Studies in Computational Intelligence 1002

Vincenzo Piuri
Rabindra Nath Shaw
Ankush Ghosh
Rabiul Islam *Editors*

AI and IoT for Smart City Applications

Springer

Studies in Computational Intelligence

Volume 1002

Series Editor

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland

The series "Studies in Computational Intelligence" (SCI) publishes new developments and advances in the various areas of computational intelligence—quickly and with a high quality. The intent is to cover the theory, applications, and design methods of computational intelligence, as embedded in the fields of engineering, computer science, physics and life sciences, as well as the methodologies behind them. The series contains monographs, lecture notes and edited volumes in computational intelligence spanning the areas of neural networks, connectionist systems, genetic algorithms, evolutionary computation, artificial intelligence, cellular automata, self-organizing systems, soft computing, fuzzy systems, and hybrid intelligent systems. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output.

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

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

More information about this series at https://link.springer.com/bookseries/7092

Vincenzo Piuri · Rabindra Nath Shaw ·
Ankush Ghosh · Rabiul Islam
Editors

AI and IoT for Smart City Applications

Springer

Editors
Vincenzo Piuri
Department of Computer Science
University of Milan
Milano, Italy

Ankush Ghosh
School of Engineering and Applied Sciences
The Neotia University
Sarisha, West Bengal, India

Rabindra Nath Shaw
Department of Electrical, Electronics and Communication Engineering
School of Engineering
Galgotias University
Greater Noida, India

Rabiul Islam
School of Electrical, Computer and Telecommunications Engineering (SECTE)
Faculty of Engineering and Information Sciences
University of Wollongong
Wollongong, NSW, Australia

ISSN 1860-949X ISSN 1860-9503 (electronic)
Studies in Computational Intelligence
ISBN 978-981-16-7497-6 ISBN 978-981-16-7498-3 (eBook)
https://doi.org/10.1007/978-981-16-7498-3

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

Human society is rapidly moving towards smart cities which provide better quality of life to its citizens with the help of advanced technologies like IOT, artificial intelligence, cloud computing, blockchain, etc., in the area of transport, traffic management, environment, interaction with government, and even in the local economy. Because of the comfortable lifestyle and digital security, maintaining a system is needed for time-saving life. Smart city is bringing a cloud-connected system that revolves around the smart city ecosystems; whether they are smart homes, smart factories, smart hospitals, smart public places, smart shopping malls, smart traffic systems, smart waste management systems, or UAVs and AGVs. Therefore, a lot of advanced technologies are associated to develop the smart city ecosystem which needs a lot of research in the area of smart city.

This book provides a valuable combination of the relevant research work on developing a smart city ecosystem from the Artificial Intelligence (AI) and Internet of Things (IOT) perspective. The technical research works presented here are focused on a number of aspects of smart cities: smart mobility, smart living, smart environment, smart citizens, smart government, and smart waste management systems as well as related technologies and concepts. This monograph offers critical insight into the key underlying research themes within smart cities, highlighting the limitations of current developments and potential future directions.

Milano, Italy — Vincenzo Piuri
Greater Noida, India — Rabindra Nath Shaw
Sarisha, India — Ankush Ghosh
Wollongong, Australia — Rabiul Islam

Contents

Editors and Contributors

About the Editors

Dr. Vincenzo Piuri is Professor at the University of Milan, Italy (since 2000). He was Associate Professor at Politecnico di Milano, Italy, Visiting Professor at the University of Texas at Austin, USA, and Visiting Researcher at George Mason University, USA. He has founded a start-up company in the area of intelligent systems for industrial applications and is active in industrial research projects. He received his M.S. and Ph.D. in Computer Engineering from Politecnico di Milano, Italy. His main research and industrial application interests are artificial intelligence, intelligent systems, computational intelligence, pattern analysis and recognition, machine learning, signal and image processing, biometrics, intelligent measurement systems, industrial applications, distributed processing systems, Internet of things, cloud computing, fault tolerance, application-specific digital processing architectures, and arithmetic architectures. He published over 400 papers in international journals, international conference proceedings, and books. He is Fellow of the IEEE and Distinguished Scientist of ACM. He has been IEEE Vice President for Technical Activities (2015), Member of the IEEE Board of Directors (2010–2012, 2015), and President of the IEEE Computational Intelligence Society (2006–2007). He is Editor-in-Chief of the IEEE Systems Journal (2013–2019).

Dr. Rabindra Nath Shaw is currently working as Associate Professor in the Electrical Engineering Department also holding the post of Director, International Relations of Galgotias University India. He is an alumnus of the Applied Physics department, University of Calcutta, India. He is Senior Member of IEEE Industry Application Society, USA, and Fellow of Nikhil Bharat Shiksha Parisad, India. Dr. Shaw is a global leader in organizing international conferences. His brand of world-leading conference series includes IEEE International Conference on Computing, Power and Communication Technologies (GUCON), IEEE International Conference on

Computing, Communication and Automation (ICCCA), IEEE IAS Global Conference on Emerging Technologies (GlobConET), International Conference on Electronics & Electrical Engineering (ICEEE), International Conference on Advances in Computing and Information Technology (ICACIT), etc. He holds the position of Conference Chair, Publication Chair, and Editor for these conferences. These conferences are held in collaboration with various international universities like Aurel Vlaicu University of Arad, University of Malaya, and University of Siena. Many world leaders are working with Dr. Shaw in these conferences. Most of these conferences are fully sponsored by IEEE Industry Applications Society, USA, and Springer Nature, Singapore. He is also an expert in organizing International Seminars/Webinars/Faculty Development Program in collaboration with leading institutes across the world. His research interests include optimization algorithms and machine learning techniques for power systems, IoT applications, renewable energy, and power electronics converters. He has published more than seventy-five papers in Scopus/Web of Science/SCI-indexed international journal/proceedings including high-impact factor journals in the field of renewable energy. He has also published several edited books from Springer and Elsevier publishing houses. Dr. Shaw has worked on many national/international patents. Dr. Shaw has successfully executed his duty in various positions like Governing Body Member, Center in Charge, NBA Coordinator, University Examination Coordinator, University MOOC's Coordinator, University Conference Coordinator, and Faculty in Charge, Centre of Excellence for Power Engineering and Clean Energy Integration.

Dr. Ankush Ghosh is Associate Professor in the School of Engineering and Applied Sciences, The Neotia University, India, and Visiting Faculty at Jadavpur University, Kolkata, India. He has more than 15 years of experience in Teaching, research as well as industry. He has outstanding research experiences and published more than 60 research papers in International Journal and Conferences. He was Research Fellow of the Advanced Technology Cell—DRDO, Govt. of India. He was awarded National Scholarship by HRD, Govt. of India. He received his Ph.D. (Engg.) Degree from Jadavpur University, Kolkata, India in 2010. His UG and PG teaching assignments include microprocessor and microcontroller, AI, IOT, Embedded and real-time systems, etc. He has delivered Invited lectures in a number of international seminars/conferences, refresher courses, and FDPs. He has guided a large number of M.Tech. and Ph.D. students. He is Editorial Board Member of seven International Journals.

Md. Rabiul Islam received the Ph.D. degree from University of Technology Sydney (UTS), Sydney, Australia, in 2014 in electrical engineering. He was appointed Lecturer at RUET in 2005 and promoted to Full Professor in 2017. In early 2018, he joined the School of Electrical, Computer, and Telecommunications Engineering (SECTE), University of Wollongong (UOW), Wollongong, Australia. He is Senior Member of IEEE. His research interests are in the fields of power electronic converters, renewable energy technologies, power quality, electrical machines, electric vehicles, and smart grid. He has authored or co-authored more than 230 papers including 70 IEEE Transactions/IEEE Journal papers. He has written or edited 5 technical books published by Springer and Taylor & Francis. He has received several Best Paper Awards including 2 Best Paper recognitions from IEEE Transactions on Energy Conversion in 2020. He has served as Guest Editor for IEEE Transactions on Energy Conversion, IEEE Transactions on Applied superconductivity, and IET Electric Power Applications. Currently he is serving as Editor for IEEE Transactions on Energy Conversion and IEEE Power Engineering Letters, and Associate Editor for IEEE Access. He is also editing a special issue entitled "Advances in High-frequency Isolated Power Converters" for IEEE Journal of Emerging and Selected Topics in Industrial Electronics. He has received funding several times from Government and Industries including Australian Government ARC Discovery Project 2020 entitled "A Next Generation Smart Solid-State Transformer for Power Grid Applications".

Contributors

Sambhav Aggarwal Department of Computer Science Engineering, Maharaja Agrasen Institute of Technology, New Delhi, India

Tanweer Alam Islamic University of Madinah, Madinah, Saudi Arabia

Avishek Banerjee Department of Information Technology, Asansol Engineering College, Asansol, India

Pradeep Bedi Computer Science and Engineering, KCC Institute of Technology and Management, Greater Noida, Uttar Pradesh, India;
Computer Science and Engineering, Lingaya's Vidyapeeth, Faridabad, Haryana, India

Vedansh Bhardwaj Department of Electrical and Electronics Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, India

Samiran Chattopadhyay Department of Information Technology, Jadavpur University, Kolkata, India

Vijay Kumar Chaurasiya Indian Institute of Information Technology, Devghat, Jhalwa, Prayagraj, Uttar Pradesh, India

Reny Joy Chennattu Singapore Institute of Technology, Singapore, Singapore

Nataraj Das Deptartment of Computer Science and Engineering, NIT Agartala, Agartala, India

Victor Das Department of Information Technology, Asansol Engineering College, Asansol, India

Sudip Kumar De Department of Information Technology, Asansol Engineering College, Asansol, India

Suman Deb Deptartment of Computer Science and Engineering, NIT Agartala, Agartala, India

Jai Garg Department of Electronics and Communication Engineering, Dr. Akhilesh Das Gupta Institute of Technology and Management, New Delhi, India

Ankush Ghosh School of Engineering and Applied Sciences, The Neotia University, Sarisha, West Bengal, India

Hardik Gossain Department of Electronics and Communication Engineering, Dr. Akhilesh Das Gupta Institute of Technology and Management, New Delhi, India

S. B. Goyal City University, Petaling Jaya, Malaysia

Ruchi Gupta Ajay Kumar Garg Engineering College, Ghaziabad, Utter Pradesh, India

Anjali Jain Department of Electrical and Electronics Engineering, Amity University Uttar Pradesh, Noida, India

Rachit Jain Department of Electrical and Electronics Engineering, Dr. Akhilesh Das Gupta Institute of Technology and Management, New Delhi, India

Dinesh Kumar Marwadi University, Rajkot, Gujarat, India

Peter Kok Keong Loh Singapore Institute of Technology, Singapore, Singapore

Koushik Majumder Department of Computer Science and Engineering, Makaut, Kolkata, India

Krishna Mridha Marwadi University, Rajkot, Gujarat, India

Debosmit Neogi Deptartment of Computer Science and Engineering, NIT Agartala, Agartala, India

Anand Singh Rajawat Department of Computer Science Engineering, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, India

Yaswanth Rasamsetti Department of Electrical and Electronics Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, India

Bhavya Sharma Department of Electrical and Electronics Engineering, Dr. Akhilesh Das Gupta Institute of Technology and Management, New Delhi, India

Rabindra Nath Shaw Department of Electrical, Electronics and Communication Engineering, Galgotias University, Greater Noida, Uttar Pradesh, India

Sunakshi Singh Indian Institute of Information Technology, Devghat, Jhalwa, Prayagraj, Uttar Pradesh, India

Mohd Tajammul Department of Computer Science, Jamia Millia Islamia, New Delhi, India

Gunjan Taneja Department of Electrical and Electronics Engineering, Amity University Uttar Pradesh, Noida, India

Vipina Valsan Department of Electrical and Electronics Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, India

Chandra Sekar Veerappan Singapore Institute of Technology, Singapore, Singapore

Neelam Verma Department of Electrical and Electronics Engineering, Amity University Uttar Pradesh, Noida, India

Shivnath Yadav Indian Institute of Information Technology, Devghat, Jhalwa, Prayagraj, Uttar Pradesh, India

Smart Drone Controller Framework—Toward an Internet of Drones

Chandra Sekar Veerappan, Peter Kok Keong Loh, and Reny Joy Chennattu

Abstract There has been an increasing trend to use multiple drones to cooperate autonomously beyond visual line-of-sight missions such as remote services, digital governance and planning, control of safety and security in a smart nation/smart city. In addition, machine learning (ML) has emerged as a key enabler to achieve efficiency in missions such as object detection and intruder detection. In this context, most of the commercially off-the-shelf Wi-Fi drones have limited resources and do not offer any firmware customization; these inherent limitations and technical gaps highlight the need for a software-based smart controller framework to realize support for a team of autonomous drones working together as an Internet of Drones (IoD). This can form the basis for strategic management of new Smart Cities that aim to optimize resources utilization and autonomize services. In this chapter, we present a preliminary architectural design to support needed capabilities and features of a cross-platform Smart Drone Controller (SDC) framework. An SDC framework supports a deployed team of Wi-Fi-based drones to conduct assigned missions collaboratively. The SDC's ML engine has an option to choose algorithms according to the assigned mission. Overall, our SDC framework prototype improves the reliability of the team-based mission and enables a mixed selection of commercial drones to be deployed remotely and collaboratively as an IoD to create positive impact in service autonomy offered to smart city residents. This chapter details framework's implementation and results with multiple Tello Edu drones assigned to an intruder drone detection mission.

Keywords UAV · Drones · Controller framework · Smart city · Machine learning · Object detection · Computer vision · Surveillance

---

C. S. Veerappan (✉) · P. K. K. Loh · R. J. Chennattu
Singapore Institute of Technology, Singapore, Singapore
e-mail: chandra.veerappan@singaporetech.edu.sg

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_1

Abbreviations

UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft Systems
SDC	Smart Drone Controller
C3I	Command Control Communication and Intelligence
MME	Mission Management Engine
MLE	Machine Learning Engine
FCE	Flight Control Engine
IoD	Internet of Drones
YOLO	You Only Look Once
CNN	Convolution Neural Networks
SSD	Single Shot Detection

1 Introduction

Drones/UAV's are increasingly becoming part of a smart city's infrastructure [1]. Smart city core applications include traffic monitoring, crowd monitoring, critical infrastructure inspection, management of limited resources such as air/water quality, tourism-related activities, geodetic works for remote sensing, delivery of goods, solution to natural disasters, and healthcare applications[2]. With the advent of the Internet of Things (IoT), drone networking has been given a new terminology called "Internet of Drones" (IoD). IoD works as a layered network control architecture designed mainly for coordinating the access of Drones in controlled airspace and providing navigation services between locations referred to as nodes [3]. Since drone communication lacks standards, they face several challenges in interoperable implementation, design, and deployment in smart city applications and other domains. For example, multiple Wi-Fi Drones working on large-scale missions or swarm operations face the following issues.

Cross Platform: Drone vendor supplied Software Development Kit (SDK)/Application Programming Interface (API) may be limited to mobile operating system (OS) platforms only. Usually, an SDK may be used to execute custom code in the drone during the flight. When missions involve heterogenous drones then controllers with more interoperable platforms, e.g., Windows/Linux OS may be needed for special-purpose applications and services.

Data Harnessing: With multiple missions, the drone's flight control data and sensor data need to be stored in the backend (example: video surveillance footage). This historical data helps enhance future drone incidents; mission statistics and outcomes can help to improve the efficiency and effectiveness of operational protocols and procedures. Further, to get actionable insights from this data, support from ML-based analysis with implementation/customization of appropriate ML algorithms and computer vision-based solutions are needed. In some remote missions, it would be operationally effective if drone behavioral autonomy can be extended in real time, e.g., able to change the altitude of the drone or the camera angle, when certain infrastructural or object points or areas require closer observation.

Extending Range: Wi-Fi drones supported by the 802.11 family of protocols offer less than 250 m range in open space [4]. Operating environment interference, device used, and other parameters can affect the operating range which leads to degradation of operational effectiveness of the team-based drone mission. These issues clearly point to the need for a Smart Drone Controller (SDC) framework, which supports the Internet of Drone (IoD) infrastructure to realize better operational decision-making and consensus achievement for the mission's drone team. For example, the SDC can be implemented on mobile endpoint nodes inside a mesh network to increase the drone team's operating range. In this context, we propose a cross-platform (Linux, Windows, Android OS) SDC framework. It communicates directly with the Drone's access point via Wi-Fi. The SDC comprises four core sub-systems as follows

(1) Command, Control, Communications, and Intelligence (**C3I**)
(2) Mission Management Engine (**MME**)
(3) Machine Learning Engine (**MLE**)
(4) Flight Control Engine (**FCE**).

The rest of the chapter is organized as follows. Related work and the SDC framework's technical overview are reviewed in Sect. 2. The proposed SDC framework's design and functionality are then discussed in Sect. 3. Section 4 examines the application of the SDC framework in an Intruder drone detection mission. The results in Sect. 5 shows the outcome of the deployed mission—a real-time object detection task in the Intruder drone detection mission. Object detection is implemented using SDC's ML Engine with YOLO4/Darknet library, and performance evaluation is done empirically. In Sect. 6, we present our conclusions and future work.

2 Related Work

Ground drone controller or smart drone controller-related works are not readily available in the literature. However, we have reviewed some of the important articles related to IoT for drones or swarm operation's domain. In Ref. [5], the authors describe how the multiple UAV or drone services with IoT platform operate with oneM2M global standard. An automated UAV-based surveillance system using multiple drones (**Patrol** UAV and **Tracking** UAV) was also implemented. However, their surveillance mission depends on the video being transmitted through the camera mounted on the UAV, for a user to act and no implementation of machine learning approaches is involved for the mission. In Ref. [6], authors have attempted to provide vision-based drone swarms by Imitation Learning (another approach of reinforcement learning). It is more toward a fully decentralized, vision-based swarm with no communication. In Ref. [4], the authors analyze UAV IoT framework views and challenges to efficient deployment of drones as "Things" with architecture, security, and privacy points of view. Furthermore, the literature covers how to extend the IoT security layers to UAV including vision-based security enhancements that support self-protection and path/destination identification, safe landing locations by using video-processing and computer-vision (CV) techniques. However, no implementation details of these techniques were discussed. In reference [7], the authors explained well about machine-learning-based real-time object detection on an Android OS mobile platform with some benchmarking results. We note the details mentioned and consider these points when implementing SDC on the Android OS platform. A lot of related works found in the literature [8–11].

As an alternative to drone firmware customization, commercial drones like Tello Edu can be programmed via predefined code blocks to do basic flight navigation. Currently, there is no support for autonomous teamwork. Similar limitations are inherent in the AR Parrot Drone system. A comparison analysis overview of related commercial offerings follows:

- **Services** companies offer drones equipped with computer vision and AI. AI-processed image data from such drones yields actionable insights, however, no autonomous teamwork is supported. Examples include Drone Sense, Neurala, Scale, Skycatch, Alive, Skydio, etc. [12].
- **Domo** uses IP mesh technologies [13] that provide decision-support with predictive analytics to business users. Drones need to be coordinated and controlled via human operators via the mesh-based network.
- **Skylark Drones** uses cloud-based intelligence with system-integrated drones to enhance a customer's insights in sectors like utilities and infrastructure [14]. Machine learning is used only to process drone data. User-managed services that the company offer includes analysis, tracking, and detection.
- **Optelos** is a leading provider of secure drone data management and AI analytics software. However, the software executes on backend servers that depend on a cloud-based platform for connectivity. An app is available to streamline delivery of actionable drone data [15].
- **DroneDeploy** is a leading cloud software platform for commercial drones. Software automates individual drone's flight and facilitates the capture of aerial data with a mobile app. The DroneDeploy software platform processes the imagery using computer vision. There are solutions for user-controlled drone-based mapping, modeling, and data analytics capabilities [16].
- **Garuda Robotics** uses a BVLOS platform that will be controlled by a Drone Operations Centre [17]. There is currently no reported work on autonomous teamwork in drones.

Often, the remote physical environments that drones operate in, may prohibit the use of enterprise cloud-based platforms. Further constraints include the data transfer overheads and the limited computing resources on each drone. Beyond these, the above offerings apply machine learning to drone-collected data and not operational mission-focused data, e.g., mission progress, drone actions/status, or event history etc. They also still require human intervention and control via internet/cloud connectivity with no support for smart autonomous teamwork among multiple drones. Unlike any other approach in recent literature, our main contribution in this chapter is to design and develop smart drone controller (SDC) framework with implementation of mission-based deep learning algorithm like YOLO/Darknet for real-time object detection while SDC receiving video streaming from the drone/UAV; further in this process, we evaluate the deep learning algorithms and benchmark it.

