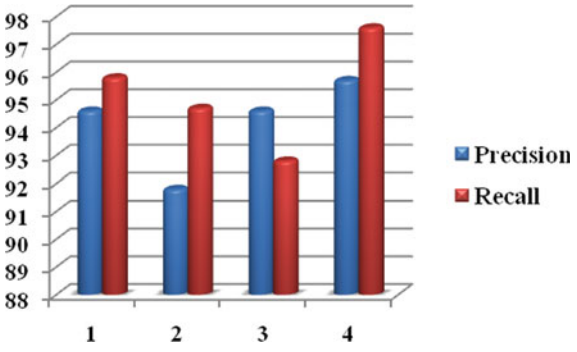


Figure 6 graphically represents the performance proposed model. The precision and recall values for the proposed model are 94.175% and 95.225%, respectively, from Table 1.

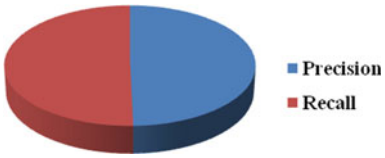


Fig. 6 Pie chart for the average value of the precision and recall

6 Conclusion

The media sector has seen a significant amount of exploration work focused on various aspects of big data analysis, including indexing, capture, storage, mining, and retrieval of multimedia big data. The entertainment industry now does a huge amount of business online in this digital age. This pandemic, when social isolation is required, made the idea of this online entertainment very popular. An intelligent hybrid recommendation model is suggested in this paper to improve the existence model. Crow search-based optimization technique is used to get an optimized decision for the movie recommendation. A real-time dataset called *MovieLens* is used as a testbed to validate the model and determine the performance metrics. The model is validated by fourfold cross validation technique. Four different strategies are applied for validation. The precision and recall values for the proposed model are 94.175% and 95.225%, respectively. Future research will focus on developing intelligent models based on deep learning that can be used to improve recommendation systems' precision and recall values while also reducing the problem of sparsity.

References

1. Adiyansjah, A., Gunawan, A. A., & Suhartono, D. (2019). Music recommender system based on genre using convolutional recurrent neural networks. *Procedia Computer Science, 157*, 99–109.
2. Arnold, A.N., & Vairamuthu, S. (2019). Music recommendation using collaborative filtering and deep learning. *International Journal Innovation of Technology Exploring Engineering (IJITEE), 8*(7), 964–968. ISSN: 2278-3075
3. Sánchez-Moreno, D., Zheng, Y., & Moreno-García, M. N. (2020). Time-aware music recommender systems: Modeling the evolution of implicit user preferences and user listening habits in a collaborative filtering approach. *Applied Sciences, 10*(15), 5324–5356.
4. Ferwerda, B., & Schedl, M. (2014). Enhancing music recommender systems with personality information and emotional states: A proposal. *CEUR Workshop Proceding, 1181*, 36–44.
5. Aurén, M., Bååw, A., Karlsson, T., Nilsson, L., Olzon, D. H., & Shirmohammad, P. (2018). *Music recommendations based on real-time data.* Chalmers University of Technology/Department of Computer Science and Engineering (Chalmers).
6. Su, J.-H., Chang, W.-Y., & Tseng, V. (2013). Personalized music recommendation by mining social media tags. In *17th International Conference in Knowledge Based and Intelligent Information and Engineering Systems-KES2013. Procedia Computer Science* (Vol. 22, pp. 303–312). Elsevier.
7. Sarkar, M., & Banerjee, S. (2016). Exploring social network privacy measurement using fuzzy vector commitment. *Intelligent Decision Technologies An International Journal, IOS Press, 10*(3), 285–297.

8. Sarkar, M., Banerjee, S., & Valentina E. B. (2015). Configuring trust model for cloud computing: Decision exploration using fuzzy reasoning. In *IEEE 19th International Conference on Intelligent Engineering Systems 2015* (pp. 219–223). Bratislava, Slovakia: IEEE.
9. Geetha, M. P., & Karthika, R. D. (2019). Research on recommendation systems using deep learning models. *International Journal of Recent Technology and Engineering, 8*(4), 10544–10551.
10. Koyal, D. G. (2019). A survey on recommender system. *International Journal of Applied Engineering Research, 14*(14), 3274–3277.
11. Batmaz, Z., Yürekli, A., Bilge, A., & Kaleli, C. (2018). A review on deep learning for recommender systems: Challenges and remedies. *Artificial Intelligence Review*. https://doi.org/10.1007/s10462-018-9654-y
12. Sarkar, M., Roy, A., Badr, Y., Gaur, B., & Gupta, S. (2021). An intelligent music recommendation framework for multimedia big data: A journey of entertainment industry. *Studies in Big Data, Springer Nature Singapore, 2*, 39–67.
13. Zhang, F., Yuan, N. J., Lian, D., Xie, X., & Ma, W. Y. (2016). Collaborative knowledge base embedding for recommender systems. In *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, ACM* (pp. 353–362). San Francisco, CA, USA: ACM
14. Shapira, B., Ricci, F., Kantor, P. B., & Rokach, L. (2011). *Recommender systems handbook*. Springer.
15. Bobadilla, J., Ortega, F., Hernando, A., & Gutiérrez, A. (2013). Recommender systems survey. *Knowledge Based System, 46*, 109–132.
16. Schafer. J. B., Konstan, J., & Riedl. J. (1999). Recommender systems in e-commerce. In *Proceedings of the 1st ACM Conference on Electronic Commerce* (pp. 158–166). Denver, CO, USA: ACM
17. Lu, J., Wu, D., Mao, M., Wang, W., & Zhang, G. (2015). Recommender system application developments: A survey. *Decision Support System, 74*, 12–32.
18. Adomavicius, G., & Tuzhilin, A. (2005). Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions. *IEEE Translated Knowledge and Data Engineering, 17*(6), 734–749.
19. Kennedy, J., & Eberhart, R. C. (1995). Particle swarm optimization. In *Proceedings of the International Conference on Neural Networks* (pp. 1942–1948). Perth, Australia: IEEE.
20. Askarzadeh, A. (2016). A novel metaheuristic method for solving constrained engineering optimization problems: Crow search algorithm. *Computer Structure, 169*, 1–12.
21. Mandal, S., & Maiti, A. (2020). Explicit feedback meet with implicit feedback in GPMF: A generalized probabilistic matrix factorization model for recommendation. *Applied Intelligence, 50*, 1955–1978.
22. Dataset: MovieLens available on https://grouplens.org/datasets/movielens/tag-genome-2021. Last accessed September 01, 2022.

Application of Artificial Intelligence in Software Development Life Cycle: A Systematic Mapping Study

Shilpi Singh and Saurabh Sambhav

Abstract Building a quality maintainable software product is the necessity of any organization and it depends on various factors. The selection of an appropriate model is one of the factors to achieve this objective. Primarily any Software Development Life cycle (SDLC) model consists of seven phases: requirement gathering, planning, designing, coding, testing, implementation, and maintenance. Each phase has its own importance and will have to optimize those to get an optimal result. And for that, artificial intelligence (AI) offers a lot of potential for improving all aspects of the software development life cycle phases. The revolution of AI in software engineering (SE) is showing an upsurge in research. It becomes evident that a variety of AI paradigms might be used to improve the process and address many of the fundamental issues that the SE sector has been dealing with. Incorporation of AI in SE significantly impacts the developer's productivity and product reliability which leads to achieving quality maintainable software products. This work presents a comprehensive study on AI methods in SDLC (model-wise) and AI methods in SDLC (phase-wise) with the help of different parameters. The author's aim is to provide insights to the researchers and practitioners belonging to the field of SE, who will benefit from this study and get the future direction as well.