3 Smart Drone Controller Design and Functions

The Smart Drone Controller (SDC) is designed in Qt C++, a cross-platform application development technology for desktop, embedded and mobile applications on Linux platform. The SDC framework prototype is installed on laptop computers running Ubuntu 20.04 LTS platforms. Each laptop computer has an external Wi-Fi access card to enable wireless connection to a mission drone. The laptop's internal Wi-Fi card connects, in turn, to a wireless local area network (LAN) supported by router. This forms the mesh network and facilitates other SDCs to connect within network range. For user identification purpose, we label the first connected laptop computer as SDC 1. Subsequent laptop computers joining the LAN network are identified as SDC 2, SDC 3, etc., though each SDC's IP address act as unique identifier referenced as ***SDCi@192.160.0.102,where i = 1, 2, 3…***

Tello Edu drones are used drone team (Patrol and Tracking), which can capture 5MP photos, streaming 720p HD video, and around 13 min flight time per fully charged battery. Its SDK connects to the aircraft through a Wi-Fi UDP port, allowing programmatic control of the drone with text-based commands. A GUI (Graphical User Interface) dashboard provides administrative control during development, testing and mission specification, and selection phases. The completed SDC framework is envisaged to be operationally deployed as depicted in Fig. 1.

The SDC framework deployed in a basic network is shown with SDC 1 and SDC 2 running different operating systems in Fig. 2. One of the SDC design goals is to support cross-platform deployment. It has four core sub-systems with dedicated functionalities as shown in Fig. 3.

i. **Command, Control, Communications, and Intelligence (C3I) Sub-system**

   The C3I sub-system is used to support the sharing of mission-focused data and actionable insights, assist the correlation and generation of decisions as well as the achievement of team consensus. Mission-focused data is based on specified surveillance and inspection scenarios. Examples include mission progress, drone actions/status or event history, etc. The (C3I) sub-system is designed to run cross-platform and supports multi-media data transmissions. It is customized from an existing C3I sub-system used in an earlier IoT Real-time Security Framework [18].

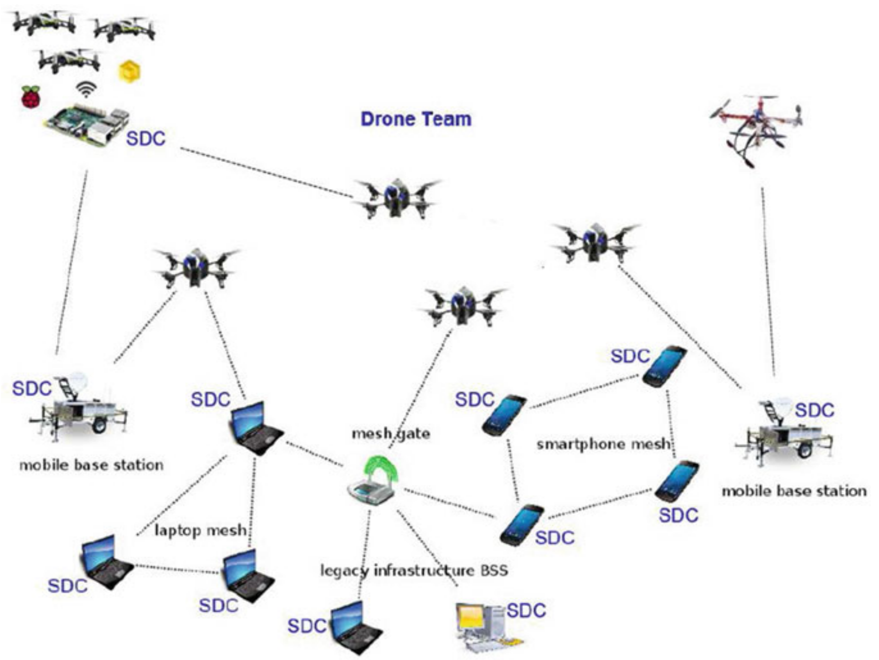


Fig. 1 SDC framework architecture

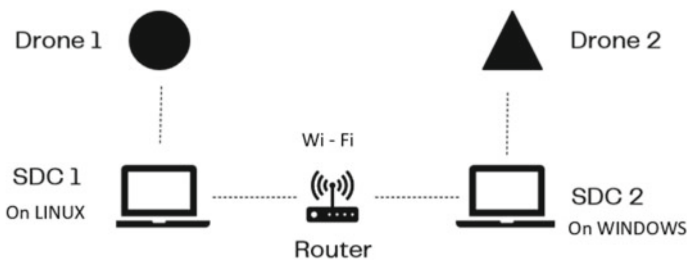


Fig. 2 SDC framework basic network

ii. **Mission Management Engine (MME)**

The MME references and correlates mission-focused data, actionable insights shared by the C3I sub-system to decide on the next course of action. Its main objective is to coordinate mission flight progress and drone team actions. A prioritized set of decisions will be derived and validated by each drone controller to achieve team consensus. The Plug-and-Play Mission Interface facilitates the integration of a range of mission-specific surveillance and inspection apps with no change of the core SDC framework code.

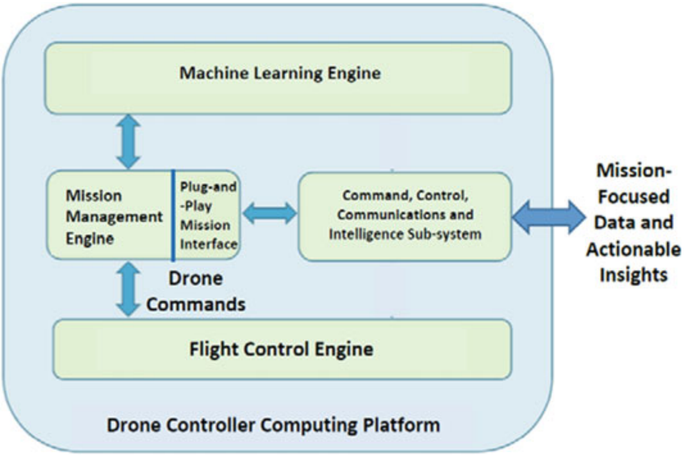


Fig. 3 SDC core sub-systems

iii. **Machine Learning Engine (MLE)**

Mission-specific directives are disseminated to the drone team via the C3I sub-system. A mission-focused machine learning algorithm considers the data (mission flight configuration, team actions, events history, and mission progress) to generate actionable insights. These insights will be shared with the drone team before consensus is derived. This differs from commercial offerings that apply machine learning only to collected drone data.

iv. **Flight Control Engine (FCE)**

The Flight Control Engine's primary purpose is to control drone flight behavior. It will support the integration of a set of customized flight navigation parameters and code libraries for the specified deployed drones. In addition, we design the SDC framework prototype with a Graphical User Interface (GUI) dashboard application that supports developer administration during the implementation, integration, and testing phases as well as mission administration.

3.1 GUI Support for C3I

The core functionalities of C3I may be programmed pre-mission in the SDC dashboard's home page where mission selection, network connectivity of SDC, and drone's network and battery status updates are displayed. Figure 4 shows the screenshot of C3I page. It has the following functions:

- Get the IP address (self) of SDC
- Show the available SDC in the network
- Get the IP address of drone and network status

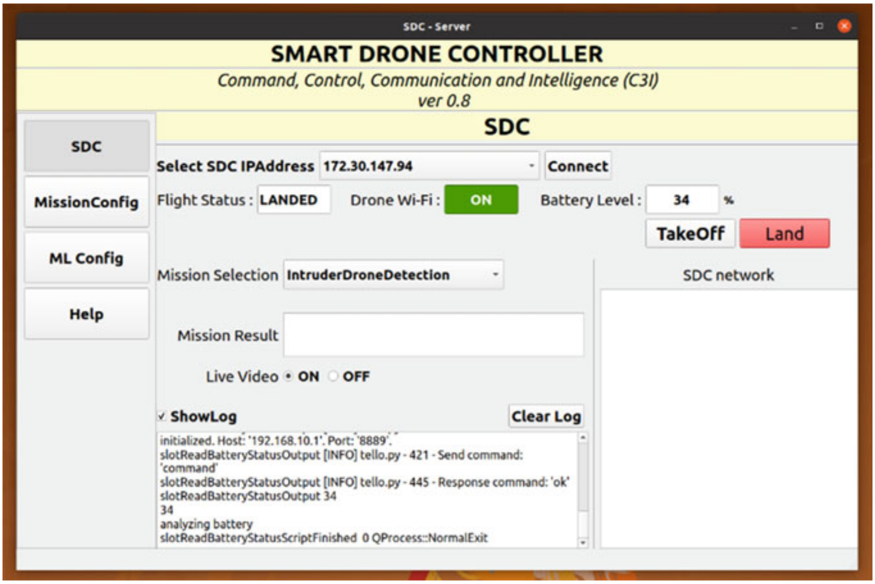


Fig. 4 Dashboard (C3I) home page

- List the available missions for user selection
- Send the Take-off and other mission commands
- Showing the streaming video during flight
- All SDC messages are shown as log and stored in SDCLog folder.

The selected mission routine starts when the user clicks the "**TakeOff**" button. The C3I sub-system verifies that the required mission and machine learning parameters are configured correctly. If there are errors, error messages will be shown in the log. Overall, the C3I plays a critical role to support successful mission completion.

3.2 GUI Support for MME

The drone mission flight details such as Takeoff altitude **<UP>**, distance to move **<FORWARD/BACKWARD>**, movement direction **<RIGHT/LEFT>** options are available to user on the MME page. These mission configuration details are saved in the **SDC.ini** file for each mission and passed to the C3I sub-system. The distance to move is referred as the distance between "Point A to Point B" where point A is the starting point of the mission and Point B is the destination. Figure 5 shows the MME's configuration page.

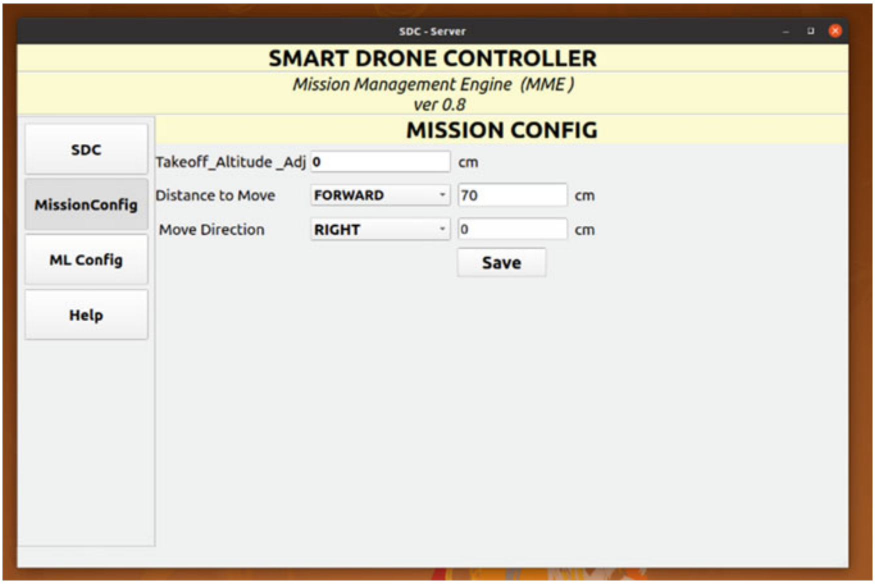


Fig. 5 MME configuration page

3.3 GUI Support for MLE

When a new mission is created, the MME's configuration is uploaded by user as shown in Fig. 6. Following this, the selected mission's ML configuration will be loaded automatically by MLE from the SDC.ini file. Clicking the **Add** button, a new mission is created, the related machine learning weights, configuration, data file, and names file are uploaded by the user. These files are saved in the **SDC.ini** file and mission folder. The selected mission and files are deleted from mission folder and SDC.ini file by the **Delete** button. The **Edit** option serves to update the ML configuration file.

The values are passed to C3I module where the selected mission's machine learning model, configuration files, and other related modules are loaded. Hence, the SDC mission routine starts when the user clicks the "Take-off" button on the C3I Home page. We have implemented the real-time object detection using YOLOv4/Darknet [19]—Neural Networks library for Object Detection. The following section describes the Intruder drone detection mission used to verify the functionality of the SDC framework prototype.

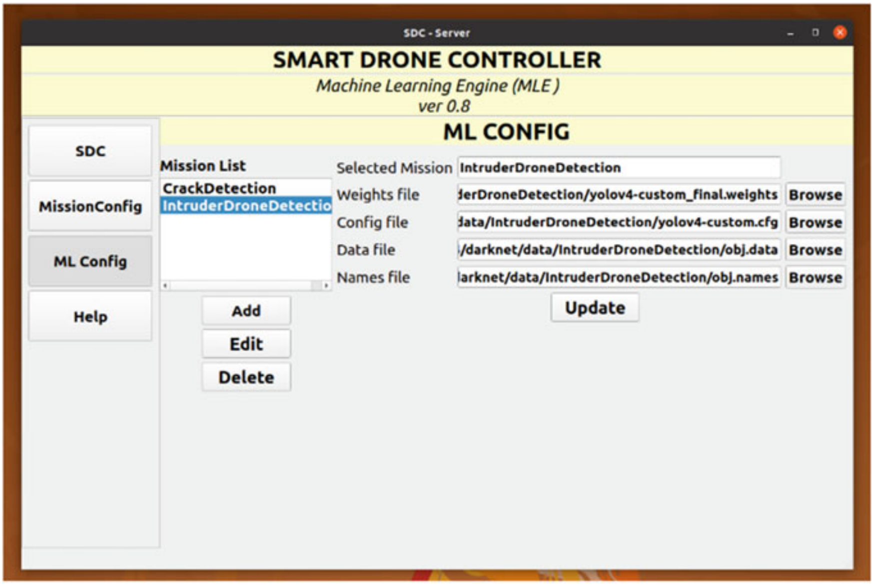


Fig. 6 MLE configuration page

4 Mission Deployment

Deployment of the drone team (**Patrol and Tracking drone**) in the Intruder drone detection mission involves the following steps

(1) At point A, SDC 1's—Patrol drone 1 checks the mission configuration, takes off and flies to waypoint B.
(2) At waypoint B, the Patrol drone searches for the Intruder drone and detects the target. The drone then informs SDC 1 and alerts the user.
(3) SDC 1 then informs the other SDCs in the local network, i.e., SDC 2, SDC 3 via the C3I sub-system.
(4) The corresponding Tracking drones 2 and 3 are remotely tasked by SDC 2 and SDC 3, independently, to fly to waypoint B to confirm the detection of the intruder drone. Upon confirmation, drones 2 and 3 informs SDC 2 and SDC 3, respectively.
(5) With receipt of intruder alert messages from all 3 SDCs via the C3I sub-system, SDC 1 correlates all received alerts and reaches consensus that there is an intruder detected at waypoint B. The mission flow is described in Fig. 7.

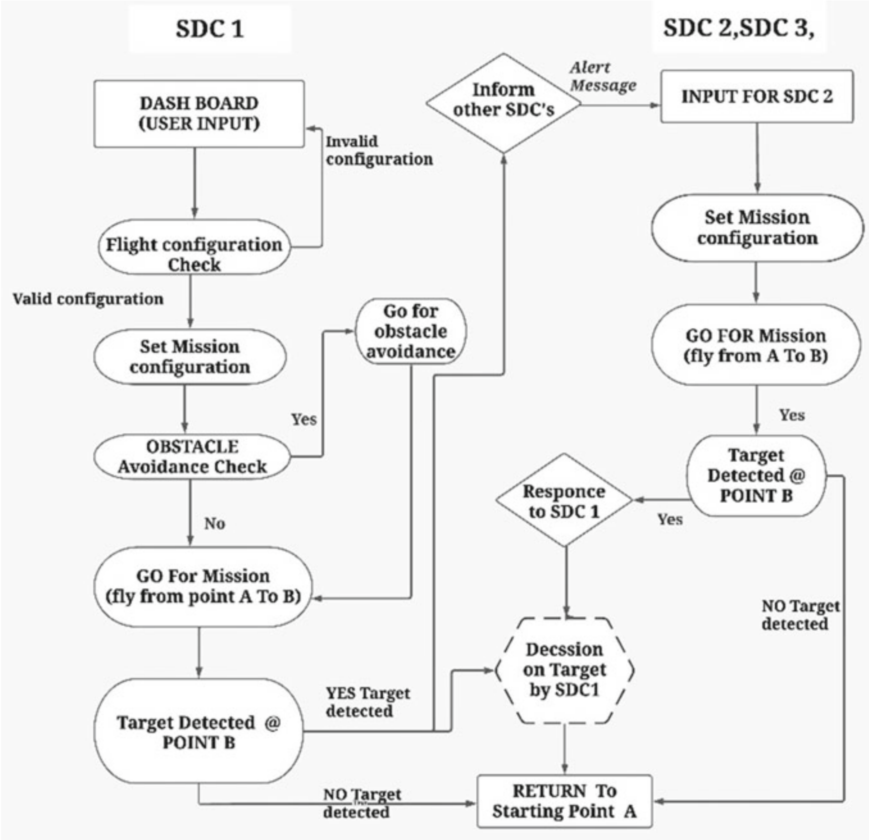


Fig. 7 Intruder drone detection routine

5 Intruder Drone Detection Mission Results

Intruder drone detection is an object detection problem. Recent developments in convolution neural networks (**CNN**) have increased the deep learning methods in the image detection algorithms. Algorithms such as Single Shot Detection **(SSD),** Faster Region-based Convolutional Neural Networks (**Faster R-CNN**), and You Only Look Once (**YOLO**). Among this YOLO version 3 (YOLOv3) shows the best overall performance [20]. Last year, the YOLOv4 was released by Alexey Bochkovskiy, and **there** were a large number of features that are said to improve Convolutional Neural Network (**CNN**) accuracy [21]. In this preliminary research work, we have experimented with and used YOLOv4/YOLOv4 Tiny as deep learning library with Darkent as a backbone in Machine Learning Engine (MLE). Our training dataset parameters are:

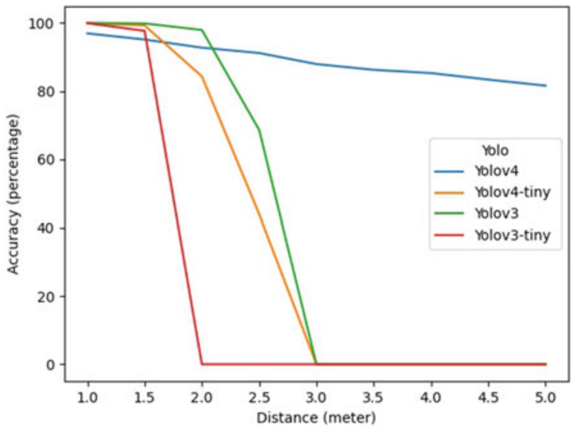


Fig. 8 YOLO version comparison

- 200 DJI MINI drone images to train as an intruder drone
- Transfer learning used with pre-trained YOLOv4 weights
- Image size: 416 × 416
- Batch size 6000
- Size of yolov4-custom_best.weights = 256 MB
- Size of yolov4-tiny- custom_best.weights = 23.5 MB
- Test System configuration: i7 i7-10750H CPU @ 2.60 GHz/RTX 2060 (6 GB)/Memory 32 GB RAM.

The training dataset consists of DJI Mini's images from the public-domain and images captured by our team.YOLOv4 Tiny/YOLOv3 Tiny are simplified versions of YOLOv3/YOLOv4. YOLO-Tiny algorithm developed for embedded devices with poor data processing capabilities. Its model structure is simple but the detection accuracy is low.

Figure 8 shows our experimental outcomes with different YOLO models on detecting intruder drone. In this test, we found that only YOLOv4 can detect the Intruder drone target with >80% accuracy up to a 5 m distance. But the YOLO-Tiny version is faster and more lightweight than others. This mission requires detection of the Intruder drones at maximum distance. To conclude, the YOLO v4 model is the best choice.

The next stage of our experiment is to improve the accuracy in the YOLO v4 model with different sized image sets—320 × 320, 416 × 416, 608 × 608. The image size is dimensions width and height of the neural network in the YOLOv4 configuration file during training. As shown in Table 1, we can see that when the image size increases, we get more accuracy percentage on the detection, but it also incurs more processing time during training the dataset. We have decided to use YOLOv4 with 416 × 416 frame size model for this performance verification stage for near optimality.

Table 1 YOLOv4 training image size comparison

Distance (m)	Accuracy at image size		
	320 × 320	416 × 416	608 × 608
1.0	97.65	96.92	99.16
1.5	88.53	95.12	98.28
2.0	75.25	92.73	98.36
2.5	55.23	91.16	94.35
3.0	55.23	87.91	93
3.5	Not detected	86.23	85.69
4.0	Not detected	85.27	76.43
4.5	Not detected	83.36	65.64
5.0	Not detected	81.58	Not detected

6 Conclusion and Future Work

In this work, we have presented the context, design, and functionality of the Smart Drone Controller (SDC) framework. The real-time object detection mission implemented with ML engine in the SDC framework prototype was verified. The intruder drone was detected with 80% accuracy consistently. This is an important use case that leverages the current developments in Machine Learning/Deep Learning domain and introduce value-added benefits to smart city planning, governance, and support. Our Smart Drone Controller (SDC) enables access to more collaborative drone-based services and technologies, support standardization of cross-platform development efforts, facilitate seamless integration of drone networks in a digital economy and lifestyle.