Keywords Software engineering · Software development life cycle · Artificial intelligence (AI)

1 Introduction

Software is an essential component to make the human life more comfortable. Specifically, in the present scenario where the computer system is widely used in many fields

S. Singh (✉) · S. Sambhav
Amity University Patna, Patna 801503, India
e-mail: shilpi.singh.it@gmail.com

S. Sambhav
e-mail: ssambhav.iit@gmail.com

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_60

of our life. As per the history of software engineering (SE) and the survey results of software development methodologies, development organizations are highly dependent on the software that makes it more interesting and attractive as well. There are many types of software systems, from simple embedded systems to complex global information systems. Depending on different types of software product, development procedure and related complexities are also varying. Hence, software engineering needs optimized software development life cycle model. Some fundamental questions that are likely to arise in your mind are: How do you define software and software engineering? What exactly is artificial intelligence? What features of software engineering lend themselves to artificial intelligence concepts and techniques? The term software crisis and software engineering was coined in 1986 by NATO. The software engineering discipline incorporates different aspects of software development from requirement gathering to maintenance to delivery.

To develop software products in a disciplined and systematic manner, we need a software development life cycle (SDLC). Without a SDLC model, it is impossible to identify the phase's entry or exit criteria. Without software life cycle models, software project managers will struggle to keep track of the project's development. There are 6 phases in SDLC are: requirement analysis, planning, designing, developing, testing, and maintenance. Alternatively, artificial intelligence, which is part of computer science, seeks to make machines do things humans have traditionally performed. Its goal is to develop machines that can engage in actions that humans see as intelligent. Despite the complexity of AI, the introduction of machine learning and deep learning has led to a paradigm change in almost every area of the software business. In software engineering, AI plays a crucial role in streamlining processes, reducing waste, and automating repetitive manual tasks. A number of research and practice areas have demonstrated the effectiveness of AI techniques in software engineering, including probabilistic engineering, learning and prediction, and search-based engineering. This is true not only of the software systems we create, but also of the methods we use to create them, which are frequently based on estimates. As a result of its use, machine learning develops ways to compute that are more efficient. When AI tools are used successfully, human developers' creative potential is multiplied.

2 Literature

In the literature, the importance of AI on various phases of software development life cycle can be seen. Robert et al. presented AI in software engineering application levels taxonomy, which categorizes different applications based on the nature of AI technology employed and the level of automation allowed [1]. Their work demonstrates the use of presented taxonomy by classifying numbers of research work and various workshop editions. Their work is helpful for businesses in determining how to incorporate AI into their software products and developing AI strategy. Software engineers haven't paid much attention to artificial intelligence (AI), despite its

growing importance in self-organizing IT applications. The current state of AI application to software engineering, prospective future developments, and risks related to it is evaluated by Barenkamp et al. [2]. Several qualitative interviews with various stakeholders who are utilizing or desiring to utilize artificial intelligence tools are paired with a systematic evaluation of prior studies in the subject. Insights from the software development life cycle are also categorized in the study. Automated test tools and agile testing automation would also benefit from improved software development environments. According to Narayan et al. [3], artificial intelligence can be used to improve software quality and the software engineering process. A major focus of their research is improving software quality systems using artificial intelligence and reducing time to market. Al-Ahmad et al. [4] developed a swarm intelligence-based model with the goal is to improve the prediction rate as much as possible in the software development process. After comparison from most of the AI techniques, they found that as compared to distinctive ML classifiers and traditional model, their suggested model consistently outperforms them. Additionally, Ammar et al. [5] evaluated how artificial intelligence approaches can be applied to software engineering. They suggested that enterprises need to closely partner with Microsoft to utilize cloud-first technology and AI solutions improve software system quality overall, shorten time to market, and operational efficiency. It also necessitates a number of distinct stages in order to combine these different sorts of knowledge into a single final result. By considering this, Ebbah et al. [6] examined AI techniques from the point of view of their use in software development process. The technique examines AI techniques that can solve problems in software engineering procedures that have been discovered (or are looming in future). Rech et al. [7] presented and looked at an approach to SE that focuses on artificial intelligence: KBS, AmI, and CI. They review the strong ties between artificial intelligence and SE with emphasis on areas the publications focus on.

Artificial intelligence (AI) and machine learning (ML) approaches have been heavily applied in software engineering to enhance decision-making, programme quality, and developer productivity. Such AI/ML models for software engineering, however, continue to be unreliable, mysterious, and useless. These problems frequently hinder AI/ML model adoption in software engineering methods. Tantithamthavorn et al. [8] emphasized the need of explainable AI in software engineering. They provided a variety of case examples to validate the work. The impact of automation and AI on the practice of software engineering is not well understood. In their research, Latinovic et al. [9] interviewed skilled software practitioners to find a solution to this problem. Their findings demonstrate that incorporation of AI and SE with the effect of automation makes the SDLC process more effective in terms of cost, effort, and time.

Kulkarni et al. [10] proposed an integrated architecture to optimize software development processes. They have incorporated AI activities with the extended waterfall and agile model. In addition to that, five projects were also used to measure and validate the performance of the architecture. UGAM and IoI metrics they used to assess the project against proposed goals.

Hourani et al. [11] have made an attempt to present the AI pillars that can be applied specifically in the testing phase. In terms of AI and software testing, they have also recommended several potential future research directions.

Sofian et al. [12] have given a thorough mapping assessment of the contributions and trends involving AI approaches. The stages of SE, the AI methods utilized in SE, and performance evaluation have all been covered. Following a thorough investigation, their findings indicate that machine learning (ML) has been utilized most frequently for the automation and efficient improvement of SDLC procedures.

Dam [13] highlighted few AI applications and use of machine learning in SE. They have also discussed other areas of AI like: evolutionary computing, knowledge representation, and agent technology to solve software development problems.

3 AI in Software Development Life Cycle Phases

The problems that beset all low-quality software endeavours were the reason why software engineering was developed. The bulk of problems arise from software projects that go above their allotted spending, timelines, and quality standards. Because of how quickly the user environment is changing and the demands that applications must fulfil, there is a greater demand for software engineers [14–16].

Adding another layer of indirection can solve all problems in computer science except for those caused by too many layers of indirections [17, 18]. This is particularly true when the user-friendliness, rapidity, and ease of deployment of software development processes can be demonstrated that can be enabled by the aforementioned programming and modelling abstraction layers. Millions of computer programmes needed to be developed, updated, modified, or improved for specific tasks during the 1960s, and as a result, the need for software programmers increased tremendously. Everyone was writing code in a more complex, inefficient way that didn't take advantage of hardware capabilities, making it difficult for others to understand. This resulted in delays in finding bugs and troubleshooting, which delayed the creation of software and led to what was at the time referred to as a "software crisis".

It is the goal of artificial intelligence (AI) to make computers smart, yet some of the most challenging systems ever built by humans are defined, built, and implemented by software engineers. Current AI approaches to SE are geared towards solving specific problems, such as finding test data for certain branches or criteria and fitting equations to predict system quality. Instead of staying at the lowest level of abstraction, we can transcend individual instances of problems to whole classes of problems, and then present solutions methodologies. Several aspects of the software development process have benefited greatly from software intelligence automation. Design, deployment, quality assurance, and testing are the areas that have been most impacted. AI has been successfully used in earlier parts of the software engineering process, such as real software development and requirements engineering, according to numerous advances and studies [3]. Research suggests that incorporating AI into

the software development process might minimize work and risks throughout the process.