At present, the SDC framework design and features are still at an early stage of development and the software is in beta mode. There is potential for improvement, and we plan to add:

- Collision avoidance to ensure safe operations of mission routes.
- Collect the metrics like route length, minimum distance, battery used, total time, time per each computation step, no. of unsuccessful missions, etc.
- Optimization of ML algorithms to reduce the latency and improve accuracy for a chosen mission.
- Add features to enhance the drone's network security and operational security.
- More real-time object detection applications like finding building wall cracks.
- Develop the SDC version to work in Windows OS and mobile device platform with Android OS.

Acknowledgments This research work is funded by the Ministry of Education, Singapore Translational R&D and Innovation Fund under grant MOE2019-TIF-0027.

References

1. Drones are a part of Singapore's Smart Nation strategy. https://opengovasia.com/drones-are-a-part-of-singapores-smart-nation-strategy/. Accessed 1 Sep 2021
2. Mohamed N, Al-Jaroodi J, Jawhar I, Idries A, Mohammed F (2020) Unmanned aerial vehicles applications in future smart cities, Technological forecasting and social change, vol 153. https://doi.org/10.1016/j.techfore.2018.05.004
3. Gharibi M, Boutaba R, Waslander SL (2016) Internet of drones. IEEE Access 4:1148–1162. https://doi.org/10.1109/ACCESS.2016.2537208
4. Lagkas T, Argyriou V, Bibi S, Sarigiannidis P (2018) UAV IoT framework views and challenges: towards protecting drones as "Things". Sensors 18(11):4015. https://doi.org/10.3390/s18114015
5. Park J, Choi S, Ahn I, Kim J (2019) Multiple UAVs-based surveillance and reconnaissance system utilizing IoT platform. In: 2019 International conference on electronics, information, and communication (ICEIC), 2019, pp 1–3. https://doi.org/10.23919/ELINFOCOM.2019.8706406
6. Schilling F, Lecoeur J, Schiano F, Floreano D (2019) Learning vision-based flight in drone swarms by imitation. IEEE Robot Autom Lett 4(4):4523–4530. https://doi.org/10.1109/LRA.2019.2935377
7. Martinez-Alpiste I, Casaseca-de-la-Higuera P, Alcaraz-Calero J, Grecos C, Wang Q (2019) Benchmarking machine-learning-based object detection on a UAV and mobile platform. IEEE Wirel Commun Netw Conf (WCNC) 2019:1–6. https://doi.org/10.1109/WCNC.2019.8885504
8. Mandal S, Biswas S, Balas VE, Shaw RN, Ghosh A (2021) Lyft 3D object detection for autonomous vehicles. Artif Intell Fut Gener Robot 119–136. https://doi.org/10.1016/B978-0-323-85498-6.00003-4
9. Mandal S, Md Basharat Mones SK, Das A, Balas VE, Shaw RN, Ghosh A (2021) Single shot detection for detecting real-time flying objects for unmanned aerial vehicle. Artif Intell Fut Gener Roboti 37–53. https://doi.org/10.1016/B978-0-323-85498-6.00005-8
10. Biswas S, Bianchini M, Shaw RN, Ghosh A (2021) Prediction of traffic movement for autonomous vehicles. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_12
11. Soni A, Dharmacharya D, Pal A, Srivastava VK, Shaw RN, Ghosh A (2021) Design of a machine learning-based self-driving car. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_11
12. Sam Daley, "Fighting Fires and Saving Elephants: How 12 Companies are using the AI Drone to solve Big Problems", 30 April 2019, https://builtin.com/artificial-intelligence/drones-ai-companies/
13. Domo Tactical Communications. https://www.unmannedsystemstechnology.com/company/domo-tactical-communications/. Accessed 26 July 2021
14. Skylark Drones. https://skylarkdrones.com/. Accessed 26 July 2021
15. Kaur K (2021) One-north to be designated as Singapore's first drone estate. The Straits Times, 5 Feb 2018: https://www.straitstimes.com/singapore/transport/one-north-to-be-designated-as-singapores-first-drone-estate. Accessed 26 July 2021
16. DroneDeploy: https://www.dronedeploy.com/solutions/. Accessed 26 July 2021.
17. Garuda Robotics: https://garuda.io/. Accessed 26 July 2021
18. Peter KK Loh, Tang LZ, Forest SL Tan, Wee C (2017) CELLS—a cross-platform, real-time security framework for IoT endpoints. Grant MOE 2016-TIF-1-G-02, 27 Jan 2017
19. YOLO v4: https://github.com/AlexeyAB/darknet
20. Srivastava S, Divekar AV, Anilkumar C et al (2021) Comparative analysis of deep learning image detection algorithms. J Big Data 8:66. https://doi.org/10.1186/s40537-021-00434-w
21. Paper YOLO v4: https://arxiv.org/pdf/2004.10934.pdf

Building of Efficient Communication System in Smart City Using Wireless Sensor Network Through Hybrid Optimization Technique

Avishek Banerjee, Sudip Kumar De, Koushik Majumder, Victor Das, Samiran Chattopadhyay, Rabindra Nath Shaw, and Ankush Ghosh

Abstract The 'Smart City' is a notion that has evolved in the latest period and encompasses a broad of aspects of urban life. Smart Cities will have to address several issues in the future, such as community security, transportation infrastructure, energy consumption, environmental sustainability, and cost-saving. Several elements of Smart Cities are intrinsically tied to the Internet of Things (IoT). The sensors on various IoT-enabled devices will produce heterogeneous data (data of temperature, moisture, heat, air pollution level, traffic, heath-related medical data, etc.) and that data should be sent to the server for taking a decision based on the received data. To send the data to the server an effective smart communication system should the integrated as a soul part of a Smart City. A key role is played by Wireless Sensor Networks (WSNs) in the construction of an effective smart communication network to interlink city centers using existing infrastructure with minimum investment. The WSN can be used as an alternative to building a smart network between IoT devices and the local server (Sink Node). The battery-powered sensor nodes of WSN collect, process, and communicate with the sink node using the limited battery stored energy. Because the WSNs operate unsupervised in a harsh atmosphere, it is not possible to recharge the sensors' batteries. The power of WSN nodes may also be disrupted by several hazards, resulting in node failure. As a result, the most essential aspect to look for in a smart communication system in a Smart City is energy efficiency. Another major important challenge for the construction of an effective Wireless Sensor Network is

A. Banerjee · S. K. De · V. Das
Department of Information Technology, Asansol Engineering College, Asansol 713305, India

K. Majumder
Department of Computer Science and Engineering, Makaut, Kolkata, India

S. Chattopadhyay
Department of Information Technology, Jadavpur University, Kolkata, India

R. N. Shaw
Department of Electrical, Electronics and Communication Engineering, Galgotias University, Greater Noida, India
e-mail: r.n.s@ieee.org

A. Ghosh (✉)
School of Engineering and Applied Sciences, The Neotia University, Sarisha, West Bengal, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_2

to use the existing infrastructure of a city. Therefore, in this chapter, the challenges of constructing an energy-efficient WSN network using existing infrastructure have been considered.

Keywords Wireless sensor network (WSN) · Effective construction of WSN in Smart City (***ECwSC***) · Genetic algorithm (GA) · Ant colony optimization (ACO) · Hybrid algorithm · Global pheromone update (GPU) rule · Local pheromone update (LPU) rule

1 Introduction

The fast growth in population and congestion of cities necessitates immediate improvements in their operations to enhance the quality and sustainability of urban life. Many cities in India are being planned to convert into Smart Cities to make city life more comfortable. Communication in today's Smart Cities should be smart as well. In a smart communication system, a Wireless Sensor Network (WSN) may be used as a backbone for a variety of smarter applications. The Wireless Sensor Network is a wireless network made up of interconnected inexpensive Wireless Sensor Nodes. The wireless sensor node is a small device with limited processing ability, communication range, data storing capability, battery-powered backup unit. Due to the limited resources of WSNs, the effective use of resources is always given top importance in the design of WSN networks.

The wireless sensor nodes are deployed in a specified region to establish a multihop, self-organized Wireless sensor network. The wireless sensor nodes sense the external environment to gather the data needed, which is then processed by the built-in tiny processor and the processed data is transmitted to a base station (Sink Node) via the network. The storage device of the WSN node is used for storing processed data, before and after the transmission.

The proper energy utilization, transportation infrastructure, environmental sustainability, health monitoring, intruder detection, and cost-savings are the important considerations for Smart Cities in the future. Using a wireless sensor network, an efficient and safe smart grid can be constructed. The WSN enabled smart grid senses and analyzes the power-related data and provides effective data such as meter readings, monthly bills, energy usage, etc. The smart street light monitoring & controlling system can be implemented using WSN and existing infrastructure like TCP-IP gateways of CCTV. This system can reduce the costs related to energy consumption on street lights. WSN with wearable hardware can help medical hospitality systems to monitor a patient's health condition in real time. The patient may be within the hospital or maybe at home. A quick emergency alert for a patient can save the life of that patient also. By using WSN, the standard of fresh drinking water can be measured. The data collected from various installed Air Pollution sensor stations can be sent to the Sink node through WSN and those data can be used to monitor air quality to avoid pollution-induced infectious diseases and to minimize people's health risks. In the earthquakes monitoring System, the WSN may be used to monitor seismic activity in real time which will help the authority to take precautionary measures in advance. Heat and moisture sensors can be used by the smart Assistance system to detect the exterior temperature, allowing residents to be informed about the external environment and provide appropriate suggestions. The intelligent car parking system can be built using WSN, which will help the people in different ways such as to find the vacant position in the parking, to increase safety &security, to decrease managerial costing, etc.

Contribution(s):

I. To construct an efficient Wireless Sensor Network as the backbone of the communication system the **E**ffective **C**onstruction of **W**SN in **S**mart **C**ity (***ECwSC***) Algorithm and the modified GA-ACO hybrid algorithm have been used in this chapter.
II. To minimize the energy consumption of WSN, a modified GA-ACO algorithm has been employed in this chapter.
III. A major benefit of GA lies in its ability, during crossover and mutation, to choose the best offspring from the parent chromosome.
IV. The ACO algorithm's main purpose is to improve the attractiveness function value. When it comes to solving the optimization challenge, a higher attractiveness function value might lead to better outcomes. Using the "Local Pheromone Update" (LPU) rule and the "Global Pheromone Update" (GPU) rule, the attractiveness function value was computed and the best value was picked. There is a distinction between this and the traditional approach. In the case of the traditional approach, the local search for each ant is done through the LPU rule, and after the **completion of every ant,** the pheromone is modified through the GPU rule. But in this approach, the comparison of attractiveness function values by LPU rule and GPU rule is done after each local search.

In this chapter, to construct an Energy-efficient WSN as a backbone of the Smart City the hybridized meta-heuristic algorithm named modified GA-ACO has been developed and used. The Genetic Algorithm (GA) has been used to obtain the global optima and the Ant Colony Optimization (ACO) has been used to find the local optima. Once the WSN network is constructed, the total number of nodes is determined to cover the area efficiently. The distance between each node, as well as the distance between the sink node and the WSN nodes, are then computed and shown in the table to determine the energy used by the network. The distance and data-transmission rate are two main factors used to determine the energy spent by the WSN and, effectively, a measurement of the WSN's life expectancy. It has been compared with some published literature and a notable improvement in lifespan enhancement has been observed for two existing literature, with an improvement of 84.913% for one and 21.425% for the other.

2 Literature Survey

Many researchers, as well as engineers, have worked as well working on the development [1, 2] of Wireless Sensor Networks. Since the advent of WSN, it has been used in a variety of ways in our everyday lives. When Rashid and Rahmani [3] published their work in 2016, they presented the application of WSN in an urban community. There is also an increasing tendency in the use of WSN outside of urban communities. Ojha et al. [4], released a study in 2015 on the use of WSN in agriculture. The book, "Current Status and Future Trends of Wireless Sensor Network," was published in 2016 by Khan et al. [5]. The authors reviewed recent advances and future uses of WSN.

WSN has an immense role in the configuration of the Smart City due to many reasons. In WSN the tiny node can communicate with each other very efficiently. The WSN can be attached with IoT devices to integrate and design smart models for Smart Cities [6]. Due to low infrastructure cost [7] and easy portability, the WSN can be widely used in different smart model designs in Smart Cities. Various noble applications can be materialized with the hybridization [8] of WSN and IoT. Several researchers have contributed many ideas in different engineering fields. In 2016, Komninos et al. [9] have focused on different Smart City applications. In 2019, Lau et al. [10] also have discussed many applications of WSN in Smart Cities.

The various kinds of facilities attract the people in cities. The constant growth of urbanization causes an increase in population density in the city. For this reason, cities around the world need to be equipped with rigorous infrastructure to provide necessary modern supports such as adequate and clean water supply, power supply, communication, hospitals, schools, etc. Governments and the concerned authority want to provide great quality of living in cities. This initiative will help in the economic development of the country also. To make a city intelligent or Smart City, various components [11] need to be considered. A Smart City is built with different intelligent smart components such as Smart People, Smart Home, Smart School, Smart College, Smart Hospital, Smart Surveillance, Smart Traffic, Smart Pollution Detection Technique, Smart Weather Forecasting, Smart waste management, Smart governance, and lots more [12–19]. In this paper, the authors have developed an IoT/Cloud-oriented Air Pollution Monitoring System [20] in Smart City. A mobile application has been developed which shows the Pollution level, provides the necessary guidelines in polluted areas. The WSN can help in Smart City Building process. Using WSN smart network can be established which will be considered as the backbone of the Smart City. In this chapter, the authors use the WSN and IOT to develop an environmental monitoring framework [21] to monitor the weather.

Evolutionary algorithms [22] are a subset of computational intelligence algorithms in which the repetition of different operators on a competent population improves the likelihood of generating viable solutions. A Genetic Algorithm is an efficient, metaheuristic, and biologically inspired Evolutionary algorithm that can be used to solve optimization problems [23]. GA allows for a great deal of flexibility in combining it with domain-specific heuristics to provide an efficient solution to a given problem.

In the year 1999, the researchers Gen and Cheng [24] clarified the significance of the algorithm to solve combinatorial problems.

When it comes to establishing the link between Wireless Sensor Nodes and the Sink Node, the probabilistic technique, Ant Colony Optimization (ACO) is extremely successful. A WSN is an interconnected network of WSN nodes and Sink node(s) which can be represented as a connected graph. The fundamentals of ACO is to search potential pathways on the graph to choose the best solution. So ACO can be used to choose minimized path in a WSN network. There have been relatively few works where the ACO algorithm has been utilized to build a Wireless Sensor Network. Banerjee et al. [25] worked in 2016 to develop an effective Wireless Sensor Network utilizing the ACO algorithm. There were many challenges in that work, such as determining the position of the sink node, deployment of Wireless Sensor Node, connection establishing between the sink node and various sensor nodes, and so on, and the authors addressed all of them to construct an effective Wireless Sensor Network using the Ant Colony Optimization Algorithm.

This chapter is divided into five sections: introduction, literature survey, solution methodology, problem formulation, numerical solutions, and conclusion.

3 Methodology

Genetic Algorithm (GA)

The following essential mechanisms have been considered in the modified Genetic Algorithm.

(a) Different Parameter Initialization
(b) Representation of Chromosome
(c) Evaluation of the fitness function
(d) Use of different Genetic operators (crossover operator, mutation operator, and selection operator).

Different Parameter Initialization

Different GA parameters such as population size (*Population-size(time)*), the highest count of generations (*Generation*), the rate of crossover (*crossover-rate*), as well as the rate of mutation (*mutation-rate*) has been initialized to an initial value chosen with the help of experience.

Chromosome Representation

The chromosome has been constructed using the two important parameters used in this problem i.e., the distance between two nodes (d) and the data-transmission rate (k). The structure of the chromosome has been depicted below in Fig. 1.

Here, the initial, intermediate, and final chromosome structures have been depicted in Fig. 1. The suffix denotes the number of occurrences of different combinations of the two parameters.

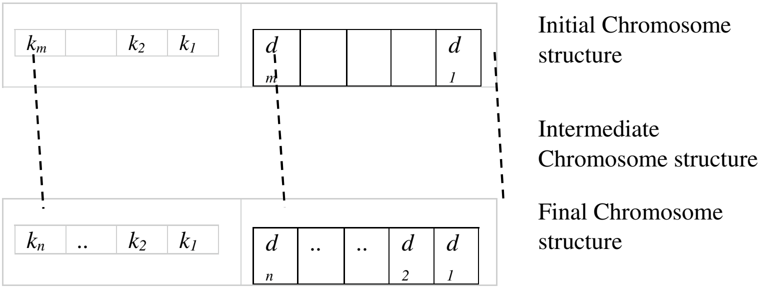


Fig. 1 The chromosome structure

Evaluation of the Fitness Function

The fitness function value of the objective function is evaluated in this phase. The different random combination of decision parameters (the threshold distance and data-transmission rate of the wireless sensor network) is used to calculate the fitness function value. The random value of the decision parameters is selected in the feasible range of the threshold distance and data-transmission rate used to construct the feasible WSN network.

Use of different Genetic Operators

Generally, the strength of the genetic algorithm is dependent upon different genetic operators. In this chapter, three different genetic operators have been involved namely

A. **Power Crossover operator** [23]: Generally, the crossover operator is used to generate the offspring chromosome from two parent's chromosomes. In this chapter, a newly developed crossover operator called power crossover is being used. In this crossover operator, the equation contains polynomial degree that is the power function to generate the offspring set from the parent set of chromosomes. Since in this type of crossover operator the power function is being used therefore the crossover operator is called "power crossover."
B. **Non-Uniform Mutation Operator** [23]: The mutation operator is used to avoid converging into local optima. In the case of mutation operator, the convergence to local optima can suppress the result-set and there is a high chance to lose the global optima. In this chapter the mutation used is called "Non-Uniform mutation Operator." Since the nonlinear problem (see equation no. 3) is a real problem and the Non-Uniform Mutation Operator is suitable for floating-point variables, therefore, this special type of mutation operator is being used.
C. **Roulette Wheel Selection Operator** [26]: This is the best parent chromosome selection process from the population. In this type of parent selection process, the probability of selection is imposed on the different chromosomes and the probabilities are summed up cumulatively. Then after the range selection is done for different chromosomes and if a certain range is chosen by the Roulette Wheel that specific chromosome gets the chance to participate as the parent chromosome.

In Fig. 2, the genetic algorithm has been described thoroughly.

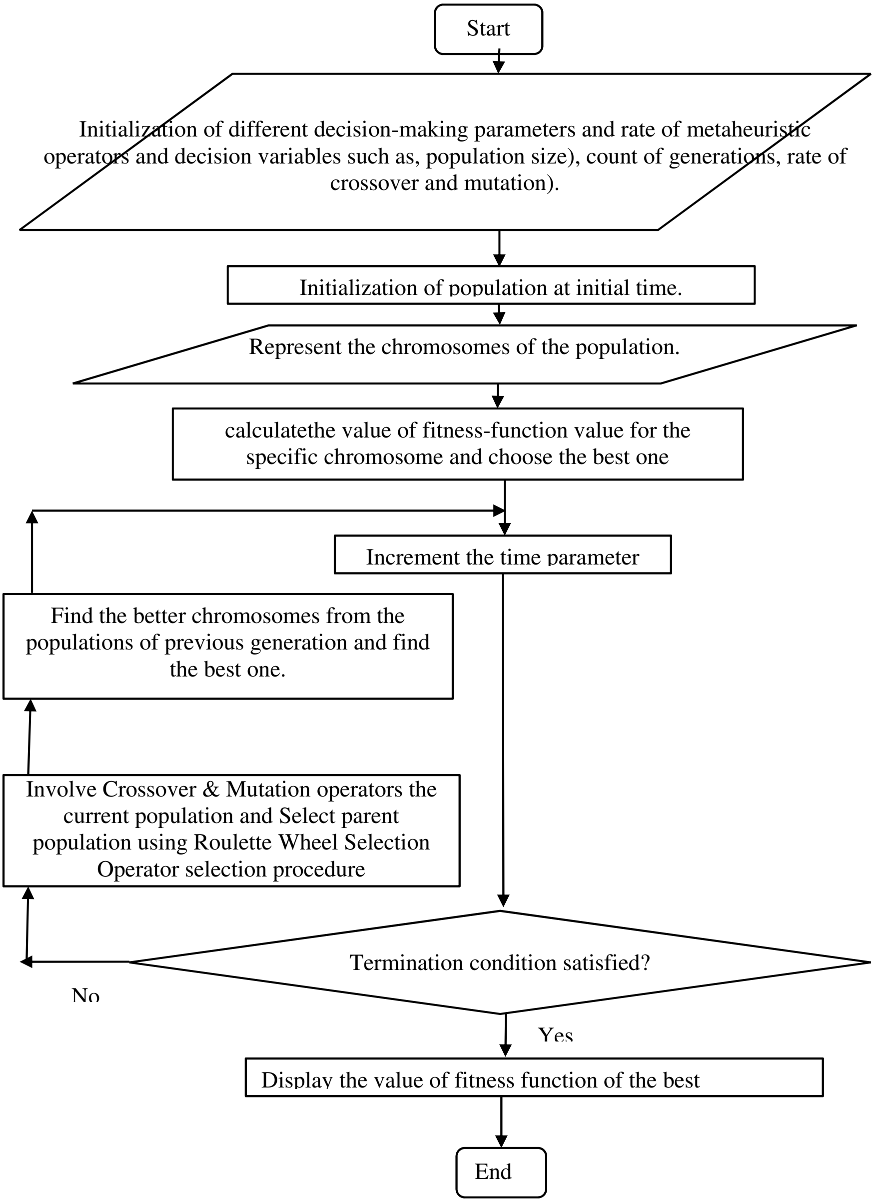


Fig. 2 Flowchart of the genetic algorithm

Ant Colony Optimization (ACO)

To solve challenging combinatorial optimization issues using a unique nature-inspired technique, the Ant Colony Optimization (ACO) was proposed in 1992.

The Ant Colony Optimization method is based on the bio-inspired phenomena of the actual ant. When ants look for food then ants randomly explore the region surrounding their colonies. Ants examine sources of food as soon as they come across them and take some part back to the colony. Pheromone trails are left behind by the ant on its return trip. Ants are guided to food sources by the pheromone produced by the ants. Ants use pheromone trails to communicate indirectly with one another and discover the shortest routes between their colony and food sources.

The main aim of this research is to establish an efficient WSN network. The modified Ant Colony Optimization method has been applied for the WSN network's route minimization purpose. The artificial ants [25] travels through the routes and reach the sink node. In an optimization problem, each artificial Ant brings a solution. That solution is refined by following the Local Pheromone Update (LPU) rule and Global Pheromone Update (GPU) rule. In the conventional ACO algorithm, the LPU rule is applied to every edge of the route that has been visited by the ant. In each iteration, the pheromone is updated by the GPU rule after all ant solutions have been refined by the LPU rule. It is possible that by doing this, the solution may be localized (stuck at local minima), as opposed to globalized (Global optima). So, to neutralize the phenomena, stuck at local minima, a reasonable balance between the GPU rule and LPU rule has been established in this chapter. So, in the proposed methodology, every ant solution is passed through LPU and GPU rules, and after comparing the absolute magnitude values (attractive function values) of the GPU rule and LPU rule the promising solution is chosen to update the ant solution. In this way, the ant solution is refined. This methodology can solve the problem of Local minima convergence. The attractive function for both LPU and GPU rule is given below:

The attractiveness function for the GPU rule.

$$\tau_{ij} = \begin{cases} (1-\rho).\tau_{ij} + \rho.\Delta\tau_{ij}, \text{if(i,j)} \in \text{best solution} \\ \tau_{ij} \qquad \text{otherwise} \end{cases} \tag{1}$$

The attractiveness function for the LPU rule

$$\tau_{ij} = \{\tau_{ij}.(1-\varphi) + \varphi.\tau_0 \tag{2}$$

The steps of the proposed *meta-heuristic ACO* algorithm [17] are given below:

Algorithm *ACO_m ().*

Input: Graph (G) [node: ant's position, edge: distance], velocity of ants.

Output: Efficient Network.

Steps:

Step 1: Generate the ant solution i.e., $P_{ANT}(time)$.

Step 2: Set the iteration as $time = 0$.

Step 3: Compute the next ant solution according to the Attractiveness function (τ_{ij}) as described above. The attractiveness function is dependent upon the LPU rule and GPU rule.

Step 4: Compare the absolute magnitude value of the attractiveness function generated by the GPU rule with the LPU rule, then update each ant solution using the acceptable GPU rule or LPU rule.

Step 5: Find the best ant solution (P_g^{ANT}) with the best fitness function value.

Step 6: Increase the number of iterations by time = time + 1.

Step 7: Proceed to Step 3 if the termination criteria are not met, otherwise, go to Step 8.

Step 8: Display the value of the fitness function of the best solution.

Step 9: End.

The Block diagram of the *modified GA-ACO* algorithm has been given below (Fig. 3)

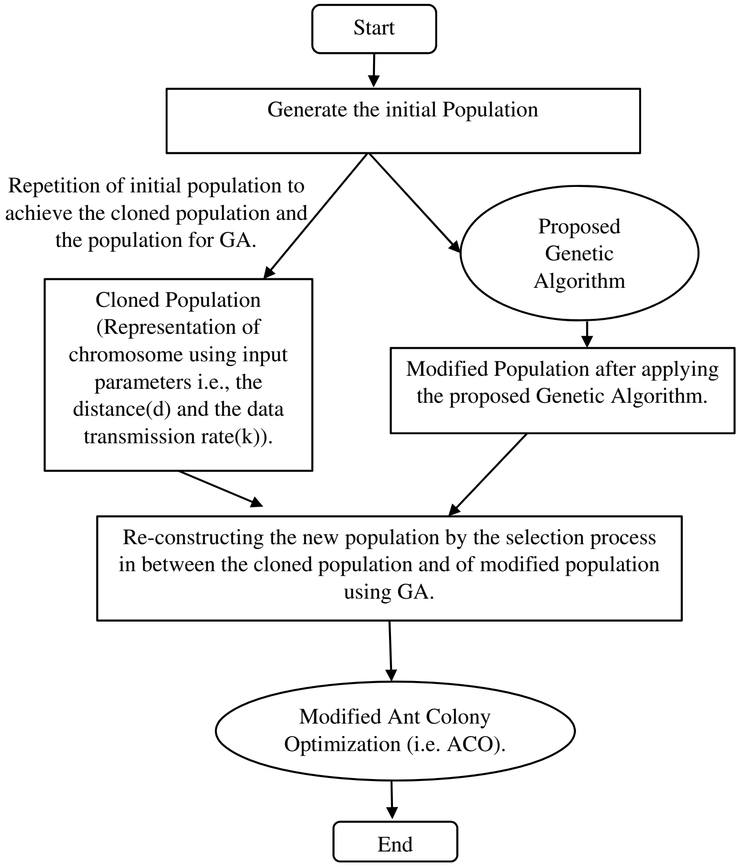


Fig. 3 Block diagram of *modified GA-ACO* algorithm

4 Problem Formulation and Numerical Solutions

The goal of this chapter is to build an effective Wireless Sensor Network to create a smart communication system for the Smart City utilizing existing resources. The WSN nodes would be deployed on the existing resources, the Lamp Post of the road. Any city may be selected to create a Smart City. In this chapter, a portion of the Durgapur A-Zone has been used for experimental purposes. It is referred to as an experimental zone in this chapter. The API "http://overpass-api.de/api" was used to obtain different geoinformation on the experimental zone. The Latitudes and Longitudes help to define an experimental zone. This is known as the Bounding Box. The experimental zone's bounding box is specified by a quadruplet of Latitudes and Longitudes (south, west, north, east) (23.56513, 87.28018, 23.57465, 87.29116). The experimental zone is depicted in Fig. 4. The experiment zone has a total area of 1.12 $\times$ 1.06 km^2.

From the experimental zone various geographical information like coordinates, type of location (street, Post-office, School, Bank, Hospital, etc.) has been fetched and it has been stored as a geojson file format. From that geojson file, all the street information has been fetched. It is planned to deploy the WSN on the Lamp Posts of the street. The distance between the two lamp posts is determined by considering the height, lumens of light, etc. Generally, the distance between the two lamp posts varies from 30 to 50 m. In this experiment, the radius of the WSN radiofrequency has been considered as 42.5 m (a value between 30 and 50 m). The location of WSN nodes for all streets has been found out from the geojson file. The location of the sink node is also a factor for the configuration of a better WSN. Using the K-Mean algorithm the position of the Sink Node has been found out and it is depicted in Fig. 5.

Fig. 4 Experiment zone, depicted by blue lines

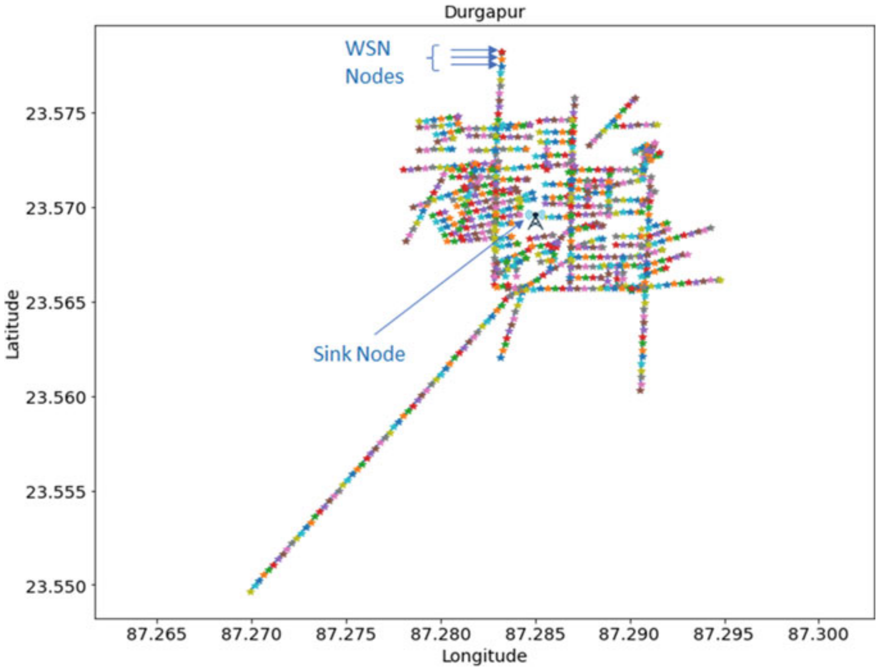


Fig. 5 Street and the positions of all WSN nodes with Sink Node's Position

The WSN nodes installed on the streets are denoted by the * sign. However, the colors of the WSN nodes do not have any specific meaning in Fig. 5. The symbol of Tower ( ) represents the position of the Sink Node. The GA-ACO optimization technique has been utilized to establish the WSN network.

The Flowchart of the algorithm, **E**ffective **C**onstruction of **W**SN in **S**mart **C**ity (***ECwSC***), is given below. (Fig. 6)

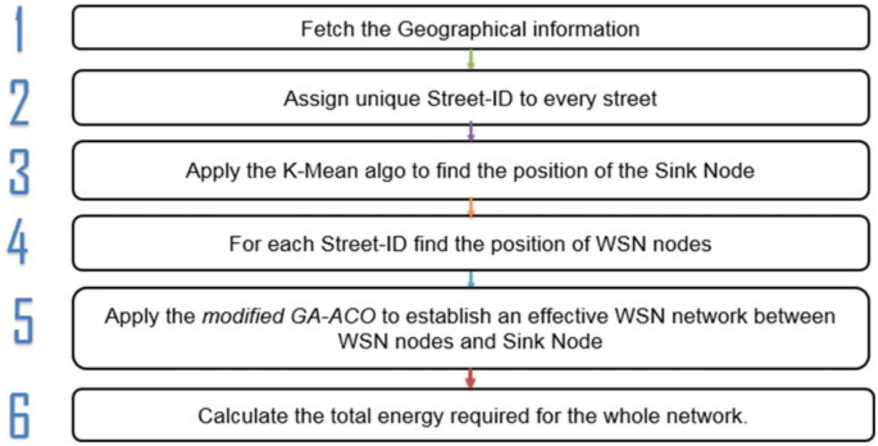


Fig. 6 Flowchart of the algorithm, effective construction of WSN in Smart City (ECwSC)

The Algorithm, **E**ffective **C**onstruction of **W**SN in **S**mart **C**ity (***ECwSC***) is given below.

Algorithm*ECwSC (Bbox bbox)*:

Input: Accept the boundary of Experimental Zone in bbox.

Output: An Effective WSN network.

Steps:

1. Get all of the geographic data (in terms of *Latitudes & Longitudes*) within the bbox and store it in the "*GeoData*" variable.
2. Get all the Streets from *GeoData* and give each one a unique *Street-ID*and save it in *GeoStreetData.*
3. Determine the location of the Sink Node (*Psn*) using the K-Mean algorithm on *GeoData*
4. For each *Street-ID*, retrieve the information from *GeoStreetData* and execute the following operations:

   Identify the positions (Location) of WSN nodes on a specific *Street-ID*
   Store all the Locations in the triplet format *[Street-ID, WSN-ID, (Latitude,Longitude)]* in "*GeoWsnData*"

5. Use *GeoWsnData* and *Psn* and apply the modified GA-ACO optimization technique to build an effective WSN network between WSN nodes and Sink Node.
6. Calculate the total energy required for the whole network.
7. End

In this chapter, the modified GA-ACO algorithm is used to minimize the energy consumption of WSNs using Eqs. (3)–(6).

$$f(k,d) = Minimize\left(Energy\_two\_ray\_ground^{Total}_{transmission}(k,d)\right) \quad (3)$$

Subject to, d > d_o for "two-ray ground propagation model."
Where d_o is the "threshold transmission distance."

$$Energy^{Total}_{transmission}(k,d) = Energy^{Total}_{tx}(k,d) + Energy^{Total}_{rx}(k) \quad (4)$$

$$Energy^{Total}_{tx}(k,d) = Energy_{Electronic-energy}(k) * k + Energy_{Amplifier}(k,d) \quad (5)$$

$$Energy^{Total}_{rx}(k) = E_{Electronic-energy}(k) * k \quad (6)$$

$Energy_{Amplifier}$ The energy required for transmitting "data packets" between two nodes for the amplification to preserve an acceptable "signal-to-noise ratio (SNR)."

$E_{Electronic-energy}$ The amount of power deterioration during the transmission between two nodes.

After establishing the WSN with the modified GA-ACO algorithm, Eqs. (3)–(6) were used to calculate the "energy consumption to stabilize the network for 1 s."

It was observed that the suggested algorithms produced superior results than certain existing literature [27, 28] as shown in Table 1. As seen in the table above,

Table 1 Comparison between different parameters for exiting literature [19, 20] and the proposed algorithm

Essential parameters	Exiting literature [19]	Exiting literature [20]	Proposed algorithm	Improved longevity compared to current literature [19, 20]
Coverage area	1 km^2	500 m^2	1.12 × 1.06 km^2	21.425% improvement in a lifetime for [19] and 84.913% improvement in a lifetime for [20]
Initial energy	2.17E+14	1E+14	1.83E+14	
Energy consumption to stabilize the network for 1 s	1,756,090,368 Pico-joules	3,512,180,736.0 Pico-joules	4.19E+12 Pico-joules	
No of nodes involved in one duty cycle	49	100	183	
The total lifetime of the WSN (h)	34.32499	6.590465	43.68454	
The total lifetime of the WSN (Days)	1.430208	0.274603	1.82018	

the suggested method outperforms the current literature in several important aspects (Coverage area, Energy consumption to stabilize the network, and Total lifetime of the WSN).

5 Conclusions

In this chapter, the hybridization has been done in between a global search algorithm (GA) and a probability-based searching algorithm (i.e., ACO algorithm). The modification of the GA-ACO hybrid algorithm is what makes this research effort innovative.

In the conventional ACO algorithm, the local search is carried out by the LPU rule, and the pheromone is changed by the GPU rule once each ant has been completed. This technique may result in the convergence of local minima. Local minima convergence is less likely in this modified GA-ACO method since the author has compared the ANT solutions obtained by the LPU rule and GPU rule to choose the superior one. The construction of an efficient Wireless Sensor Network (WSN) is the ultimate objective of this chapter for Smart City initiatives. Since the modified GA-ACO method produces better results than existing literature, this chapter has a stronger impact. Researchers have compared the results of the study with those of previous studies [19, 20] and 21.425% improvement in a lifetime for [19] and 84.913% improvement in a lifetime for [20] has been recorded.

A better algorithm can lead to a more effective network. In the future, there is still a lot of room for developing updated GA and ACO algorithms. There are several opportunities to build effective WSN construction utilizing a better GA and ACO operator.

References

1. Varshney S et al (2018) Energy efficient management of pipelines in buildings using linear wireless sensor networks. Sensors 18(8):2618
2. Banerjee A et al. Development of energy-efficient and optimized coverage area network configuration to achieve reliable WSN network using meta-heuristic approaches. Int J Appl Metaheur Comput (IJAMC) 12(3), Article 1
3. Rashid B, Rehmani MH (2016) Applications of wireless sensor networks for urban areas: a survey. J Netw Comput Appl 60:192–219
4. Ojha T, Misra S, Raghuwanshi NS (2015) Wireless sensor networks for agriculture: the state-of-the-art in practice and future challenges. Comput Electron Agric 118:66–84
5. Khan S, Al-Sakib Khan Pathan, Alrajeh NA (eds) (2016) Wireless sensor networks: current status and future trends. CRC Press
6. Rani S, Maheswar R, Kanagachidambaresan GR, Jayarajan P (eds) (2020) Integration of WSN and IoT for smart cities. Springer Nature
7. Faragardi HR, Fotouhi H, Nolte T, Rahmani R (2017) A cost efficient design of a multi-sink multi-controller WSN in a smart factory. In: 2017 IEEE 19th international conference on high

performance computing and communications; IEEE 15th international conference on smart city; IEEE 3rd international conference on data science and systems HPCC/SmartCity/DSS), pp 594–602. IEEE
8. Bajaj K, Sharma B, Singh R (2020) Integration of WSN with IoT applications: a vision, architecture, and future challenges
9. Komninos N, Bratsas C, Kakderi C, Tsarchopoulos P (2016) Smart city ontologies: improving the effectiveness of smart city applications. J Smart Cities (Transferred) 1(1)
10. Lau BPL, Marakkalage SH, Zhou Y, Hassan NU, Yuen C, Zhang M, Tan UX (2019) A survey of data fusion in smart city applications. Inf Fus 52:357–374
11. Osman AM (2019 Feb) A novel big data analytics framework for smart cities. Futur Gener Comput Syst 1(91):620–633
12. Banerjee A et al (2022) Construction of effective wireless sensor network for smart communication using modified ant colony optimization technique. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_22
13. Bodapati S, Bandarupally H, Shaw RN, Ghosh A (2021) Comparison and analysis of RNN-LSTMs and CNNs for social reviews classification. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_4
14. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Smart luminaires for commercial building by application of daylight harvesting systems. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_24
15. Mandal S, Biswas S, Balas VE, Shaw RN, Ghosh A (2021) Lyft 3D object detection for autonomous vehicles. Artif Intell Fut Gener Robot 119–136. https://doi.org/10.1016/B978-0-323-85498-6.00003-4
16. Biswas S, Bianchini M, Shaw RN, Ghosh A (2021) Prediction of traffic movement for autonomous vehicles. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_12
17. Soni A, Dharmacharya D, Pal A, Srivastava VK, Shaw RN, Ghosh A (2021) Design of a machine learning-based self-driving car. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_11
18. Sampurna Mandal, Sk Md Basharat Mones, Arshavee Das, Valentina E. Balas, Rabindra Nath Shaw, Ankush Ghosh, "Single shot detection for detecting real-time flying objects for unmanned aerial vehicle", Artificial Intelligence for Future Generation Robotics (2021)Pages 37–53. https://doi.org/10.1016/B978-0-323-85498-6.00005-8
19. Gautam J, Atrey M, Malsa N, Balyan A, Shaw RN, Ghosh A (2021) Twitter data sentiment analysis using naive bayes classifier and generation of heat map for analyzing intensity geographically. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_10
20. Jovanovska EM, Davcev D (2020) No pollution smart city sightseeing based on WSN monitoring system. In: 2020 Sixth international conference on mobile and secure services (MobiSecServ) 2020 Feb 22, pp 1–6. IEEE
21. Sampathkumar A, Murugan S, Elngar AA, Garg L, Kanmani R, Malar AC (2020) A novel scheme for an IoT-based weather monitoring system using a wireless sensor network. In Integration of WSN and IoT for smart cities 2020, pp 181–191. Springer, Cham
22. Pétrowski A, Ben-Hamida S (2017) Evolutionary algorithms. ISTE
23. Sahoo L, Banerjee A, Bhunia AK, Chattopadhyay S (2014) An efficient GA–PSO approach for solving mixed-integer nonlinear programming problem in reliability optimization. Swarm Evol Comput 19:43–51

24. Gen M, Cheng R (1999) Genetic algorithms and engineering optimization, vol 7. John Wiley & Sons
25. Banerjee A et al (2016) A fuzzy-ACO algorithm to enhance reliability optimization through energy harvesting in WSN. In: 2016 International conference on electrical, electronics, and optimization techniques (ICEEOT). IEEE
26. Alla K, Ramachandran V (2020) A novel encryption using genetic algorithms and quantum computing with Roulette wheel algorithm for secret key generation. In: ICT analysis and applications 2020, pp 263–271. Springer, Singapore
27. Banerjee A et al (2019) Development of energy-efficient and optimized coverage area network configuration to achieve reliable WSN network using meta-heuristic approaches. Int J Appl Metaheur Comput (IJAMC) 12(3), Article 1
28. Lande SB, Kawale SZ (2016) Energy efficient routing protocol for wireless sensor networks. In: 2016 8th International conference on computational intelligence and communication networks (CICN). IEEE

Estimation of Range for Electric Vehicle Using Fuzzy Logic System

Gunjan Taneja, Anjali Jain, and Neelam Verma

Abstract Smart cities act as an essential tool in providing adequate supplies in the world of urbanization and increasing population. To improve the quality of living, development of social and economic life, smart cities play a vital role. Integration of infrastructure, essential goods together in a single place by keeping track of security system as well, Smart cities are a boon to mankind. The use of Electric vehicles (EVs) in the transportation industry acts as one of the primers in the development of smart cities. They run on battery or solar energy in addition to the motors that make them friendly for the environment. But range and energy of these vehicles are limited. Efficient use of energy is an important parameter for these vehicles. Monitoring of different parts and parameters affecting EV performance is done. For this purpose, different methods are used. This chapter aims to improve the rapidly going transportation industries by involving Electric Vehicles and keeping track of the range of electric vehicles, considering parameters such as state of charge (SOC) of battery, acceleration of vehicle, and power consumption of the vehicle. The fuzzy logic classifier is used for estimating the range that can be used for research work in many places. In this method battery state, power used by the vehicle, acceleration of the vehicle is considered as inputs. Study shows that the range of the vehicle gets impacted to a large extent by decreasing the charging of the battery. Thus, SOC plays an important role in estimating the range of EV.