3.1 AI Techniques Used in SDLC Phases

In SDLC life cycle phases, we use different AI techniques to automate things which have their own advantages and disadvantages. Let us discuss them one by one.

A software project begins with the establishment of goals and client specifications by software developers and clients. It is of the utmost importance to schedule and plan software development projects to ensure technical efficacy and financial viability. In the project planning stage, we can utilize search-based software engineering techniques to make the process more effective [18–21].

Recently, numerous requirement engineering strategies have concentrated on determining the requirements for employing AI to solve client problems [17]. Some strategies have since looked into how to use AI with the RE phase. Techniques employed in this era include self-learning algorithms, ontology-based approaches, and big data strategies.

The software project is distinctly organized at the design phase, and development jobs are delegated. The analysis of conclusiveness of code or stories, testing programme logics, and probabilistic planning is done during the software design process. Search algorithms, genetic algorithms, etc., are used to optimize this phase.

Artificial intelligence (AI) techniques are used to convert natural language into code. Procedures for automatic encoding, debugging, and optimization decreased implementation costs and timelines, more effective teamwork.

We use different AI techniques in testing phase to check and test scripts, predict errors probabilistically using big data, shorten test times and reduce costs, integrate existing programmes, and increase efficiency through automated debugging and compiling. Self-adaptive software routines, pattern recognition, and artificial neural networks are employed in the software deployment and maintenance phase for classifying inquiries, evaluating mistakes, and other tasks. Eliminate unnecessary code, increase speed, and simplify maintenance.

4 Discussion

This section highlights major outcomes in the form of table based on our survey study. Table 1 presents the systematic mapping of AI techniques corresponding to each phase of software development life cycle. The first column represents the SDLC phase like: planning, requirement gathering, designing, testing, development, and deployment/ maintenance. Each of the mentioned phase has their own importance in the development of any software. And the aim of this paper is to provide an insight to optimize the product and quality of all those phases with the incorporation of

different AI techniques. The second column represents problem associated with each phase during the software development process. As per the study, there are various issues which hampered the effectiveness of development process. During the software development, the main factors that greatly affect the whole procedure is: customer requirements, project type with their associated risk and status of development team. So, the problem is formulated accordingly. Third and fourth column shows the AI techniques and tools that are identified from the previous work and can be used by the user/ developer to solve the associated problem with the phases. The next column is for methodologies that have been used extensively by many researchers to facilitate different activities in software development phases as per the problem associated with them. And we have observed that ontology-based approach, natural language processing (NLP), search-based approach, and many machine learning techniques that is increasingly being adopted in the system development phases. The last two columns are for outcome after using AI in each phase and limitation corresponding to each technique.

Study observed that major category of AI techniques like: machine learning, deep learning, data-driven approach, and heuristic algorithm in SDLC phases that are extensively used till now. We can also use possible combination of the mentioned AI techniques like: machine learning (ML) with data driven (DD), ML with deep learning (DL), ML with heuristic algorithm (HA), etc., to optimize the outcomes. Figure 1 shows the number of publications between year 2010 and year 2021. And it is being observed that the numbers are increasing gradually as per the importance of software engineering is also increasing.

5 Conclusion

Systematically mapping contributions to the SE literature using AI techniques provides an overview of trends. Several AI techniques have been used in SE in the literature, which is heterogeneous in this study. Literature on SE phases and AI is mainly devoted to these topics. Summarized table on various parameters is presented to get an insight on AI techniques used in each one of the phases of software development life cycle. Machine learning effectiveness and precision are always increasing. Machine learning has been heavily utilized mostly for automation and enhancement tasks throughout the requirement gathering stage. Furthermore, hybrid strategies that combine ML with other AI techniques improved the usefulness of the metrics in their respective assessments. In dynamic or uncertain contexts, this combination can handle multidimensional and multi-variety data effectively. Along with the benefits of AI, we have also listed phase-by-phase restrictions or problems that many researchers encountered when applying AI approaches. It was also noted that AI techniques have a great deal of potential to be effectively applied in numerous other software development operations. There are a couple stages of SE that have seen very little application of AI. The future study stage was to conduct additional

Table 1 Summarized table For AI in software engineering

Phase	Problem associated with each phase	Techniques	Tools	Methods	Outcome	Limitation
Planning	Predictions of effort spent on planning phase, effective project management are very dynamic in nature, software project scheduling problem	Neuro fuzzy model, NLP technique	Fuzzy inference system, TensorFlow, Scikit-learn, Pareto Front, MOCell, jMetal, strategy-driven simulation	Neuro fuzzy approach, ANN, ant colony optimization algorithm, multi-objective metaheuristics based on genetic algorithms	Good estimation capabilities, facilitate the process, fragmented output, alternative release plans, an optimized resolution for software project plan	The amount and size of the instances used More investigation, analysis, and evaluation of additional cases
Requirement analysis	Incomplete, ambiguous and vague requirements, communication gap between the stakeholders	Natural language requirements (NLR), knowledge-based systems (KBS), computational intelligence (CI)	IBM SPSS, object-based NLP, READS tool, and ontology-based software (ODE)	The ontology-based model	Detection of ambiguities in the NL requirements, improved decision-making and communication, managed requirements and model problem domains	The characteristics of the programme being tested frequently interfere with the methodologies that are being created, inadequate management of the development environment

(continued)

Table 1 (continued)

Phase	Problem associated with each phase	Techniques	Tools	Methods	Outcome	Limitation
Designing	There is insufficient communication between the construction and design teams, poor design procedures	DSPL language, case-based reasoning, artificial life, automate transformation, intelligent search, fuzzy system, neural network	QSynth	Genetic algorithms (GAs), worklist algorithm with a two-level optimization technique in the forward search as well as backward search	Improved designing processes and eliminate various issues relating to designing, achieves greater accuracy and scalability	
Development	Need improvement in automation process, time-consuming portion of development process, cost factor	Search-based approach, artificial agents, evolutionary algorithm, constraint programming	NSGA-II, pattern trace identification, detection and enhancement iJava (PTIDEJ)	Refactoring, NSGA-II encoding, analogical reasoning technique for reuse: case-based reasoning (CBR)	Support the reuse of software packages, an efficient method for identifying refactoring opportunities	How to handle systems without a history of applied refactoring is one of the search-based approach's primary constraints
Testing	Test case generation, test case selection, test case prioritization, test case classification, early defect detection	Search-based software engineering, (SBSE) technique, data driven, machine learning, and deep learning techniques	Knowledge-based interactive test script (KITSS), GAs and fuzzy logic tools	Ant colony optimization, genetic Algorithms (GA), ACO algorithm, natural language processing (NLP)	Auto test case generation, predictions and optimization, eliminating redundant test cases, automated selecting and prioritizing test cases	Certain resources become unavailable at unpredictable times are still time-consuming and difficult to define and generate

(continued)

Table 1 (continued)

Phase	Problem associated with each phase	Techniques	Tools	Methods	Outcome	Limitation
Deployment/maintenance	Estimating a software's maintainability effort and cost	Neural network, pattern recognition, genetic algorithm, machine learning	NN topology	Create a runtime decision engine to modify a program, use of neural network	Maintainability index can be predicted, AI can enable the classification of user queries	Only used data in one system, data collection process is semi-automated