Keywords Electric vehicle · Fuzzy classifier · Range · State of charge · Smart grids · Acceleration · Power and smart cities

1 Introduction

According to the report of UN 2012 [1], the urbanization of the world's population has reached up to 50%. Sustainability is an important factor to meet the demands of the world. The balance in the ecosystem is disturbed due to uneven economic

G. Taneja (✉) · A. Jain · N. Verma
Department of Electrical and Electronics Engineering, Amity University Uttar Pradesh, Noida, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_3

growth, climate change, and population growth [2]. Development of cities has been downturn due to issues arising because of poor health structure, infrastructure, not proper waste management, water treatment [3–6]. Thus, these problems have led to looking for smart technologies that improve the condition and help in the upliftment of infrastructure. Smart cities refer to cities that are self-sufficient, sustainable, and easier to live in. Smart cities provide facilities of mobility, water, and air quality, good infrastructure to the people [7]. To meet the demand for energy in these cities, smart grids act as a great choice. Smart grids involve the use of renewable energy, to fulfill the needs of energy requirements. Optimization of real-time data is possible because of the use of smart grids. The most fruitful development of smart grids is the integration of Electric Vehicles (EV) with the distribution of electricity. In smart cities, there is a need to look for a sustainable choice that can reduce harmful emissions, reduce the use of fossil fuel as by extensive use they are slowly getting depleted. As a result, it has become the need of the hour to use some other form of energy that helps in making our cities smarter. In areas such as transportation, heating, and electricity generation, fossil fuels play an important role. Thus, with the use of electric vehicles in transportation industries this demand can be fulfilled to some extent. Also, it is less harmful to the environment [8]. This EV helps in building greener cities with no emission of carbon[9]. EV or electric vehicles involve the integration of mechanical and electrical systems. They are mainly of 2 types-Firstly hybrid electric vehicle that involves the combination of combustion engine and motor, and secondly battery electric vehicle [10] that consists of the battery management system, and its component for working. In an electric vehicle, the range is directly related to the power consumed ad the state of charge of the battery. Thus, range estimation is an important concept in designing electric vehicles. Standards by Environmental Protection Agency are used for defining range estimation. As these standards do not involve load impact, they do not give useful results [11]. Other methods like the historical approach [11] based on parameters and prediction technique and model-based approach [12] are now being used for estimation. All subsystems are designed in a model-based approach. So, it gives better results. High precision is required [13]. Scientists are working for the improvement of the range of EVs. Various AI techniques are being used for this purpose [14–18]. Fuzzy Logic is one such method that is used in controlling units in EV. In this chapter, a Fuzzy control scheme is used for modeling the range estimation of an electric vehicle. Mitchell et al. [19] discussed smart cities in terms of digital city and platform for a transaction. Smart city categorization in terms of digitization, economy, socialization is explained by Komninos [20]. Silva and Santiago performed a study about the use of hybrid EVs in microgrids involving solar power [21]. Weiller and Neely focused on the industrial use of electric vehicles [22]. A study has been performed to identify the vehicle in traffic [23, 24]. A hybrid system was developed by integration of fuzzy and ANN in this study. Greene [25] worked on the daily use of EV for traveling. Using gamma distribution curve parameters were identified. It showed that even with short-range, demand for use of EVs was high. Pearre et al. [26] highlighted that range of EV can exceed 160 km for more than 90% of the cars. Franke and Krems [27] collected data for 79 households that use EVs and concluded that the

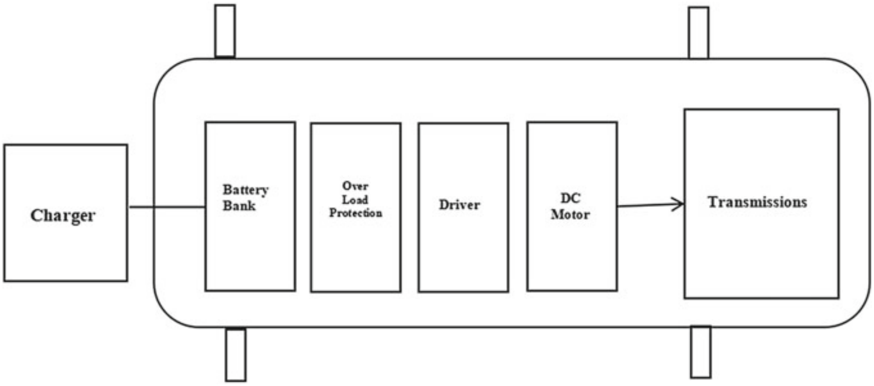


Fig. 1 Electric vehicle components [33]

range desired by people is higher than the distance traveled. Tal et al. [28] worked on hybrid EV data and found that EVs having large battery sizes can be used to travel long distances. Woodjack et al. [29] in his study shows that a large number of people cancel the ride of EV because their range is short and they take a longer time to get charge. Javid and Nejat [30] proved that the income of the people and density of charging stations impacts the choice for the selection of EVs to large extent. Li et al. [31] designed the model showing daily distance traveled by taxis. It highlighted that small traveling distance can be covered using a sort range of EV but can't be used for daily traveling purposes. Thus, it is necessary to have an adequate range of electric vehicles. Hinz et al. [32] focused on the costings of Electric vehicles. By considering different parameters like road, traffic, slope, and their effect on EV, it is assumed that state of charge of battery and power are the main factors that impact the range of EV. So, with the help of a fuzzy inference system, mathematical model, range estimation is done. Figure 1 [33] describes the basic components of the electric vehicle.

1.1 Smart City Pillars

There are 6 main pillars in the development of smart cities namely social, management, economy, legal, sustainability, and technology [34]. Society plays a vital role in the development of the individual, its surrounding. Grouping of smart people and discussion helps in providing great ideas for building smart cities. Proper management also acts as a major supporter in development. For driving and running smart cities, the economy acts as an essential tool. Legal Compliance unable smooth working of smart cities. For any city to turn from conventional form to smart form, technology acts as a seed source. Environmental protection and balance in the ecosystem are also very crucial to ensure survival and sustainability. Figure 2 [34] describes the basic framework for Smart City Development.

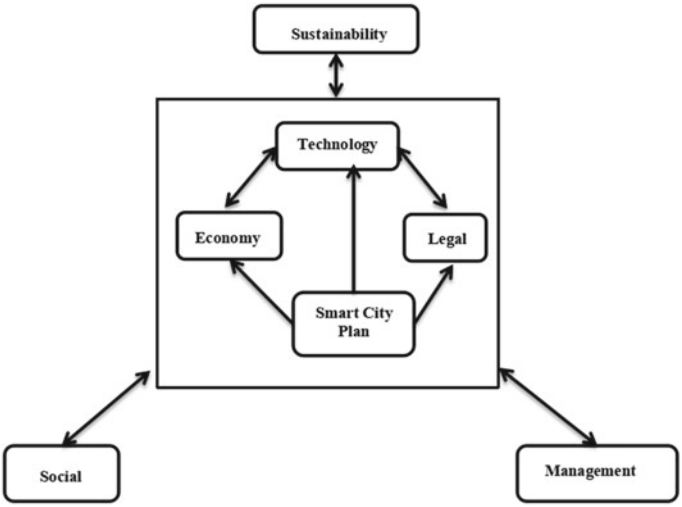


Fig. 2 Pillars of smart city [34]

1.2 EV Role in Smart Cities

According to Eidar et al. [35] vehicles that are the combination of motors involved in both railways and roadways, can be used in air crafts, underwater systems are referred to as Electric Vehicles. EV acts as energy storage devices. They can be used in disaster-prone areas by integration with the smart grid. It helps in reducing fluctuations in electricity. It reduces dependency on diesel engines and looks or renewable energy and other greener choices. Voltage and power regulation can be done by Electric Vehicles. Vehicle and grid integration is possible. Figure 3 explains the various application of electric vehicles.

2 Mathematical Modeling

Figure 4 describes the effect of different forces acting on Electric vehicles.

To undergo motion, EVs need to get rid of some forces of gravity, wind, rolling, and inertia. Physical forces that restrict movement have to be removed.

Thus, Force for driving can be calculated as in (1).

$$Ft = fi + fg + frr + fwind \tag{1}$$

$$fi = mvehicledvvehicle \tag{2}$$

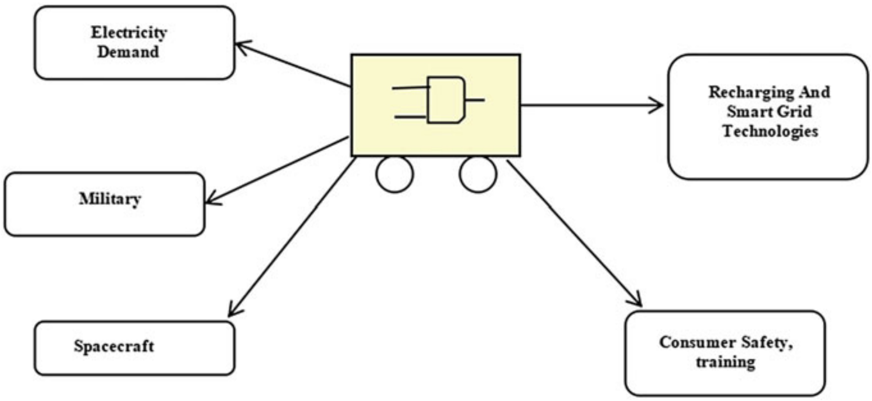
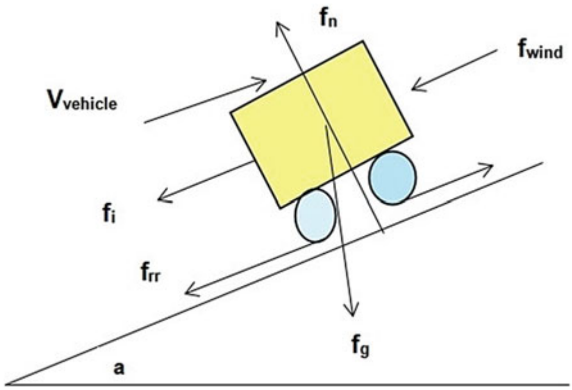


Fig. 3 Application of electric vehicles

Fig. 4 Model of forces acting on EV



$$fg = m_{vehicle} gsin(a) \tag{3}$$

$$frr = m_{vehicle} gcosaC_{st} \tag{4}$$

$$fwind = \frac{1}{2pairCdAya} Vvehicle + Vwind2 \tag{5}$$

$$Cst = 0.01 * \left(1 + \frac{3.6}{100} * Vehicle\right) \tag{6}$$

Here Ft is force (driving), fi is inertia, for is rolling resistance force, fg is the gravitational force, fwind is the force due to wind resistance, a defines slope, mvehicle is mass of the vehicle, Vvehicle is the velocity of the vehicle, dvvehicle is acceleration, pair is the density of air, Cst is coefficient of rolling resistance, Cd is the aerodynamic coefficient, Aya is area, and Vwind is the velocity of the wind.

τ_T gives a torque of the vehicle in Nm (7), r_W is the radius of the vehicle's wheel, P_T denotes Power (8) and w_w is angular speed (9)

$$\tau T = fTr_w \tag{7}$$

$$PT = ftVvehicle \tag{8}$$

$$wW = Vvehicle/rW \tag{9}$$

3 Design of Fuzzy Logic Classifier

Range estimation is done by using Fuzzy Logic. Fuzzy classifier gives better performance speed and is easy to design that unable to use them for estimation of range. The basic model for understanding the system is given in Fig. 5.

Mamdani Type system is used for this range estimation. It is described in Fig. 6. 3 inputs are considered namely State of Charge of battery denoted by "SOC"; power denoted by "POWER" and Acceleration of vehicle denoted by "Acceleration". A fuzzy toolbox in MATLAB is used to obtain the fuzzy model. Output is the range of the vehicle denoted by "RANGE". SOC and Power are represented by 7 linguistic variables namely (NS, N, NL, NPZ, PL, P, PS), Acceleration by (low, med and high) and Range by 7 variables namely (NS, N, NL, NPZ, PL, P, PS).Triangular and trapezoidal membership functions are used. Limits for SOC % is (0–100), POWER (Watt) (0–100,000), Acceleration (−1 to 1) and Range (−1 to 1). Rules are defined for the system by considering the effect of inputs.

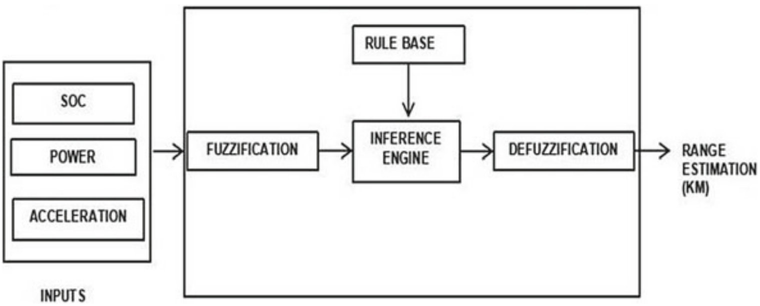


Fig. 5 Basic FLC model

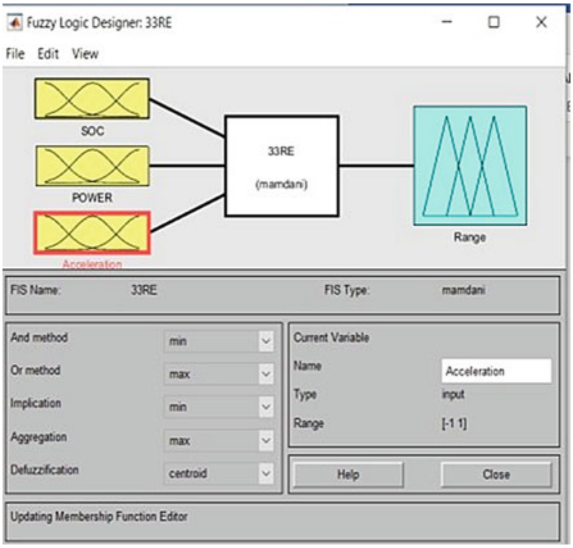


Fig. 6 Mamdani model

3.1 Fuzzy Set for Input Variables

SOC % [0–100]

Table 1 defines the variables and their range used to describe SOC%. Membership Functions are shown in Fig. 7.

Power (Watt) [0–10000]

Table 2 defines the variables and their range used to describe the Power of the vehicle. Membership Functions are shown in Fig. 8.

Acceleration [−1 to 1]

Table 3 defines the variables and their range used to describe the Acceleration of the vehicle. Membership Functions are shown in Fig. 9.

Table 1 SOC membership functions and their range

Variables	Membership function	Range
NS	Triangular	[−53.3–0.317 15.75]
N	Triangular	[0 18 32]
NL	Triangular	[18 32 50]
NPZ	Triangular	[32 50 68]
PL	Triangular	[50 65 82]
P	Triangular	[65 82 100]
PS	Triangular	[82 100 144]

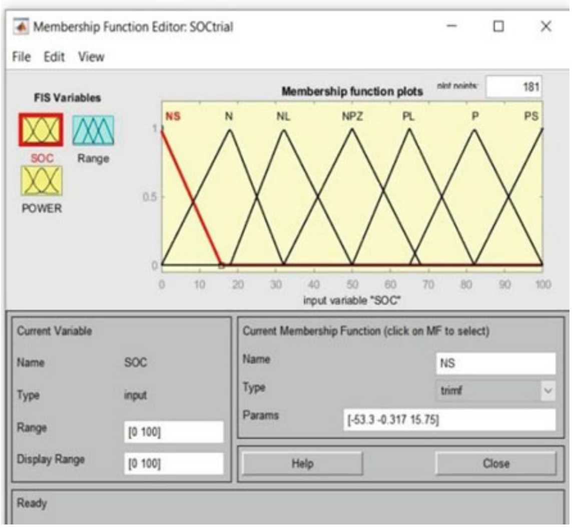


Fig. 7 Membership Function For SOC(%)

Table 2 Power membership functions and their range

Variables	Membership function	Range
NS	Trapezoidal	[−2680 −15.6 600 1500]
N	Triangular	[600 1500 2600]
NL	Triangular	[1500 2600 4200]
NPZ	Trapezoidal	[2600 3500 4200 5296]
PL	Triangular	[4200 5200 7600]
P	Triangular	[5200 7600 9400]
PS	Trapezoidal	[7600 9670 1.03e+04 1.3e+04]

3.2 Fuzzy Set for Output Variables

RANGE [−1 to 1]

Table 4 defines the variables and their ranges used to define the Range of EV. Membership Functions are shown in Fig. 10.

Fig. 8 Membership function for power (Watt)

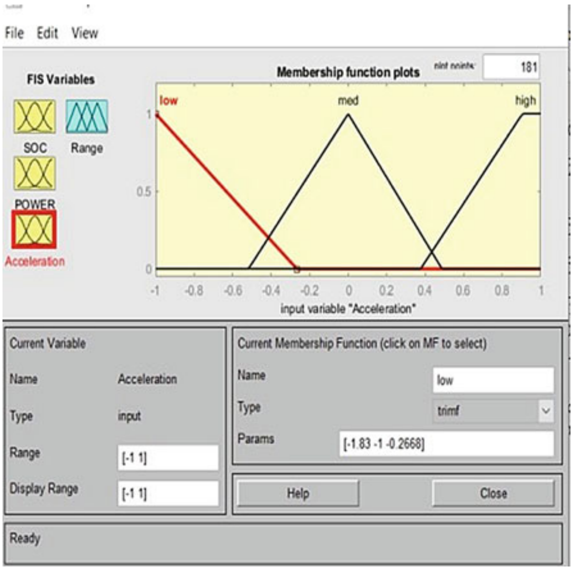


Fig. 9 Membership function for acceleration

Table 3 Acceleration membership functions and their range

Variables	Membership function	Range
Low	Triangular	[−1.83 −1 −0.2668]
Med	Triangular	[−0.518 0 0.4873]
High	Trapezoidal	[0.3763 0.905 1.08 1.75]

Table 4 Range membership functions and their limits

Variables	Membership function	Range
NS	Trapezoidal	[−1 −1 −0.8 −0.6808]
N	Triangular	[-0.8 -0.688 -0.4]
NL	Triangular	[−0.688 −0.4 0]
NPZ	Trapezoidal	[−0.4 −0.1 0.1 0.4]
PL	Triangular	[0 0.33 0.7]
P	Triangular	[0.4 0.6 0.8]
PS	Trapezoidal	[0.7 0.82 1 1.4]

Fig. 10 Membership function for range

3.3 *Rule Editor*

Rules are constructed with the help of a graphical Rule editor. By using input and output variables, defined with a fuzzy inference system, rule statements can be created directly using Rule editor. They are described in Table 5.

4 Simulation Model

The model for range estimation is given in Fig. 11. A fuzzy Logic System is used in this model. It is prepared with the variables, membership functions defined in Tables 1, 2, 3 and 4. State of charge, power, and acceleration are given on the input

Table 5 Rules

1 1 0, 4 (1): 1	5 3 0, 2 (1): 1	1 6 0, 4 (1): 1
2 1 0, 2 (1): 1	6 3 0, 1 (1): 1	2 6 0, 7 (1): 1
3 1 0, 2 (1): 1	7 3 0, 1 (1): 1	3 6 0, 6 (1): 1
4 1 0, 1 (1): 1	1 4 0, 4 (1): 1	4 6 0, 5 (1): 1
5 1 0, 1 (1): 1	2 4 0, 4 (1): 1	5 6 0, 4 (1): 1
6 1 0, 1 (1): 1	3 4 0, 3 (1): 1	6 6 0, 3 (1): 1
7 1 0, 1 (1): 1	4 4 0, 3 (1): 1	7 6 0, 2 (1): 1
1 2 0, 4 (1): 1	5 4 0, 2 (1): 1	1 7 0, 4 (1): 1
2 2 0, 3 (1): 1	6 4 0, 2 (1): 1	2 7 0, 7 (1): 1
4 2 0, 2 (1):1	7 4 0, 1 (1): 1	3 7 0, 7 (1): 1
5 2 0, 2 (1): 1	1 5 0, 4 (1): 1	4 7 0, 6 (1): 1
6 2 0, 1 (1): 1	2 5 0, 4 (1): 1	5 7 0, 5 (1): 1
7 2 0, 1 (1): 1	3 5 0, 4 (1): 1	6 7 0, 5 (1): 1
1 3 0, 4 (1): 1	4 5 0, 3 (1): 1	7 7 0, 4 (1): 1
2 3 0, 4 (1): 1	5 5 0, 3 (1): 1	0 0 1, 6 (1): 1
3 3 0, 3 (1): 1	6 5 0, 5 (1): 1	0 0 2, 4 (1): 1
4 3 0, 2 (1): 1	7 5 0, 2 (1): 1	0 0 3, 2 (1): 1

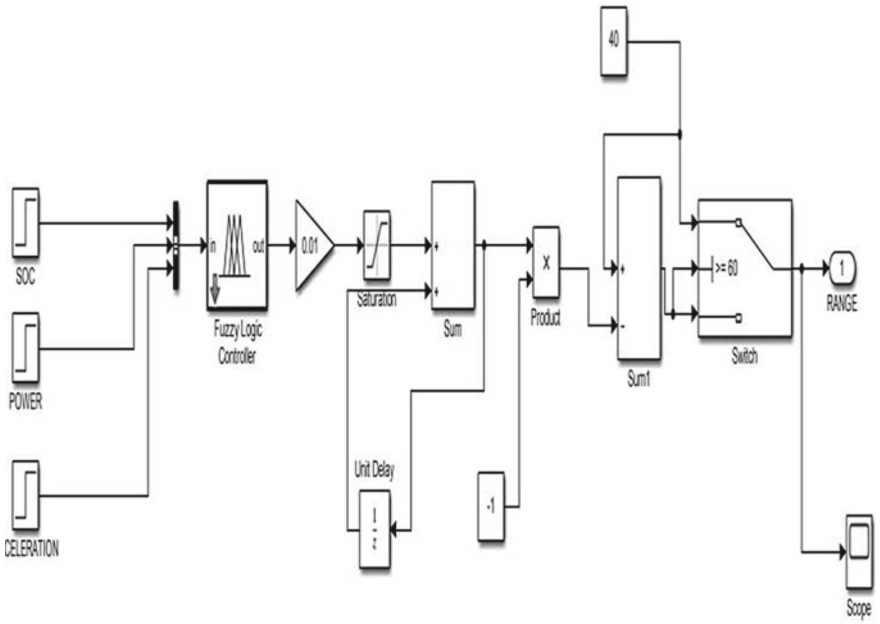


Fig. 11 Simulink model for range estimation

side and are connected to the controller to check out the value of the range of the vehicle. Scope gives the maximum value of the range of the vehicle.

5 Results and Discussions

Rule Viewer

According to the rules defined in Table 5, the output is obtained using Rule viewer. Figure 12 shows the rules used in graphical form. Here 3 inputs are described namely SOC, POWER and Acceleration with value of 50[0–100 limit], 5000[0–10,000 limit] and 0[−1 to 1 limit], respectively. Range is obtained from the graphical representation and is observed to be −0.133 [−1 to 1 limit]. It can be observed that on decreasing SOC, the range of vehicles turns out to be negative. If we further increase SOC, Range will be positive. Thus, SOC is an important parameter for range estimation.

Surface Viewer

The surface viewer enables us to view the output surface. Input variables, membership functions, fuzzy rules defined above in Tables 1, 2, 3, 4, and 5 are used to obtain this surface output. Figure 13 shows the surface view for input and output. Only 2 inputs are considered at the time of plotting surface viewer. Here we are considering SOC and POWER as inputs, Range as output to display on surface viewer. SOC is plotted

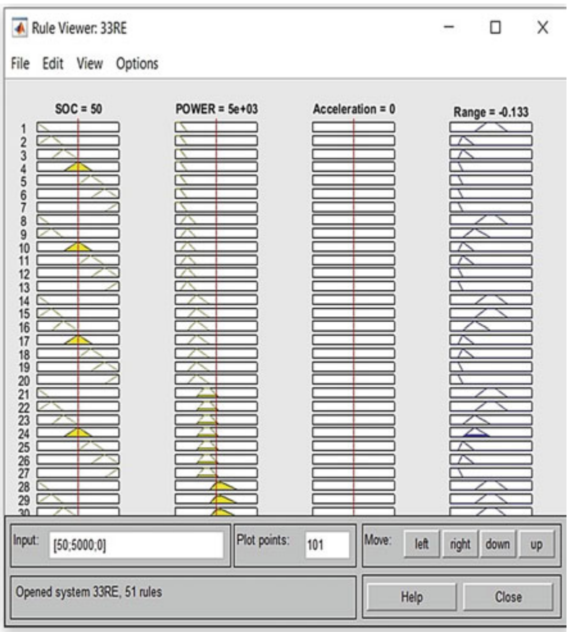
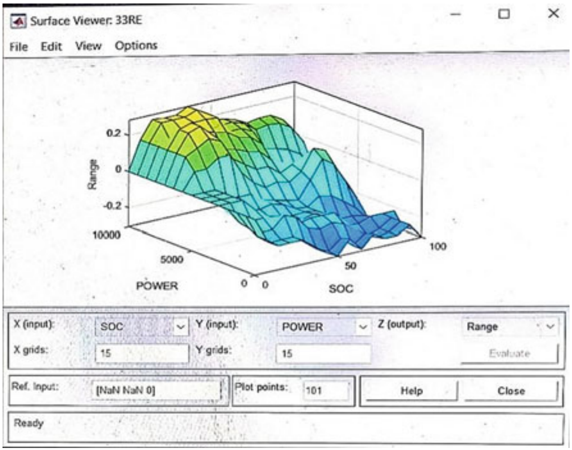


Fig. 12 Rule viewer

Fig. 13 Surface viewer showing input and output variables surface

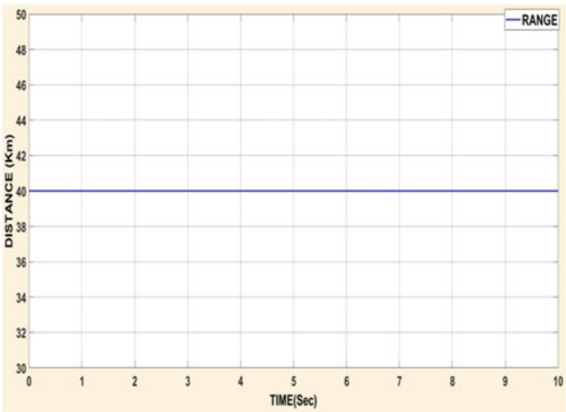


on X-axis with range of [0 −100], Power on Y-axis with range of [0–10000], and Range on Z-axis[−1 to 1].

Simulink Output

Figures 14 and 15 describe the Simulink output obtained for vehicle range estimation. In Fig. 14, only 2 inputs SOC and POWER is considered, and range is obtained as output. By using a different set of values of SOC and POWER, it is observed that the maximum range of the vehicle is 40 km as shown in Fig. 14. In Fig. 15, 3 inputs SOC, POWER and acceleration is used, and range is obtained for the same. On considering acceleration (Fig. 15), it can be seen that there is a decrease in the range from 40 km to 39.983 km. Thus, acceleration also affects the range of the vehicle to a small extent.

Fig. 14 Range with SOC and power



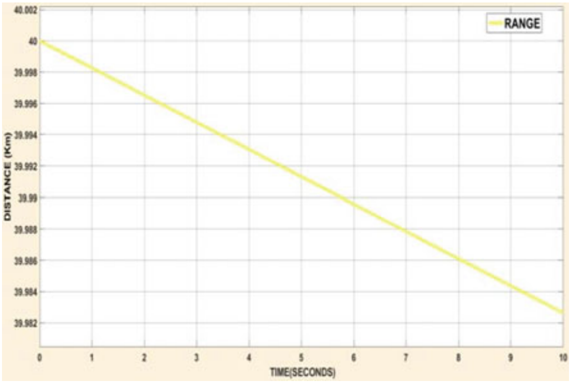


Fig. 15 Range with SOC, power and acceleration

6 Conclusion

This study focused on designing a smart city by involving the use of Electric vehicles. For this purpose, range Estimation System is made using a Fuzzy Logic Controller (FLC). The fuzzy method enables the vehicle to run on the routes which are not specified and allow to use of data for experimental testing. Different parameters of EV were also tested. FLC helps the driver to understand the total distance a person can travel. From the Simulink results, it is observed that SOC, Power, and Acceleration can impact the range of the vehicle. By considering different values of SOC and Power, it is observed that the maximum range of the EV model obtained in Fig. 14 is 40 km and when acceleration is considered it is reduced to 39.983 km. In this chapter environmental factors like wind, its speed, temperature were not taken into consideration. Force acting on the vehicle was considered in mathematical calculation These factors also affect the range of the vehicle while using electric cars on daily basis.

References

1. United Nations., World Urbanization Prospects, United Nations, Department of Economic and Social Affairs, Population Division: the 2011 Revision: Highlights (2012)
2. Cisco Report, Smart Cities and Internet of Everything. The Foundation for Delivering Next-Generation Citizen Services, sponsored by Cisco (2013)
3. Borja J, Counterpoint F (2007) Intelligent cities and innovative cities. Universitat Oberta de Catalunya (UOC) papers. E-J Knowl Soci 5. http://www.uoc.edu/uocchapters/5/dt/eng/mitchell.pdf
4. Marceau J (2008) Introduction: innovation in the city and innovative cities. Innov Manage Policy Pract 10(2–3):136–145
5. Toppeta D (2010) The smart city vision: how innovation and ICT can build smart, "Livable", sustainable cities. The Innovation Knowledge Foundation

6. Washburn D, Sindhu U, Balaouras S, Dines RA, Hayes NM, Nelson LE (2010) Helping CIOs understand "smart city" initiatives: defining the smart city, its drivers, and the role of the CIO. Forrester Research, Inc., Cambridge, MA
7. Zuccalà M, Verga ES (2017) Enabling energy smart cities through urban sharing ecosystems. Energy Proc 111:826–835. https://doi.org/10.1016/j.egypro.2017.03.245
8. Sarrafan K, Muttaqi KM, Sutanto D, Town GE (2018) A real-time range indicator for EVs using web-based environmental data and sensorless estimation of regenerative braking power. IEEE Trans Veh Technol 67:4743–56. https://doi.org/10.1109/TVT.2018.2829728
9. Karpenko A, Kinnunen T, Madhikermi M, Robert J, Främling K, Dave B et al (2018) Data exchange interoperability in IoT ecosystem for smart parking and EV charging. Sensors 18:4404. https://doi.org/10.3390/s18124404
10. Kaya S, Kilic N, Kocak T, Gungor C (2016) A battery-friendly data acquisition model for vehicular speed estimation. Comput Electr Eng 50:79–90 (2016)
11. Yavasoglu HA, Tetik YE, Gokce K (2019) Implementation of machine learning based real time range estimation method without destination knowledge for BEVs. Energy 172:1179–86. https://doi.org/10.1016/j.energy.2019.02.032
12. Daina N, Sivakumar A, Polak JW (2017) Modelling electric vehicles use:a survey on the methods. Renew Sustain Energy Rev 68:447–460. https://doi.org/10.1016/j.rser.2016.10.005
13. Qi X, Wu G, Boriboonsomsin K, Barth MJ (2018) Data-driven decomposition analysis and estimation of link-level electrivehicle energy consumption under real-world traffic conditions. Transp Res Part D Transp Environ 64:36–52. https://doi.org/10.1016/j.trd.2017.08.008
14. Sergaki E-S. Electric motor efficiency optimization as applied to electricvehicles
15. Uysal KA. Fuzzy logic controlled brushless direct current motor drive design and application for regenerative braking
16. Milligan T, Smith MI. A comparitive range approach using real world drive cycles and battery electricvehicles
17. Masjostusmann C, Kohler C, Decius N, Buker U. A vehicle energy management system for a battery electricvehicle
18. Franke T, Rauh N, Krems JF (2016) Individual differences in bev drivers'range stress during first encounter of a critical range situation. Appl Ergon 57:28–35
19. Mitchell W (2000) Designing the Digital City. In: Ishida T, Isbister K (eds) Digital cities: technologies, experiences, and future perspectives. Springer, Berlin/Heidelberg, pp 1–6
20. Komninos N (2008) Intelligent cities and globalisation of innovation networks. Routledge, London
21. da Silva HB, Santiago LP (2019) Optimal energy trading policy for solar-powered microgrids: a modeling approach based on plug-in hybrid electric vehicles. In: Smart and digital cities, pp 251–273. Cham
22. Weiller C, Neely A (2014) Using electric vehicles for energy services: industry perspectives. Energy 77:194–200. https://doi.org/10.1016/j.energy.2014.06.066
23. Boyraz P, Dogan D (2013) Intelligent traction control in electric vehicles using an acoustic approach for online estimation of road-tire friction. IEEE Intell Veh Symp Proc 1336–43. https://doi.org/10.1109/IVS.2013.6629652
24. Dawei M, Yu Z, Meilan Z, Risha N (2017) Intelligent fuzzy energy management research for a uniaxial parallel hybrid electric vehicle. Comput Electr Eng 58:447–64
25. Greene DL (1985) Estimating daily vehicle usage distributions and the implications for limited-range vehicles. Transp Res Part B: Methodol 19(4):347–358
26. Pearre NS, Kempton W, Guensler RL, Elango VV (2011) Electric vehicles: how much range is required for a day's driving? Transp Res Part C: Emerg Technol 19(6):1171–1184
27. Franke T, Krems JF (2013) What drives range preferences in electric vehicle users? Transp Policy 30:56–62
28. Tal MA, Davies NJ, Woodjack J (2014) Charging behavior impacts on electric vehicle miles traveled: who is not plugging in? Transp Res Rec 2454:53–60
29. Woodjack J, Garas D, Lentz A, Turrentine T, Tal G, Nicholas M (2012) Consumer perceptions and use of driving distance of electric vehicles. Transp Res Rec 2287:1–8

30. Javid RJ, Nejat A (2017) A comprehensive model of regional electric vehicle adoption and penetration. Transp Policy 54:30–42
31. Li Z, Jiang S, Dong J, Wang S, Ming Z, Li L (2016) Battery capacity design for electric vehicles considering the diversity of daily vehicles miles traveled. Transp Res Part C Emerg Technol 72:272–282
32. Hinz O, Schlereth C, Zhou W (2015) Fostering the adoption of electric vehicles by providing complementary mobility services: a two-step approach using best-worst scaling and dual response. J Bus Econ 85:921–951. https://doi.org/10.1007/s11573-015-0765-5
33. Pérez-Pimentel Y, Osuna-Galán I, Avilés-Cruz C, Villegas-Cortez J (2018) Power supply management for an electric vehicle using fuzzy logic. Appl Comput Intell Soft Comput 2018, Article ID 2846748, 9 p. https://doi.org/10.1155/2018/2846748
34. Joshi S et al (2016) Developing smart cities: an integrated framework. Proc Comput Sci 93:902–909
35. Eider M, Sellner D, Berl A, Basmadjian R, de Meer H, Klingert S et al (2017) Seamless electromobility. In: Proceedings of the eighth international conference on future energy systems, pp 316–321. Shatin

Traffic Light Control Using RFID and Deep Reinforcement Learning

Shivnath Yadav, Sunakshi Singh, and Vijay Kumar Chaurasiya

Abstract Roads are the indispensable need of our modern society. From connecting places to exporting goods, it registers as one of the important modes of transportation. Nevertheless, existing infrastructure has some issues such as congestion, delay, and energy wastage. Therefore, to address these aforementioned concerns, there are two most probable solutions. One way is to simply expand the transportation capacity by building road systems that can handle extensive traffic flow. Another way is to operate on the existing infrastructure by improving the systems that have a significant impact on the traffic flow, such as traffic signal controllers. This approach is expedient considering low cost in implementation and reuses the current equipment. Therefore, in this chapter, we have proposed a four way-intersection which uses a feedforward neural network and the Q-learning algorithm to get value function approximation. We have tried to improve the traffic flow at the intersection point which is monitored, managed, and controlled by traffic lights. For achieving such a goal we will employ deep reinforcement learning commonly called deep Learning. To get real-time data, RFID readers will be used. The agent will be given the responsibility to manage the traffic light's phase activation so as to optimize the traffic efficiency. The agent decision is based on the analysis of the deep Q-learning algorithm. In order to choose the best light phase, deep Q-learning algorithm divides each road of intersection in the form of a one-dimensional array and calls each section as a state. Reward is awarded on the basis of the duration of the waiting time of a vehicle. Simulation is done on the SUMO tool (Simulation of Urban Mobility) to evaluate the model. The result is added at the end which clearly shows the efficiency of the model compared to others.

Keywords Traffic light control · Deep Q-learning · Artificial neural networks · RFID

S. Yadav · S. Singh (✉) · V. K. Chaurasiya
Indian Institute of Information Technology, Devghat, Jhalwa, Prayagraj 211015, Uttar Pradesh, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_4

1 Introduction

Population growth and urbanization had sped up the demand for a good transportation system. On the other hand, the existing infrastructure roads and its corresponding management are not satisfactory to bear the increasing traffic volume [1]. This had led to several problems like congestion which causes delays and subsequently had an impact on the environment through noise and air pollution [2]. So proper traffic management is a must. There were numerous research ideas that were put forward however, most of them consist of a set of codes (programs). These programs were not only computationally complex but were based on certain assumptions. As a consequence, they were not effective in the real-time scenario. Some researchers tried to employ machine learning algorithms like fuzzy logic, genetic logic algorithm, etc. Still, these methods failed to achieve the desired output because they were not considering the real-time data inputs. Therefore, a good traffic system is required which should do the continuous monitoring of the traffic in real-time and take the decision after analysing all the roads at the intersection.

In order to achieve the above goal, we are going to employ an RFID reader for continuous monitoring (assuming that every vehicle is having an RFID tag). For analysing and decision-making we will take the help of reinforcement learning [3, 4]. The reason behind using a reinforcement learning technique is that it does not depend upon the heuristic assumptions and equations and fits perfectly in the model to master the optimal control through the previous experiences of handling the traffic. The concept of reinforcement learning is based on the Markov decision process [5]. It has been extensively used as a computational tool. The traditional reinforcement learning algorithm was less optimal with limited scalability. So, Q-learning, a popular RL algorithm, and a deep neural network was chosen because of its better learning capacity [6, 7].

The use of information and communication technology to improve the quality of living is referred to as smart cities. As a result of continual development and population growth, smart cities have evolved. Smart cities seek to address these issues in order to improve inhabitants' quality of life. When a city can develop and implement creative solutions that are based on cutting-edge technologies and cutting-edge scientific knowledge, it is considered smart. To put it another way, a city gets "smarter" by developing and implementing data-driven solutions to make it easier to monitor, understand, analyse, plan, and optimize its operations, activities, services, and policies.

A. **Outline of Chapter**

The remaining portion of the chapter is tabulated in the following order: Sect. 2 gives the synopsis of the existing research work of traffic light control. While Sect. 3 outlines the preliminaries. Section 4 describes the learning mechanism of the model and describes its corresponding state, action, and reward in detail. Section 5 discusses the experimental setup and training of the whole model additionally an analysis and the performance of the results are also mentioned. Finally, the conclusion and future work are described in Sect. 6.

2 Related Work

In this paper [8] the author put forward an adaptive traffic signal control system that was trained by deep Q-learning and reduces the travel time by 20% and waiting time by 82%. In another attempt, the author tried to reduce the waiting time of the vehicle by using a multi-agent reinforcement learning algorithm. Furthermore, they showed their model outperformed even after an increase in traffic load.