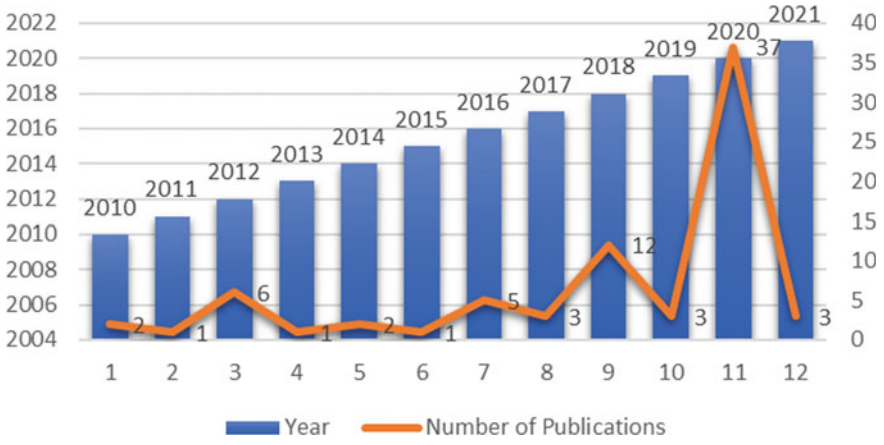


Fig. 1 Publications of artificial intelligence in software engineering (year 2010–2021)

research and review the major findings to pinpoint those SDLC phases in which AI techniques may be applied more frequently in future.

References

1. Feldt, R., de Oliveira Neto, F. G. & Torkar, R. (2018). Ways of applying artificial intelligence in software engineering. In *2018 IEEE/ACM 6th International Workshop on Realizing Artificial Intelligence Synergies in Software Engineering (RAISE)* (pp. 35–41). IEEE.
2. Barenkamp, M., Rebstadt, J., & Thomas, O. (2020). Applications of AI in classical software engineering. *AI Perspectives, 2*(1), 1–15.
3. Narayan, V. (2018). The role of AI in software engineering and testing. *International Journal of Technical Research and Applications.*
4. Al-Ahmad, B. I., Ala'a, A. Z., Kabir, M. F., Al-Tawil, M., & Aljarah, I. (2022). Swarm intelligence-based model for improving prediction performance of low-expectation teams in educational software engineering projects. *Peer Journal of Computer Science, 8*, e857.
5. Ammar, H. H., Abdelmoez, W., & Hamdi, M. S. (2012). Software engineering using artificial intelligence techniques: Current state and open problems. In *Proceedings of the First Taibah University International Conference on Computing and Information Technology (ICCIT 2012)* (Vol. 52), Saudi Arabia: Al-Madinah Al-Munawwarah.
6. Ebbah, J. O. G. (2002). Deploying artificial intelligence techniques in software engineering. *American Journal Under graded Resources, 1*(1).
7. Rech, J., & Althoff, K. D. (2004). Artificial intelligence and software engineering: Status and future trends. *KI, 18*(3), 5–11.
8. Tantithamthavorn, C. K., & Jiarpakdee, J. (2021). Explainable AI for software engineering. In *2021 36th IEEE/ACM International Conference on Automated Software Engineering (ASE)* (pp. 1–2). IEEE.
9. Latinovic, M., & Pammer-Schindler, V. (2021). Automation and artificial intelligence in software engineering: Experiences, challenges, and opportunities. In *The 54th Hawaii International Conference on System Sciences* (pp. 146–155).

10. Kulkarni, R. H., & Padmanabham, P. (2017). Integration of artificial intelligence activities in software development processes and measuring effectiveness of integration. *IET Software, 11*(1), 18–26.
11. Hourani, H., Hammad, A., & Lafi, M. (2019). The impact of artificial intelligence on software testing. In *2019 IEEE Jordan International Joint Conference on Electrical Engineering and Information Technology (JEEIT)* (pp. 565–570). IEEE.
12. Sofian, H., Yunus, N. A. M., & Ahmad, R. (2022). Systematic mapping: Artificial intelligence techniques in software engineering. *IEEE Access*.
13. Dam, H. K. (2019). Artificial intelligence for software engineering. *XRDS: Crossroads The ACM Magazine for Students, 25*(3), 34–37.
14. Shehab, M., Abualigah, L., Jarrah, M. I., Alomari, O. A., & Daoud, M. S. (2020). (AIAM2019) artificial intelligence in software engineering and inverse. *International Journal of Computer Integrated Manufacturing, 33*(10–11), 1129–1144.
15. Harman, M. (2012). The role of artificial intelligence in software engineering. In *2012 First International Workshop on Realizing AI Synergies in Software Engineering (RAISE)* (pp. 1–6). IEEE.
16. Zohair, L. M. A. (2018). The future of software engineering by 2050s: Will AI replace software engineers?. *International Journal of Information Technology and Language Studies, 2*(3).
17. Wilson, G., & Oram, A. (2007). *Beautiful code: Leading programmers explain how they think*. O'Reilly
18. Ghezzi, C., Jazayeri, M., & Mandrioli, D. (2002). *Fundamentals of software engineering.* Prentice Hall PTR.
19. Mayhew, D. J. (1999). The usability engineering lifecycle. In: *CHI'99 extended abstracts on human factors in computing systems*) (pp. 147–148) https://doi.org/10.1145/632716.632805
20. Ferrucci, F., Harman, M., & Sarro, F. (2014). Search-based software project management. In: *Software project management in a changing world* (pp. 373–99). Springer.
21. Chicano, F., Luna, F., Nebro, A. J., & Alba, E. (2011). Using multi-objective metaheuristics to solve the software project scheduling problem. In: *Proceedings of the 13*th *Annual Conference on Genetic and Evolutionary Computation* (pp. 1915–22).

CNN-based Recognition of Skin Cancer Using Contrast Limited Adaptive Histogram Equalization

Ayushi Jain, Neha Mittal, and Shubham Nain

Abstract Deep learning algorithm has been extensively utilizing for detection and recognition of medical images. Skin tumor is one of the most common and rapid growing diseases all over the world. Identification of skin cancer is crucial at initial stage. Advancement in image processing has potential to detect it at an early stage. However, the exact classification and segmentation of dermoscopic images is still challenging as these are nonlinear in nature. Most of the images have low contrast edges and may contains artifacts like hair, air bubble and blood veins. The enhancement of the infected area from the healthy skin is difficult. In this paper, we proposed a CNN-based system that also worked on hair removal and enhancement of the lesion using contrast limited adaptive histogram equalization. Our model provides accuracy of 99.2%in detecting nevi, 98.4% in df, 97.9% in akiec and overall accuracy of 87.99%. The specificity, F1-score and sensitivity performed by our system are 97.98%, 88.47% and 88.47%, respectively.

Keywords Skin cancer · Enhancement · Convolution neural network · Histogram equalization · Hair removal

1 Introduction

Skin is the outermost covering of the body, that is sensitive to the harsh environment. Foremost reason of the skin damage is exposure to harsh sun rays which can also cause cancerous skin diseases [1]. Skin cancer is the rapid growing and spreadable

A. Jain (✉) · N. Mittal · S. Nain
Department of Electronics and Communication Engineering, Meerut Institute of Engineering and Technology, Meerut, UP, India
e-mail: ayushi.jain.mtec2020@miet.ac.in

N. Mittal
e-mail: neha.mittal@miet.ac.in

S. Nain
e-mail: shubham.nain.mtec2021@miet.ac.in

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_61

disease. It is crucial to detect and identify at initial level. This concern attracted many researchers to study and work on skin tumor detection. One of the occurring and spreadable cancers is melanoma. About 15,229 new cases were detected in 2019 as state by Australian institute of health and welfare (AIHW) [2]. Clinical methods of detecting skin tumor are painful, time-consuming and costly. It can be difficult for an unexperienced dermatologist. Therefore, advancement in image processing is playing a great role in analysis of tumor. Classification of these cancer is difficult as they are nonlinear in nature. Infected area in some images is low contrast and contain fuzzy boundaries. Meanwhile, images contain artifacts like blood veins, hair and some blurriness. Several deep learning-based approaches were made for segmentation and classification of these cancer. Huisi Wu et al. presented a CNN-based system with novel and adaptive dual attention module. They utilize dual encoder and use two datasets that are ISIC2018 and ISBI2017 and achieved 94.7% and 95.70% accuracy, respectively. [3] Another encoding technique was proposing by Zhen Yu et al. which is generating different vast features to analyze the difference between melanoma and non- melanoma. They implemented support vector machine with chi-squared kernel for classification and achieved 86.81% accuracy in ISBI 2016 [4]. Muhammad Attique Khan et al. proposed a transfer learning-based model using MASK-RCNN for feature extraction. They also used contrast stretching for extracting and segmenting the feature of the infected area for precisely and achieved 88.5% accuracy in HAM10000 dataset [5]. There are two main kinds of feature involve in skin lesion images that are, namely local and global features. The difference between both the features is local features which are the patches in an image, and global features are the feature of the entire image. Boyan Zhang et al. focused on both kind of features. For local features, they utilize improved ResNet, and for global features, they utilize tonsorial regression. To improve ResNet, they implemented the idea of spatial transformer network (STN) [2]. Several researchers experimented different techniques to precisely extract, segment and classify the skin disease images. Saksham Bassi et al. made various CNN-based approaches with different interconnected techniques like transfer learning and parallel network. They used HAM10000 dataset which involves labeled and high-quality images and achieved [6]. Several techniques were implemented for feature extraction and feature selection. Muhammad Attique Khan et al. performed feature extraction, feature selection and classification using deep CNN, kurtosis controlled component and supervised learning, respectively. In supervised technique, they implemented support vector machine. They practiced three databases that are ISBI 2016, ISBI 2017 and HAM10000 and provide 90.20%, 95.60% and 89.8%, respectively [7]. The main issue faced with these images is low contrast, blurriness and irregular boundaries. M. Attique Khan et al. focused on contrast and utilized Gaussian function to enhance the contrast of the lesion, and they also used transformation of color scape like RGB to HSV. HSV is used for high intensity channel. Further, they constructed saliency map using distance formula and thresholding for lesion extraction. They practiced their model in three databases PH2, ISBI 2017 and ISBI 2016. They provide 97.74%, 97% and 96.1% Accuracy, respectively [8]. Rasool Iranpoor et al. improved pre-trained architecture in which they replace

some layers like pooling. They compared the existing CNN approaches and investigated various changes are effect by replacing some function layers. They achieved 89% classification accuracy [9]. Ruban Nersisson et al. implemented a new feature extraction method that is You Only Look Once and then concatenate it with original texture features and color feature. The resulted feature image is passed for classification and achieved 94% accuracy [1]. An another novel technique was presented by Li Zhou et al. that is mutual attention transformer (MAT). It involves guided attention and self-attention blocks then the fusion is passed for classification and achieved 92.99% accuracy [10]. The issue faced by irregular and blurry boundaries was focused by Mohammed A. Al-masni et al. by segmenting the infected skin from healthy skin using full resolution CNN (FrCN) [11].

Eliminating artifacts most importantly hair, sharpening and enhancement of low contrast between healthy skin and lesion area [12] helps to gather information from the image which later helps to extract feature more precisely. In this model, we have applied morphological black hat transform to eliminate the hair from the skin lesion images and for enhancing the contrast to a particular limit we have implemented contrast limited adaptive histogram equalization (CLAHE). In this approach, we have applied two preprocessing techniques before passing it to convolution neural network.

This study is organized in five sections. Section 1 provides basic information of the issue faced by patient and dermatologists. It also involves introduction of the technology and various approaches proposed. Section 2 explains the approach made by us including operations performed in the model. Section 3 involves the information of the dataset utilized in our system and outcome of the approach. Section 4 contains a small comparison of the results provided by us and with other recent approaches on HAM10000 dataset. Section 5 contains conclusion of the model and future preference to be carried.

2 Proposed Model

This paper presents skin cancer identification using convolution neural network which involves multiple layers for extraction and classification like pooling layer, convolutional layer, activation and dense layers as shown in Fig. 1. First, we applied preprocessing on the images for removing artifacts and enhancing the infected area. This model utilizes HAM10000 dataset which contains seven different classes of cancer. We divided into divisions that is 70% of images are training images, 15% are testing images, 15% are validation images (ratio of 70:15:15).

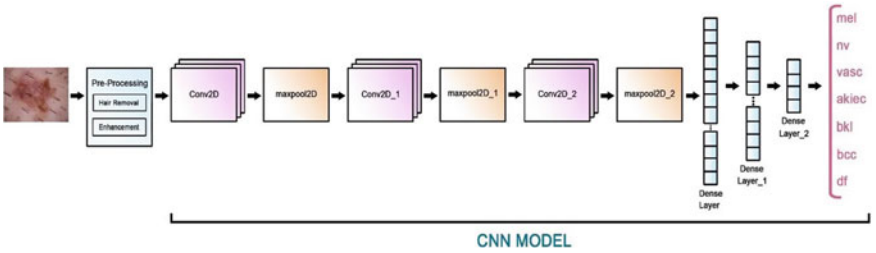


Fig. 1 Building blocks of the system

2.1 Preprocessing

This model applied two preprocessing techniques first for hair removal and second for contrast enhancement of the infected area. There are many techniques used for removal dark and light hair. The technique we used that is morphological filter are working precisely for removing dark and light hair and then we resize the image to 120 * 120 * 1.

2.1.1 Morphological Black Hat Transformation

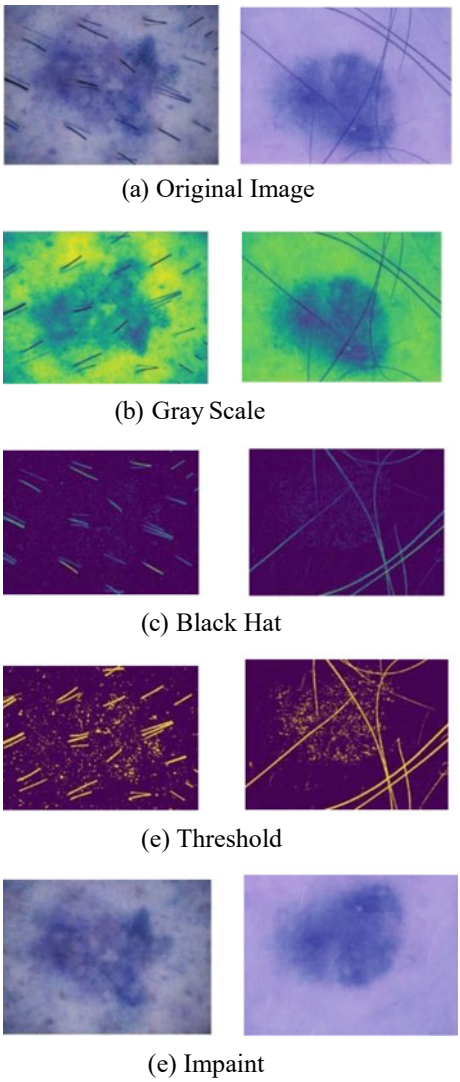
Morphological filters are utilizing for texture analysis. We applied these filters to remove unwanted artifacts like hair from the surface of the lesion It works for removing darkest hair from the surface texture. There are several filters we applied black hat. First, we transform image to grayscale then applied filter to analyze the hair marks and then in painting algorithm is applied with analysis hair intensity. The resultant images came out to be cleared and enhanced without hair as shown in Fig. 2.