In the paper [9], the author has constructed a two-way street model with a controllable traffic light which is dependent on the time function each cycle time is different from the previous one. While in [8] theauthor applied a deep reinforcement learning method to propose an adaptive traffic signal control system (simulator) and trained the model using Q-learning. In [10] paper Juntao Gao et al. modelled a deep reinforcement learning algorithm that takes the attribute from the real-time data and masters the excellent policy for adaptive signal control. In this research paper, [11] author attempted to adjust the duration of traffic lights dynamically. For that, they divided the whole scenario into smaller sections and employed conventional neural network to map the reward with the state. The state was defined by vehicle position and speed information.

Centralized reinforcement learning is not feasible for adaptive traffic signal control. This paper [12] presents a fully scalable and decentralized MARL algorithm. Proposed novel A2C-based MARL. The author put forward an intelligent driving model in [13] that functions on the input of this adaptive traffic signal control which employs a multi-agent framework that dynamically learns the behaviour of the driver. They have used the Bayesian interpretation of probability for decision-making. This paper [14] put forward a load balancing approach that relies on the prediction of the traffic situation. This is achieved by the efficient cooperation of the micro base stations. Spatiotemporal correlation with CNN is used to predict the traffic situation. In this paper [15] author integrated deep learning with the Bayesian model (proposed by Wang) to predict the traffic flow.

One advantage is that it overcomes the error magnification phenomenon. In another paper [16] employs deep learning. The model was specifically designed to learn traffic speed. In order to predict the real-time traffic speed, they employed LTE (Long Term Evolution) data.

This paper [17] presents an efficient scheduling method. The proposed method is able to control a dynamic and complex traffic environment with the help of reinforcement learning techniques. In another paper [18] author designed an adaptive signal control system and called it RHODES. For the smoother working of the adaptive signal control, real-time information is taken from the detector. In order to predict the arrival of vehicles at the intersection point, the author had used the PREDICT algorithm which was proposed by Head. For that, this algorithm uses detectors output, traffic state, and planned phase timing on reaching each upstream intersection. This adaptive model could predict both the short-term and medium-term fluctuations of the traffic. This approach could even set phases so as to maximize performance.

3 Background

Reinforcement learning [19] is a particular section of machine learning class that is entirely offbeat from the other two categories (i.e. supervised and unsupervised learning) [20, 21]. The main idea is to keep on learning and producing better results. This is done by firstly monitoring the environment and keep on analysing the situations so as to take suitable action. The reward is earned based on the effectiveness of the actions. So, the goal is to augment the rewards. We can denote the reinforcement learning model with the help of a four-tuple (S, A, R, T) which is described below:

A. **RFID**

The RFID is a special type of technology that employs radio frequency signals to identify, pinpoint, and track the target without human intervention [22, 23. RFID systems consist of transponders, transceivers, and back-end storage which are commonly called tags, readers, and databases, respectively. Tags have a microchip that has memory constraints and is used to store the unique tag identifier and other related information. They are two types: active and passive. Active tags have their own battery source while passive tags don't. They use destination electromagnetic waves to transmit the collected data. Since these tags have a longer range of transmission thus, they are preferred where there is a need to identify objects over long distances such as roadside units in traffic management, health care applications, animal tracking, object locating in logistics markets, etc. While readers are the devices that can read tags for object identification and stored information. It can transfer these data to the back-end systems.

B. **Reinforcement Learning Model**

For building a traffic light control system using deep Q-learning [17], we need to define the states, actions, and rewards.

Here we present how the three elements are defined in our model.

State: The state of the agent describes a representation of the situation of the environment in a given timestep t and it is denoted with s_t. For effective learning of agents to optimize the traffic on each road the agent should have sufficient information on the distribution of vehicles in the current environment. The objective of this representation is to allow the agent to know about the environment where vehicles are located at timestep t. To serve this purpose the approach proposed in this paper is inspired by paper [24] due to its simple representation of state which makes use of RFID reader so easy. In particular, this state design includes only spatial information about the vehicles hosted inside the environment, and the cells used to discretize the continuous environment are not regular. In this paper, we will explore the chance of getting good results from a simple state representation. In each arm of the intersection, incoming lanes will be discretized in cells that will notify whether or not a vehicle is present inside the cell (Fig. 1).

Fig. 1 State representation

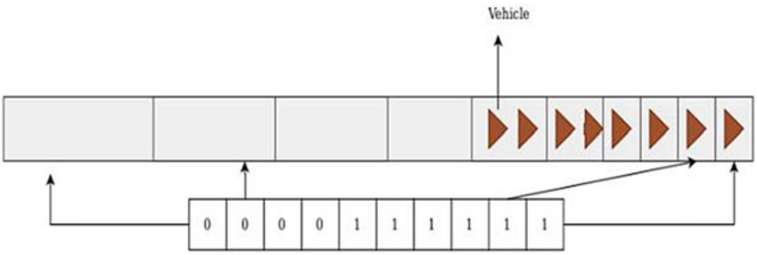


Fig. 2 DSR vector representation with respect to cells of intersection

(1) **Discrete state representation**: Basically DSR (discrete state representation) is a mathematical representation of the state space as a form of the vector where every element is computed by the following equation

$$DSR[i] = c \tag{1}$$

c = 1 if *i*th cell contains at least one vehicle else c = 0, as explained in Fig. 2.

It must be noted that the DSR vector does not represent only a single intersection. As shown in Fig. 1 we have divided a single road of intersection into 3 lanes. As described in Fig. 3 lane1 is dedicated to going straight and left, lane2 is dedicated to going right only. So lane1 and lane2 both are having different DSR vector and each lane contain 10 cells that mean every arm of the intersection there are 20 cells and in the whole intersection 80 cells.

So, the proposed state-space is composed of 80 boolean cells. This means that the number of possible states is 2^{80}. The choice of boolean cells for the environment representation is also crucial because the agent has to explore just the most significant subset of the state space in order to learn the best behaviour.

When the agent samples the environment at a timestep t, it receives a vector DSR_t containing the discretize representation of the environment in that timestep. This is the principal information about the environment that the agent receives, so it is

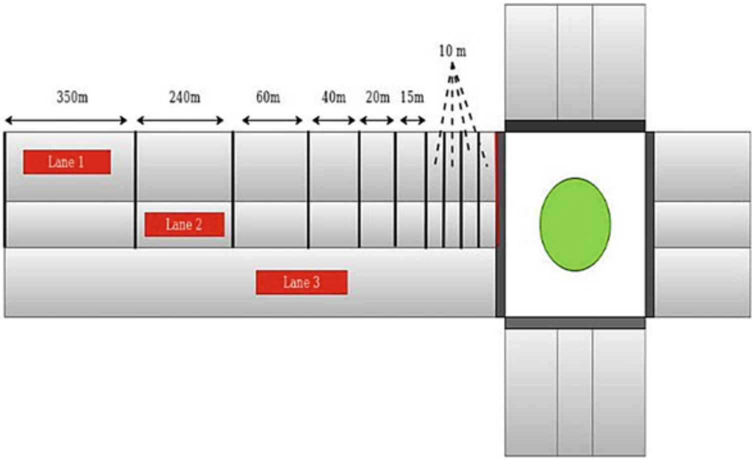


Fig. 3 State representation of the west road of the intersection, with cells length

designed to be as precise as possible but without being excessively detailed in order to not increase the computational complexity of the neural network's training [25].

Action space-The action set identifies the possible actions that the agent can take. The agent is the traffic light system, so doing an action translates to turning green some traffic lights for a set of lanes and keep it green for a fixed amount of time. In this paper we are using green time is set at 10 s and the yellow time is set at 4 s. In other words, the task of the agent is to initiate a green phase choosing from the predefined ones. The action space is defined as

$$A = \{NSSL;\ NSR;\ EWSL;\ EWR\} \tag{2}$$

The set represents every possible action that the agent can take. Every action a set is described below

- North-South Straight and Left (NSSL): the green light phase will be activated for those vehicles which are present in the north and south arm and want to proceed either straight or left
- North-South Right (NSR): the green light phase will be activated for those vehicles which are present in the north and south arm and want to proceed with their right arm.
- East-West Straight and Left (EWSL): the green light phase will be activated for those vehicles which are present in the east and west arm and want to proceed either straight or left.
- East-West Right (EWR): The green light phase will be activated for those vehicles which are present in the east and west arm and want to proceed with their right arm (Fig. 4).

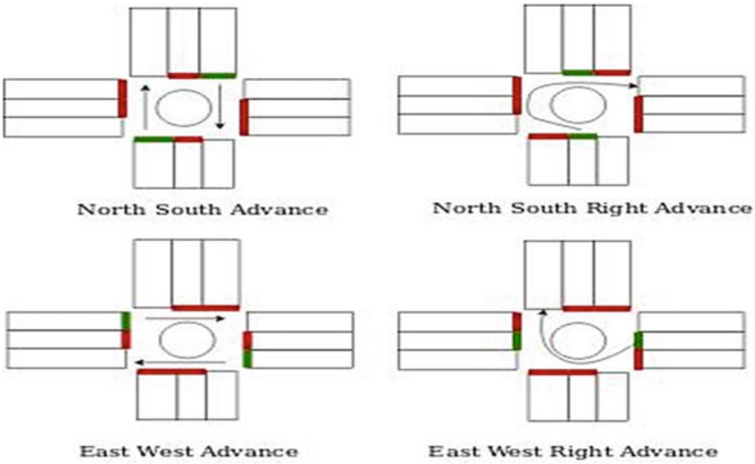


Fig. 4 The four possible actions

If the same is chosen at timestep t and timestep t – 1 (i.e. the traffic light orientation is the same) then there is no yellow phase and therefore the current green phase continues. And if the action chosen in timestep t is not equal to the previous action, a 4 s yellow phase is activated between the two actions. As explained in Fig. 5

Rewards: In reinforcement learning, based on the action chosen by the agent—the feedback will be generated from the environment in terms of reward [26, 27]. To enhance the model, based on the reward the agent will change its intuition for further future action. Therefore, the reward is a crucial aspect of the learning process. The reward usually has two possible values: positive or negative. Good action led to positive reward similarly bad action leads to negative reward. In this scenario, the objective is to maximize the traffic flow through the intersection over time. In order to achieve this goal, the reward should be derived from some performance measure of traffic efficiency, so the agent is able to know whether or not the action increases efficiency. In traffic analysis, several measures are used, such as throughput, mean delay, and travel time [28]. In this paper, the agent measures the total waiting time defined as:

Total waiting time: The sum of individual waiting times of each car in the environment in timestep t. waiting time is defined as the time duration during which a vehicle is moving with a speed of less than 0.1 m/s. The total waiting time is computed by the following equation.

Fig. 5 Possible simulation time Difference between two actions

$$\mathrm{twt_t} = \sum \mathrm{wt_{(veh,f)}} \tag{3}$$

where $\mathrm{twt_t}$ is the total waiting time at timestep t and $\mathrm{wt_{(veh;t)}}$ is the time duration (in seconds) a vehicle veh has a speed of less than 0.1 m/s at timestep t. n represents the total number of vehicles in the environment in timestep t

Reward function: The reward function that generates a reward for the agent is defined in the equation as

$$\mathrm{r_t} = \mathrm{twt_{t-1}} - \mathrm{twt_t} \tag{4}$$

where $\mathrm{r_t}$ represents the reward at timestep t. $\mathrm{twt_t}$ and $\mathrm{twt_{t\,1}}$ denote the aggregate waiting time of all the vehicles at the intersection at timestep t and t – 1, respectively.

(2) **Positioning of RFID Reader for DSR**: As explained earlier DSR vector is a discrete representation of state from a continuous environment. In the simulation, SUMO provides much functionality to get this vector but for real-time, we proposed the use of RFID reader and RFID tags. Here we are supposing that each vehicle is having an RFID tag and we are using RFID reader at the starting of each cell as shown in Fig. 6. Starting cells are having RFID readers with 2–5 m range capacity and the rest are having with a range of about 10 m capacity. As we explained earlier if there is only one vehicle in the *k*th cell then DSR[k] set to one, so basically here we are trying to detect the vehicle at starting of the cell.

RFID reader for the first 4 small cells: For the first four small cells, the RFID will be positioned at the beginning of the cell facing towards diagonal with the range capacity 5 m as shown in Fig. 7.

RFID reader for other cells: The RFID reader for other cells will be positioned 5 m apart from the beginning of the cell facing towards the road with the range 2 m. Here we are assuming the width of the road is 3.7 5 m as used in India.

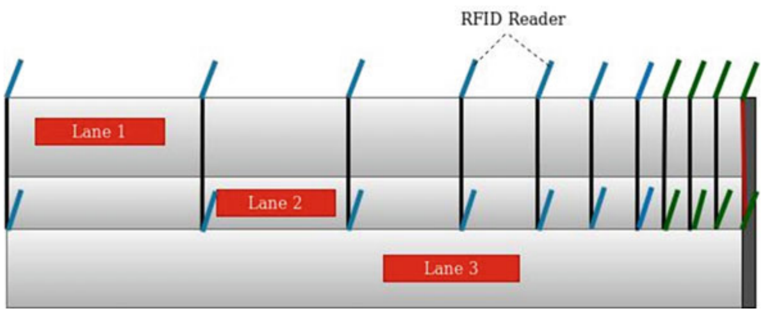


Fig. 6 RFID positions in cells of arm

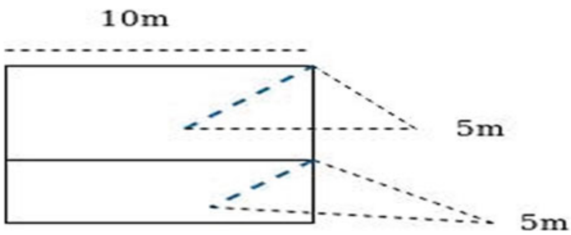


Fig. 7 RFID positions for starting 4 cells of the arm

4 The Agent's Learning Mechanism

We have employed Deep Q-learning for the purpose of learning. It is a combination of deep learning and neural networks [25].

A. Q-Learning

It is a unique form of reinforcement learning which is model-free [29]. According to the state of the environment, a value is assigned to the action which is about to be taken. This value is called the Q-value which is defined in the form of an equation (Fig. 8).

$$Q(s_t,\ a_t) = Q(s_t,\ a_t) + (r_{t+1} + \gamma \max_A Q(s_{t+1},\ a_t)Q(s_t,\ a_t)) \tag{5}$$

Where:

- $Q(s_t, a_t)$ represents the value obtained after the action a_t has been taken after analysing the state s_t.
- The above equation basically updates the present Q-value with a quantity discounted by the learning rate.
- r_{t+1} denotes the reward.
- $t + 1$ highlights the relationship between taken action a_t and the subsequently received reward.
- The immediate future's Q-value is denoted by Q (s_{t+1}, a_t), where s_{t+1} represents the evolved state after implementing action a_t.
- Among all the possible actions a_t the most valuable action is selected which is represented by max A.

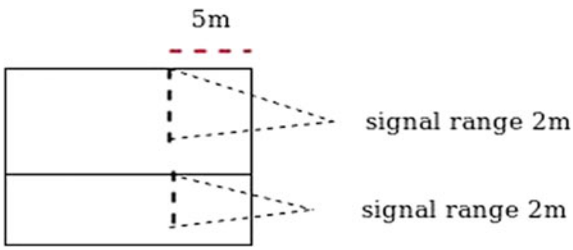


Fig. 8 RFID positions for other cells of the arm

- is the discount factor that assumes a value between 0 and 1, lowering the importance of future reward compared to the immediate reward

Here we are going to use a slightly modified version of the equation which is mentioned below:

$$Q(s_t,\ a_t) = r_{t+1} + \gamma \max_A Q'(s_{t+1},\ a_{t+1}) \quad (6)$$

where

- r_{t+1} represent the reward.
- The term $Q'(s_{t+1}, a_{t+1})$ is the Q-value associated with taking action a_{t+1} in state s_{t+1} i.e. the next state after taking action a_t in state s_{t+1}.
- As seen in the above equation $\boldsymbol{\gamma}$ denotes a small penalization of the future reward compared to the immediate reward.

B. **Deep Q-Learning**

In order to map a state of the environment s_t to Q-values representing the values associated with actions a_t, a deep neural network [25] is built. The input of the network is the vector DSR_t the state of the environment at timestep t. The outputs of the network are the Q-values of the possible action from state s_t.

The input layer of the neural network S^{in} is defined as:

$$S^{\boldsymbol{in}}_{k,t} = DSR_{k,t} \quad (7)$$

where $S^{\boldsymbol{in}}_{k,t}$ is the *k*th input of the neural network at timestep t and $IDR_{k;t}$ is the *k*th element of the vector DSR at timestep t as shown in Fig. 5 This means that $|S^{in}| = |DSR| = 80$, that is the input size of the neural network.

The output layer of the neural network S^{out} is defined as:

$$S^{\boldsymbol{out}}_{\boldsymbol{j,k}} = Q(s_{\boldsymbol{t}}; \boldsymbol{a}_{\boldsymbol{j;t}}) \quad (8)$$

where $S^{\boldsymbol{out}}_{j,k}$ is the *j*th output of the neural network at timestep t and $Q(s_t, a_{j,t})$ is the Q-value of the *j*th action taken from state s_t at timestep t. This means that the output cardinality of the neural network is $|A| = 4$, where A is the action space.

The neural network is a fully connected deep neural network with a rectified linear unit activation function (ReLU). And 5 hidden layers are used.

As explained in Fig. 9 shows the vector DSR as the input of the network, then the network itself with the hidden layers, and finally the output layer with 4 neurons representing the 4 Q-values associated with the 4 possible actions.

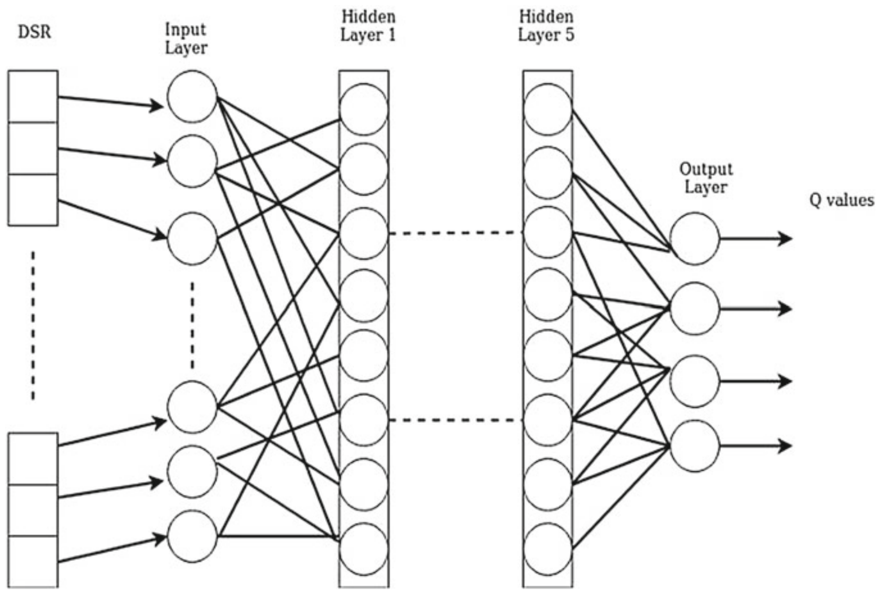


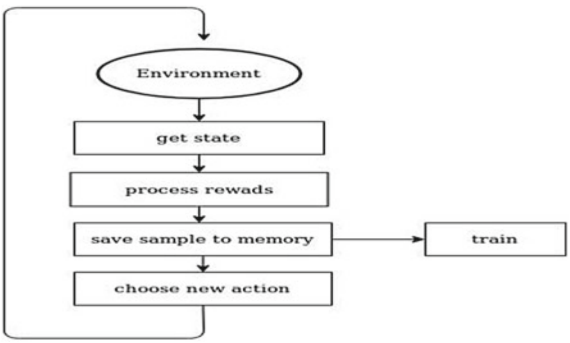
Fig. 9 Strategy of deep neural network

5 Experimental Setup and Training

As we have already defined the specification of an agent such as the state, the possible actions, and the reward. Fig. 10 shows how all these components work together to establish the workflow of the agent during one single timestep t.

After a fixed amount of simulation steps, the timestep t of the agent begins. First, the agent retrieves the environment state and the delay times next, using delay times of this timestep t and from the last timestep t − 1. It calculates the reward associated with action taken at t − 1. Then the agent packs the information gathered and saves

Fig. 10 The workflow of the agent in a timestep



it to a memory which is used for training purposes. Finally, the agent chooses and set the new action to the environment, and a new sequence of simulation step begins.