2.1.2 Enhancement

Skin lesion image enhancement is carried out by using equalization technique like histogram, adaptive histogram and CLAHE. All the three techniques resulted with variation.

2.1.3 Contrast Limited Adaptive Histogram Equalization

This technique deals with histogram equalization with variation of limitation of contrast level. In this, we can limit the level of contrast want to be enhance. Figure 3 shows the original image and contrast enhanced image. We have applied different contrast level and analyzes result with respect to accuracy and loss as given in Table 1.



(a) Original Image

(b) Gray Scale

(c) Black Hat

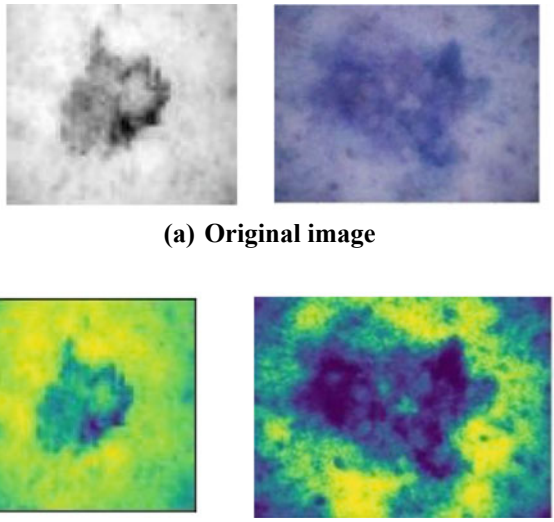
(e) Threshold

(e) Impaint

Fig. 2 Steps involved in hair removal by morphological black hat transform

2.2 Architecture

After enhancing the images, the crucial steps followed are classification and extraction. For these steps, we utilized convolutional neural network. This work proposed four 2D convolutional layers with activation function (ReLU) and 2D max pooling (2×2) then fed the feature map for classification into softmax. Our model implemented three dense layers and two dropouts of 20% as representation in Fig. 4. We applied 32 filters in initial two convolutional layers and 64 filters in following two convolutional layers. We have applied Rectified Linear Unit (ReLU) expressed as



(a) Original image

(b) Contrast enhanced image

Fig. 3 **a** Hair removed image. **b** Contrast enhanced image

Table 1 Performance based on contrast limitation

Clip limit	Accuracy (%)	Loss	Sensitivity (%)	Specificity (%)
0.5	83.31	0.56	84.14	97.14
1	86.57	0.53	87.38	97.76
2	83.20	0.63	83.99	97.22
3	80	0.71	81.34	96.72
4	83.52	0.52	84.04	97.21

$$\mathrm{ReLU}(x) = \max(x, 0)$$

The feature map size is reduced by pooling layers it picks average and maximum value. We used max pooling layer. The resulted feature map is further flattened to 1D (one dimensional) and fed to 256 nodes dense layer; we utilize dropout that is used to randomly eliminate the nodes we eliminate 20% nodes twice. HAM10000 dataset contains seven classes of tumor that is why dense layer outcome is in seven nodes.

3 Dataset

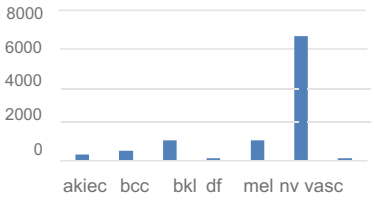
HAM10000 is the labeled and high-quality dermoscopic images dataset collected from distinct hospital and population. It contains more than 10,000 images which

Layer (type)	Output Shape	Param #
img (InputLayer)	[(None, 120, 120, 1)]	0
conv2d (Conv2D)	(None, 118, 118, 32)	320
max_pooling2d (MaxPooling2D)	(None, 59, 59, 32)	0
conv2d_1 (Conv2D)	(None, 57, 57, 32)	9248
max_pooling2d_1 (MaxPooling2D)	(None, 28, 28, 32)	0
dropout (Dropout)	(None, 28, 28, 32)	0
conv2d_2 (Conv2D)	(None, 26, 26, 64)	18496
max_pooling2d_2 (MaxPooling2D)	(None, 13, 13, 64)	0
conv2d_3 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_3 (MaxPooling2D)	(None, 5, 5, 64)	0
dropout_1 (Dropout)	(None, 5, 5, 64)	0
flatten (Flatten)	(None, 1600)	0
dense (Dense)	(None, 256)	409856
dense_1 (Dense)	(None, 128)	32896
dropout_2 (Dropout)	(None, 128)	0
dense_2 (Dense)	(None, 7)	903

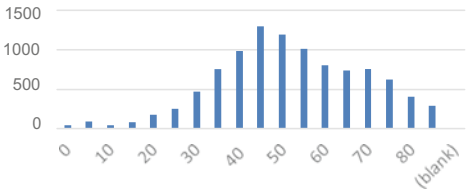
Total params: 508,647
Trainable params: 508,647
Non-trainable params: 0

Fig. 4 Proposed CNN model architecture

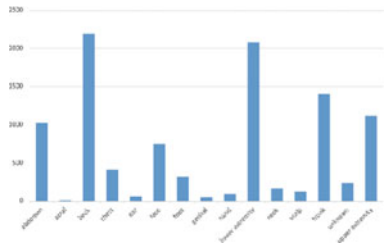
involves seven classes that is actinic keratosis and intraepithelial carcinoma, basal cell carcinoma, melanocytic nevi, benign keratosis-like lesions, vascular, dermatofibroma and melanoma. This dataset is very challenging as it is highly imbalance as shown in Fig. 5. This figure represents imbalance class that is nevi and shows images of different location of the human body like upper extremity, abdomen, neck, scalp, hand, ear, chest, etc. The location the images is also a crucial information for diagnoses and removal artifacts. It involves different age groups from 0 to 80. It involves gender-based image and contains more images of male patients than other. The format of images is JPEG and 8-bit color depth captured by Nikon Coolsan 5000 ED. This dataset provides 72DPI cropped images to 800 * 600 pixels. They



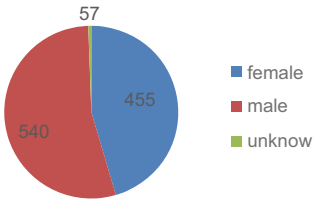
(a) Classes of Cancer



(b) Age-group



(c) Location



(d) Gender

Fig. 5 Analysis of dataset

also provide enhancement using histogram. It is a publicly freely available dataset that can be downloaded from kaggle and implemented for further research on skin cancer. This dataset is international skin imaging collaboration archive.

3.1 Balancing Dataset

As the dataset is highly imbalanced, it can be biased at the result toward a particular class, so it is important to balance the classes before proceeding toward classification. Focusing on this point, we have applied augmentation of the images. We came across many techniques for augmentation like oversampling, under sampling. We proceed with oversampling by rotating images to 40 degrees and flipping the image vertically and horizontally. We oversampled images to 5000 each other class as given in Table 2. The dataset is in three divisions that is testing, training and validation.

4 Results

This model applied morphological filters and equalization for preparing images. This technique can be increasing the rate of classification and precise extracting the infected area. The identification rate of each cancer is presented in Fig. 6. This section also involves confusion matrix of the model. Table 3 gives accuracy resulted in each

Table 2 Classes before and after augmentation

Classes	Original number of images	After augmentation
Nevi	6705	5000
Vasc	142	5000
Akiec	327	5000
Bcc	514	5000
Mela	1113	5000
Bkl	1099	5000
Df	115	5000
Total	10,015	35,000

class. The accuracy achieved is in nevi that is 98.9%. We provide training to the system using 60 epochs and resulted highest training accuracy is 97% and validation accuracy is 87%. Table 4 presents resultant accuracy and loss at each epoch. We also plotted a graph that present loss and accuracy of training and validation in Fig. 6.

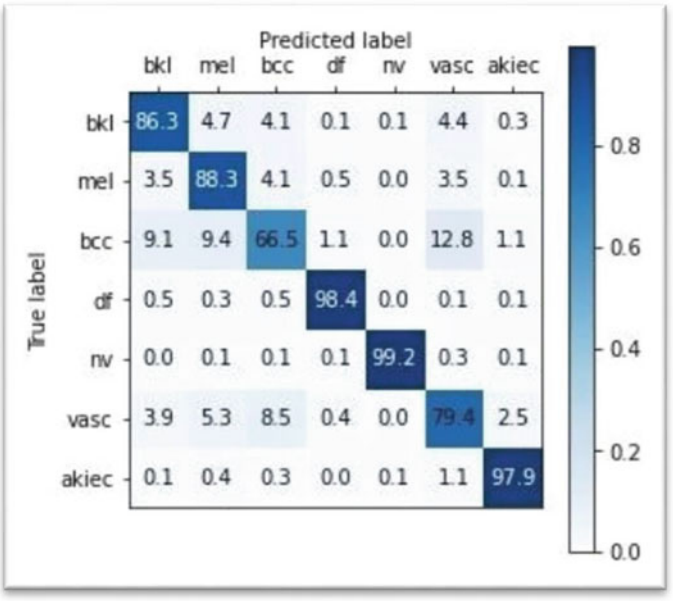


Fig. 6 Confusion matrix of the model

Table 3 Accuracy achieved in each class

Cancer (classes)	Testing accuracy (%)
Nevi	98.9
Bcc	66.5
Bkl	86.3
Df	98.4
Mela	88.3
Vasc	79.4
Akiec	97.9

Table 4 Accuracy and losses with respect to each epoch

Epochs	Training accuracy (%)	Training loss	Validation accuracy (%)	Validation loss
10	86	0.36	82	0.50
20	94	0.16	86	0.49
30	95	0.12	86	0.53
40	96	0.09	87	0.57
50	97	0.08	87	0.57
60	97	0.08	87	0.60

4.1 Performance Analysis

Performance parameters are crucial information to evaluate the result of the model. These provide the predicted and unpredicted rate of each class. The correctly predicted images are known as true positive. The image not predicted correctly are known as false positive. The graph of predicted label and true label is provided in confusion matrix presented in Fig. 6. We evaluate three performance parameter that are sensitivity, specificity and F1-score. The mathematically expression of each parameter is given below in Eqs. (1–3). Table 5 describes the comparison of the model.

$$\text{Sensitivity} = \frac{\text{TP}}{\text{TP} + \text{FN}} \tag{1}$$

Table 5 Comparative analysis of our model with other

Reference	Specificity (%)	Sensitivity (%)	F1-score (%)	Acc (%)
[2]	66.8	87.1	–	74.8
[6]	–	–	70	82.8
Ours	97.98	88.47	88.47	87.99

$$\text{F1 score} = \frac{2 \times \text{TP}}{(2 \times \text{TP}(\text{FP} + \text{FN}))} \tag{2}$$

$$\text{Specificity} = \frac{\text{TN}}{(\text{TN} + \text{FP})} \tag{3}$$

5 Conclusion

In medical field, the identification of disease at starting stage is crucial to plan the diagnoses. Mainly, the skin disease needed to be detected early because they are rapid growing. Focusing this issue, we proposed a fully automatic CNN-based model. The blurry and poor contrast lesion image make difficult to extract feature. So, we applied two techniques to prepare the image for feature extraction and classification. The preprocessing has smoothened the CNN model and achieved good results. Hence, to achieve great accuracy, the preprocessing and segmentation are required.

References

1. Nersisson, R., Iyer, T. J., Joseph Raj, A. N., & Rajangam, V. (2021). A dermoscopic skin lesion classification technique using YOLO-CNN and traditional feature model. *Arabian Journal for Science and Engineering, 46*(10), 9797–9808.
2. Zhang, B., Wang, Z., Gao, J., Rutjes, C., Nufer, K., Tao, D., Feng, D. D., & Menzies, S. W. (2020). Short-term lesion change detection for melanoma screening with novel siamese neural network. *IEEE Transactions on Medical Imaging, 40*(3), 840–851.
3. Wu, H., Pan, J., Li, Z., Wen, Z., & Qin, J. (2020). Automated skin lesion segmentation via an adaptive dual attention module. *IEEE Transactions on Medical Imaging, 40*(1), 357–370.
4. Yu, Z., Jiang, X., Zhou, F., Qin, J., Ni, D., Chen, S., Lei, B., & Wang, T. (2018). Melanoma recognition in dermoscopy images via aggregated deep convolutional features. *IEEE Transactions on Biomedical Engineering, 66*(4), 1006–1016.
5. Khan, M. A., Akram, T., Zhang, Y. D., & Sharif, M. (2021). Attributes based skin lesion detection and recognition: A mask RCNN and transfer learning-based deep learning framework. *Pattern Recognition Letters, 143*, 58–66.
6. Bassi, S., & Gomekar, A. (2019). Deep learning diagnosis of pigmented skin lesions. In *2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT)* (pp. 1–6). IEEE.
7. Khan, M. A., Javed, M. Y., Sharif, M., Saba, T., & Rehman, A. (2019). Multi-model deep neural network- based features extraction and optimal selection approach for skin lesion classification. In *2019 International Conference on Computer and Information Sciences (ICCIS)* (pp. 1–7). IEEE.
8. Khan, M. A., Akram, T., Sharif, M., Javed, K., Rashid, M., & Bukhari, S. A. C. (2020). An integrated framework of skin lesion detection and recognition through saliency method and optimal deep neural network features selection. *Neural Computing and Applications, 32*(20), 15929–15948.

9. Iranpoor, R., Mahboob, A. S., Shahbandegan, S., & Baniasadi, N. (2020). Skin lesion segmentation using convolutional neural networks with improved U-Net architecture. In *2020 6th Iranian Conference on Signal Processing and Intelligent Systems (ICSPIS)* (pp. 1–5). IEEE.
10. Zhou, L., & Luo, Y. (2021). Deep features fusion with mutual attention transformer for skin lesion diagnosis. In *2021 IEEE International Conference on Image Processing (ICIP)* (pp. 3797–3801). IEEE.
11. Al-Masni, M. A., Kim, D. H., & Kim, T. S. (2020). Multiple skin lesions diagnostics via integrated deep convolutional networks for segmentation and classification. *Computer Methods and Programs in Biomedicine, 190*, 105351.
12. Carcagnì, P., Leo, M., Celeste, G., Distante, C., & Cuna, A. (2021). A systematic investigation on deep architectures for automatic skin lesions classification. In *2020 25th International Conference on Pattern Recognition (ICPR)* (pp. 8639–8646). IEEE.

Correction to: A Novel Approach to Avoid Road Traffic Accidents and Develop Safety Rules for Traffic Using Crash Prediction Model Technique

Sk Hasane Ahammad, M. Sukesh, Mekala Narender, Sajjad Ali Ettyem, Kadhum Al-Majdi, and K. Saikumar

Correction to:
Chapter "A Novel Approach to Avoid Road Traffic Accidents and Develop Safety Rules for Traffic Using Crash Prediction Model Technique" in: D. K. Sharma et al. (eds.), ***Micro-Electronics and Telecommunication Engineering*****, Lecture Notes in Networks and Systems 617,**
https://doi.org/10.1007/978-981-19-9512-5_34

In the original version of the chapter, the following correction has been incorporated: The city name of the fourth author was incorrectly published with Muscat instead of Dhi Qar. It has now been corrected in this updated version.

The updated version of this chapter can be found at
https://doi.org/10.1007/978-981-19-9512-5_34

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*,
Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5_62

Author Index

A
AbdlNibe, Mohammed Ahmed, 379
Abdul Kadeem, Sahar R., 611
Abnave, Jayant, 297
Afshar Alam, M., 421
Agarwal, Ajay, 645
Agarwal, Gaurav, 645
Agarwal, Harshit, 115
Agarwal, Mini, 11
Agarwal, Ritu, 61
Agarwal, Sumit, 431
Aggarwal, Parul, 335
Ahammad, Sk Hasane, 367
Aicevarya Devi, S., 587
Akshaya, S., 287
Al-Ameedee Sarah A., 357, 611
Alameen, Huda A., 621
Albermany, Salah A. K., 379
AL-Hameed, Mazin R., 325
Alkhafaji, Mohammed Ayad, 629
Alkhayyat, Ahmed, 93, 495
Al-Khuzaie, Zahraa Majeed, 379
Al-Majdi, Kadhum, 367
Alzeyadi, Ahmed Kareem, 357
Anantha Prabha, P., 167
Anoop, V. S., 495
Antony Vijay, J., 317
Archana, K. S., 73
Arora, Vimal, 481
Aruchamy, Prasanth, 509

B
Bansal, Himani, 61
Bansal, Mitashi, 345
Bhandari, Gaurav, 597
Bhushan Agarwal, Bharat, 11
Bhushan, Bharat, 495, 519, 531, 543
Bhuyan, Bikram Pratim, 61
Bui, Hung Phu, 205, 243

C
Chakraborty, Partha, 37
Chandramohan, S., 227, 235
Chaudhary, Bhoopesh, 49
Chau, Mai Khanh, 243
Choudhury, Tanupriya, 61, 115
Christy Jeba Malar, A., 153, 179

D
Deva Priya, M., 153, 167, 179
Dewari, Sapna, 325
Dhanalakshmi, Samiappan, 391
Dikondwar, Sushil, 297
Dinkar, Shail Kumar, 645

E
Elisetti, Sanjay Kumar, 481
Ettyem, Sajjad Ali, 367
Ezhilarasan, N., 577

F
Felix, A., 567, 577, 587

G
Garg, Sharvan Kumar, 411

D. K. Sharma et al. (eds.), *Micro-Electronics and Telecommunication Engineering*, Lecture Notes in Networks and Systems 617,
https://doi.org/10.1007/978-981-19-9512-5

Gehlot, Anita, 455
Gomathi, B., 317
Goud, Jayant Singh, 481
Gupta, Arushi, 1
Gupta, Meenu, 325, 345
Gupta, Priyanka, 309
Gupta, Richa, 27
Gupta, Sugandh, 1
Gupta, Yamini, 93
Güneşer, Muhammet Tahir, 629

H
Habeeb, Sundus Q., 621
Hussein, Mohammed J., 611

I
Iram, Faiza, 357

J
Jacob, Suma Sira, 153
Jain, Ayushi, 667
Jothi Chitra, R., 287

K
Kareem, Noor Riyadh, 621
Karim, Lamia, 519
Kaur, Navneet, 481
Kiruthick, R., 167
Kishor, Kaushal, 83
Koushik, Katakam, 555
Kumar, Arpit, 93
Kumar, Prateek, 49
Kumar, Raghvendra, 127
Kumar, Rakesh, 325, 345
Kumar, Sanjeev, 401

L
Lavanya, K., 73
Le, Dac-Nhuong, 637
Lokesh, S., 317
Lu, Joan, 447

M
Maik, Vivek, 391
Malik, Ayasha, 495, 519, 531, 543
Malik, Pooja, 455
Malik, Praveen Kumar, 431, 447, 455, 637
Mani, Prashant, 103
Manju, I., 263
Manju, P., 431
Marudwar, Atharva, 297
Mittal, Neha, 667
Mohammad, Awwab, 421
Muthukumaran, D., 227, 235, 263

N
Naaz, Saima, 335
Nain, Aaradhya, 93
Nain, Shubham, 667
Nair, Shyam, 543
Narender, Mekala, 367
Nilofer, Shaik, 431
Nishith, M., 167

O
Obaid, Ahmed J., 325, 335, 345
Omkumar, S., 227, 235

P
Pandey, Binay Kumar, 629
Pandey, Digvijay, 629
Pandita, Shivani, 297
Paramasivam, C., 273
Parihar, Veena, 495, 519, 531, 543
Patel, Rachit, 93
Pillalamarri, Syam Sundar, 611
Prajish, 167
Puri, Gaurica, 61, 115

R
Rahim, Abdul, 637
Rajarajeshuwari, S., 287
Rao, Hamnah, 335
Raut, Roshani, 297
Rawat, Harsh, 1
Rawat, Vipin, 49
Roy, Shanta, 37

S
Sahu, Sandipan, 127
Saikumar, K., 357, 367, 611
Saini, Himanshi, 143
Saini, Kamaljit Singh, 481
Sambhav, Saurabh, 655
Sampath Dakshina Murthy, A., 357
Sam Peter, S., 179
Sanmugam, Bhuvana, 215

Sarker, Aditi, 37
Şeker, Cihat, 629
Sengathir, J., 153, 179
Seth, D. D., 309
Shafi, Pathan Mohd, 127
Shakshi, 143
Shanthini, M., 215
Sharma, Anurag, 465
Sharma, Avni, 93
Sharma, Rohit, 531
Sharma, Shanon, 345
Sharma, Vivek, 401
Shayanki, 273
Shekhar, 597
Shokeen, Safina, 465
Siddiqui, Farheen, 421
Singh, Anshika, 411
Singh, Gagandeep, 115
Singh, Harbinder, 465
Singh, Jayant, 1
Singh, Neha, 195
Singh, Prabhjeet, 83
Singh, Rajesh, 455
Singh, Ranjit, 481
Singh, Shilpi, 655
Sivakumar, M., 227, 235, 263
Sivarathinabala, M., 287
Sneha, 447
Srinivasan, K. S., 263
Srinivasan, T. S., 391
Srivastava, Jaya, 495, 519, 531, 543
Srivastava, Jyoti, 195
Stephen, M., 567
Subramanian, Radhika, 509
Sukesh, M., 367
Sumaiya, Sadia Nowshin, 37

T
Thang, Pham Chien, 251
Tomar, Ravi, 61, 115
Trang, Ta Thi Nguyet, 251
Tyagi, Sudhanshu, 597

U
Umapathy, K., 227, 235, 263

V
Varanasi, Abhiram, 115
Vashishta, Rhea, 83
Vashisht, Manisha, 49
Vathana Sree, S., 287
Venkata Suryanarayana, S., 555
Verma, Jay Prakash Narayan, 103

W
Wadhwa, Garvita, 1