A. Experience Replay

For the sake of improving the conduct of the agent and the learning efficiency, a procedure is endorsed during the training phase which is called Experience replay [30]. It requires acknowledgment of all the essential information necessary for learning to the agent, in the form of a group called a batch. Before submitting simulation information, the agent takes the batch to the data structure intuitively called memory who stores all collected samples. A sample m is formally defined as the quadruple.

$$m = \{s_t, a_t, s_{t+1}, a_{t+1}\} \tag{9}$$

where r_{t+1} is the reward that is obtained after carrying out the action a_t from state s_t, which unfolds into the succeeding state s_{t+1}. A training instance involves the gathering of a group of samples from the memory and the neural network training using the aforesaid samples.

B. The Training Process

Given the description of experience replay, a detailed explanation of the training process is explained. This process is executed every time a training instance of the agent is initiated.

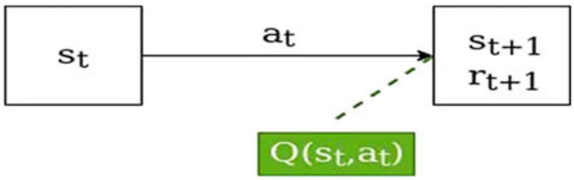
- A sample m containing the most recent information, described in Eq. (8), is added to the memory.
- A fixed number of samples (light sampling strategy used) are picked randomly from the memory constituting the batch B.

A single sample b_k ε B contains the initial state s_t with the most suitable action selected a_t and its corresponding reward r_{t+1} following the next immediate state s_{t+1}. For every sample b_k the following operations are performed.

(1) Computation of the Q-value $Q'(s_{t+1}, a_{t+1})$ by submitting the vector DSR representing s_t to the neural network and obtaining the predicted Q-value relative to action a_t. As shown in Fig. 11.

(2) Computation of Q-values $Q'(s_{t+1}, a_{t+1})$ by submitting the vector DSR representing the next state s_{t+1} to the neural network and obtaining the predicted Q-values relative to actions a_{t+1}. These represent how the environment will evolve and what values will probably have the next actions. As shown in Fig. 12.

Fig. 11 Computation of the Q-value Q for one sample



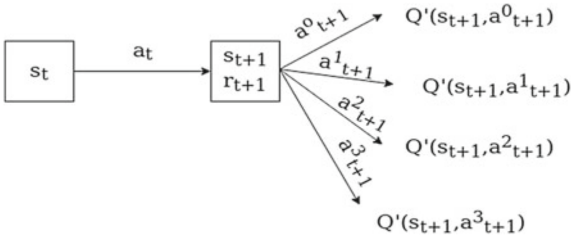


Fig. 12 Computation of Q-values Q´ for one sample

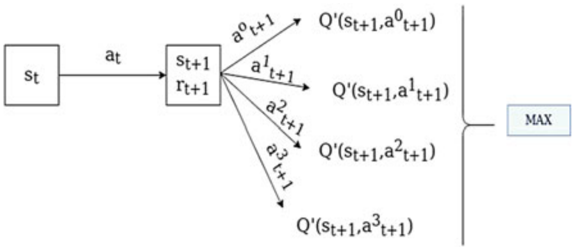


Fig. 13 Update Q-value using Eq. (6) for one sample

(3) Update of the Q-value using equation (among the possible future Q-values computed in stage two) $\max_A Q'$ indicates that the best possible Q-value is selected, representing the maximum expected future reward. It will be deducted by a factor γ that gives more importance to the immediate reward. As shown in Fig. 13

(4) Training neural network: The input is the vector DSR representing the state s_t, while the desired output is the updated Q-values Q (s_t, a_t) that now includes the maximum expected future reward due to Eq. (6), the next time the agent encounters the state s_t or a similar one, the neural network will be likely to output the Q-value of action a_t that is comprehensive of the best future situation.

III. Simulation of Urban MObility (SUMO)

The abbreviation SUMO stands for (Simulation of Urban MObility) [31]. It is a traffic microsimulation which provides a software package that allows users to design the road infrastructure and related elements. Among the packages that SUMO offers, in this paper the following were used.

NetEdit was used to design the static elements of the intersection, such as the characteristics of the roads, the distribution of traffic lights, and the lane connections across the intersection.

Package TraCI is used to define the type, characteristics, and generation of vehicles that are going to be in the simulation

IV. Result

The model is trained with the following hyper-parameters.

Parameters	Values
Neural network	8 layers, 400 neurons each
Memory size	50,000
Episodes	300
RFID range	2 and 5 m

The high gamma means that the agent is aiming at maximizing the expected cumulative reward of multiple consecutive actions. This can be considered as the true RL agent that has a long look ahead and tries to search for the policy that overall gives the best performance with respect to the reward obtained at every step.

Figure 14 shows the reward gain by RL agent at each episode, as we can see that it continuously increasing which means after each episode agent learns to take better action.

Figure 15 shows the queue length of vehicles i.e. number of cells occupied by vehicles, which is continuously decreasing which means the waiting time of the vehicles is decreasing after each episode.

Figure 16 shows the delay of the vehicle which basically represents the amount of time spent by a vehicle in the red-light phase, as we can see this delay is continuously decreasing after each episode.

E. **Performance Metrics**

In order to evaluate the agent performance, after 300 episodes when the agent has been trained, we conduct 10 more episodes to observe the following performance matrix.

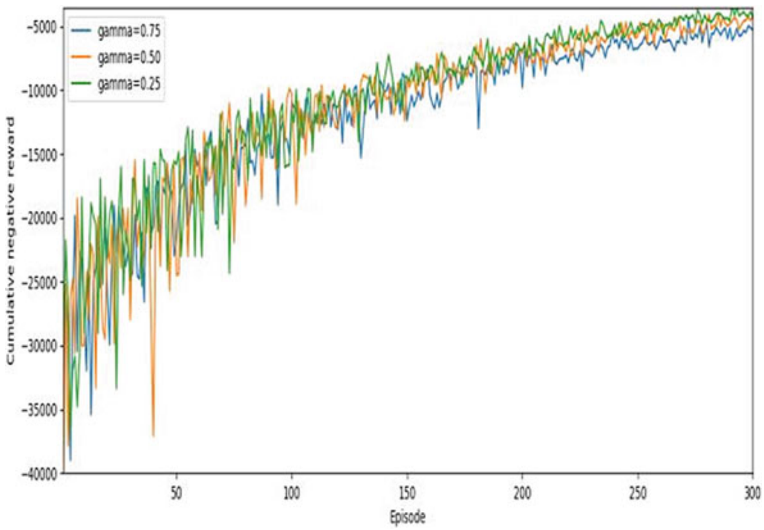


Fig. 14 Reward while training in high-traffic

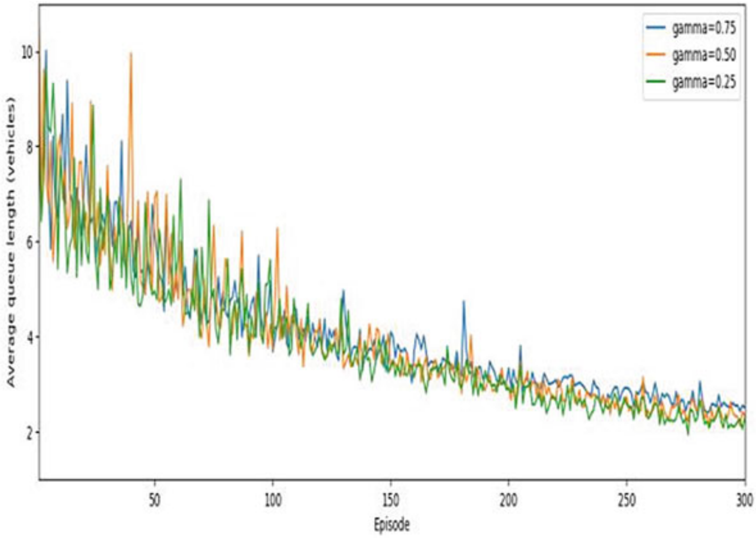


Fig. 15 Queue length of the vehicle while training in high-traffic

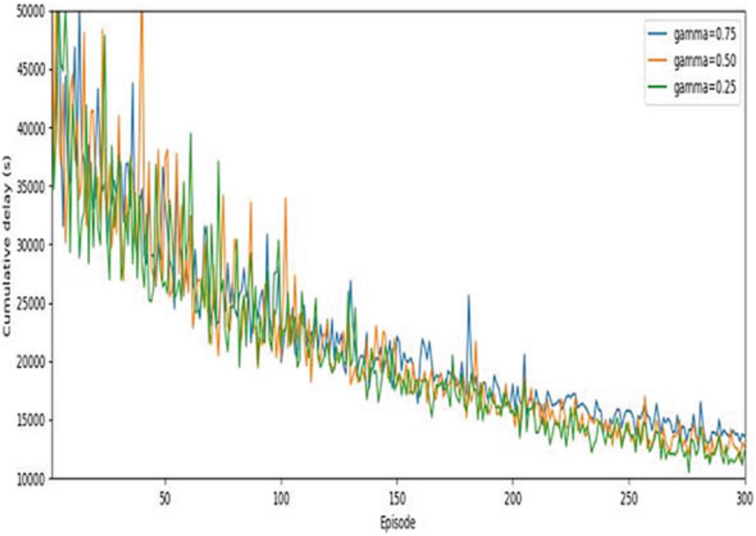


Fig. 16 Delay of the vehicle while training in high-traffic

(1) Average Negative Reward: Average of all rewards generated by the last 10 episodes when the agent has already trained.

$$anr = avg_{ep} \sum_{ep=0}^{ep=10} r_{ep} \tag{10}$$

(2) Total waiting time: Sum of delay times of last 10 episode.

$$twt = \sum_{ep=0}^{ep=10} wt_{ep} \tag{11}$$

The baseline is needed to compare the agent performance, so we perform a simulation which behaves similarly as the current traffic scenario behave that means every traffic light phase is always activated in the same order defined as

[NSR-NSSL-EWR-EWSL] and following performance matrix observed.

Parameters	Values
anr	−202, 871
twt	942, 652

As Figs. 14 and 16 show that $\gamma = 0.25$ performs best so that we perform baseline scenario with the same value and in high traffic scenario.

Now the comparison between the baseline scenario and proposed method shown below.

Parameter	Baseline	Proposed	Reduced%
anr	–	–	
	202, 871	44, 155	78.23
twt	942, 652	129, 353	86.27

6 Conclusion

Reinforcement learning is actually an environment-dependent algorithm that had achieved augmenting interests in the traffic control domain. In this chapter, we have presented a traffic light control model using a deep Q-learning method (i.e., Q-learning with the neural network) and RFID. The results were discussed. The performance of the proposed model was evaluated using SUMO and was compared. It was shown that the proposed model notably outperforms conventional approaches.

For future work, we would like to investigate other machine learning algorithms for traffic light control systems. Furthermore, we would like to test our model proposed in this study on a more realistic traffic simulator and try to give priorities to important and emergency vehicles like ambulance and a police van.

References

1. Balaji PG, German X, Srinivasan D (2010) Urban traffic signal controlusing reinforcement learning agents. IET Intell Transp Syst 4(3):177–188
2. Hartenstein H, Laberteaux LP (2008) A tutorial survey on vehicular adhoc networks. IEEE Commun Mag 46(6):164–171
3. Abdulhai B, Pringle R, Karakoulas GJ (2003) Reinforcementlearning for true adaptive traffic signal control. J Transp Eng 129(3):278–285
4. Qoniu LB, Babuska R, De Schutter B (2010) Multi-agentreinforcement learning: An overview. In: Innovations in multi-agentsystems and applications-1, pp 183–221. Springer
5. Lin L-J, Mitchell TM (1992) Memory approaches to reinforcement learning in non-Markovian domains. Citeseer
6. Lin L-J (1993) Reinforcement learning for robots using neural networks. Technical report, Carnegie-Mellon Univ Pittsburgh PA School of Computer Science
7. Hochreiter S, Schmidhuber J (1997) Long short-term memory. Neural Comput 9(8):1735–1780
8. Genders W, Razavi S (2016) Using a deep reinforcement learningagent for traffic signal control. arXiv:1611.01142
9. De Schutter B, De Moor B (1998) Optimal traffic light control for asingle intersection. Eur J Control 4(3):260–276
10. Gao J, Shen Y, Liu J, Ito M, Shiratori N (2017) Adaptive traffic signal control: deep reinforcement learningalgorithm with experience replay and target network. arXiv:1705.02755
11. Liang X, Du X, Wang G, Han Z (2018) Deep reinforcement learning for traffic light control in vehicular networks. arXiv:1803.11115
12. Chu T, Wang J, Codec‘a L, Li Z (2019) Multi-agentdeep reinforcement learning for large-scale traffic signal control. IEEE Trans Intell Transp Syst
13. Khamis MA, Gomaa W (2014) Adaptive multi-objectivereinforcement learning with hybrid exploration for traffic signal controlbased on cooperative multi-agent framework. Eng Appl Artif Intell 29:134–151
14. Li J, Luo G, Cheng N, Yuan Q, Wu Z, Gao S, Liu Z (2018) An end-to-end load balancer based on deeplearning for vehicular network traffic control. IEEE IoT J 6(1):953–966
15. Gu Y, Lu W, Xu X, Qin L, Shao Z, Zhang H (2019) An improved Bayesian combination model for short-term traffic prediction with deep learning. IEEE Trans Intell Transp Syst
16. Ji B, Hong EJ (2019) Deep-learning-based real-time roadtraffic prediction using long-term evolution access data. Sensors 19(23):5327
17. Arel I, Liu C, Urbanik T, Kohls AG (2010) Rein-forcement learning-based multi-agent system for network traffic signal control. IET Intell Transp Syst 4(2):128–135
18. Mirchandani P, Head L (2001) A real-time traffic signal control system: architecture, algorithms, and analysis. Transp Res Part C Emerg Technol 9(6):415–432
19. Sutton RS, Barto AG (2011) Reinforcement learning: an introduction, 2nd edn. http://incompleteideas.net/sutton/book/the-book-2nd.html
20. Mnih V, Kavukcuoglu K, Silver D, Rusu AA, Veness J, Bellemare MG, Hassabis D et al (2015) Human-level control through deep reinforcement learning. Nature 518(7540):529–533
21. Wiering MA (1999) Explorations in efficient reinforcement learning, Doctoral dissertation, University of Amsterdam
22. Juels A (2006) Rfid security and privacy: a research survey. IEEE J Sel Areas Commun 24(2):381–394
23. Want R (2006) An introduction to RFID technology. IEEE Pervasive Comput 5(1):25–33
24. Vidali A, Crociani L, Vizzari G, Bandini S (2019) A deep reinforcement learning approach to adaptive traffic lights management. In: WOA, pp 42–50
25. Srinivasan D, Choy MC, Cheu RL (2006) Neural networks for real-time traffic signal control. IEEE Trans Intell Transp Syst 7(3):261–272
26. Watkins CJCH, Dayan P (1992) Q-learning. Mach Learn 8(3–4):279–292
27. Watkins CJCH (1989) Learning from delayed rewards

28. Dowling R (2007) Traffic analysis toolbox volume vi: definition, interpretation, and calculation of traffic analysis tools measures ofeffectiveness. Technical report
29. Hausknecht M, Stone P (2015) Deep recurrent q-learning forpartially observable mdps. In: 2015 AAAI fall symposium series
30. Lin L-J (1992) Reinforcement learning for robots using neural networks
31. Krajzewicz D, Erdmann J, Behrisch M, Bieker L (2012) Recent development and applications of sumo-simulation ofurban mobil-ity. Int J Adv Syst Measur 5(3 &4)

Driver Drowsiness Alert System Using Real-Time Detection

Krishna Mridha, Rabindra Nath Shaw, Dinesh Kumar, and Ankush Ghosh

Abstract Modern civilization is migrating toward Smart cities, which use sophisticated technologies such as IoT, artificial intelligence, cloud computing, blockchain, and others to improve the quality of life for their citizens in areas such as transportation, traffic management, environment, government interaction, and even the local economy. Maintaining a system is necessary for a time-saving life because of the comfortable lifestyle and digital security. For instance, we must be concerned about the daily road accidents by automobiles to achieve the security required to construct a smart city. Every year, hundreds of people are killed in car accidents around the world as a result of drowsy drivers. This information emphasizes the importance of a sleep sensor application in preventing such tragedies and, ultimately, saving lives. To address this challenge, we offer a unique intensive learning strategy based on neutral neural networks (CNN). The goal of the chapter is to create a working prototype of a sleepiness detection system that can help to make a smart city. The technology works by keeping an eye on the driver's eyes and sounding the warning while it dries. The system is a non-intrusive real-time control system. The main goal is to improve motorist safety without causing any disruption. The driver's eyelid is identified in this experiment. When a motorist's eyes are closed for a long time, the driver is regarded indifferent, and an alert sound. To detect facial features, the Haar Cascade library is utilized, and programming is done in OpenCV.

Keywords Drowsy · CNN · OpenCV · Eyes · Detection system · Alarm

K. Mridha · D. Kumar
Marwadi University, Rajkot, Gujarat, India
e-mail: krishna.mridha108735@marwadiuniversity.ac.in

D. Kumar
e-mail: dinesh.kumar@marwadieducation.edu.in

R. N. Shaw
Galgotias University, Greater Noida, Uttar Pradesh, India
e-mail: r.n.s@ieee.org

A. Ghosh (✉)
The Neotia University, Sarisha, West Bengal, India
e-mail: ankushghosh@ieee.org

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_5

1 Introduction

A "Smart City" is a city that incorporates information and communication technologies to stimulate economic growth, improve the quality of life, and support governance. For example, a municipality might connect its transportation and energy grid systems, build device energy-efficient structures, and develop communication to improve healthcare, emergencies, and other public services monitoring and access. For the same, the road accident is one of the major parts of building the smart city. We have to find the reason for that many road accidents and have to find the smart solution to reduce the road accident that requires building a smart city. If we want to reduce the accident, we have to observe the driver by a smart way. For instance, Drowsy driving is one of the most common causes of car accidents. This was validated by a study [1] done by the AAA Foundation for Traffic Safety, which revealed that melatonin crashes accounted for 23.5 percent of all vehicle crashes in 2015: 16.5% of fatal crashes and 7% of non-fatal crashes. Essentially, this report claimed that over 5,000 Americans died in car accidents caused by sleep deprivation. Drowsy driving causes vehicle collisions and accidents all around the world. Each year, large numbers of people are killed in car accidents caused by drowsy driving [2]. Sweden, Denmark, Britain, and other EU nations have consistent accident reporting methods, and drowsy driving accounts for 10–30 percent of all accidents in data analyzed from these countries [3]. Vehicle sleepiness wearable sensors have been studied and developed by numerous chapters all over the world to decrease such errors and injuries to the safety of the vehicle and passengers. The following techniques [4, 5] can be used to categories these sleepiness tracking systems: car, behavior modification, and behavioral. Vehicle-based sleepiness detection systems measure lane changes, steering wheel movement, speed, and accelerator pedal pressure, among other things. Drowsiness detection systems that are based on the driver's behavior, on the other hand, are based on the driver's conduct. To be more specific, a camera monitors eye closure, yawn, and head posture to detect tiredness in such systems. Finally, physiological-based sleepiness detection systems identify driver tiredness by correlating physiological signals ECG (Electrocardiogram) and EOG (Electrooculogram). The previous chapter on this subject has largely focused on recognizing a combination of one or more of these indicators. Many types of the chapter focused on yawned detection [6, 7], whereas others emphasize eye detection [8, 9]. The width and length of the open mouth were generally examined in studies that looked into yawning detection. In [6], Wang finds a ratio between two perpendicular lines that run between the top and lower lip margins. Furthermore, he identifies sleeping when the ratio exceeds 0.5 in more than 20 current frames in 30 frames a second movie. In [7] detects yawning by comparing geometric feature changes in two successive frames and calculating the angular velocity between the nose center and the center of the mouth. These algorithms, on the other hand, are unable to distinguish between persons opening their mouths for regular activities (saying, smiling, singing, etc.) and yawning. Eye detection, on the other hand, is a crucial indicator for identifying tiredness. Some articles proposed utilizing Support Vector Machine (SVM) and Eye

Aspect Ratio (EAR) to count blinking eyes. However, in varied lighting circumstances, the accuracy of these approaches decreases. While driving, lighting conditions might fluctuate rapidly, affecting the accuracy of eye detection. Additionally, wearing glasses while driving should be considered (Fig. 1).

Drivers even without spectacles, as well as continually shifting light conditions, are considered in this study. Furthermore, to identify the level of tiredness for different individuals, a combination of both eye and mouth movements is used. For this experiment, the Media Chapter Lab (MRL) eye dataset was chosen, which includes open and closed eyes with/without spectacles, good/bad light sources, and none/small/big reflecting both to left and right eyes [10] (Fig. 2).

This study proposes a novel Convolutional Neural network (CNN) to detect tiredness to analyze the level of sleepiness. This network is used to merge features from

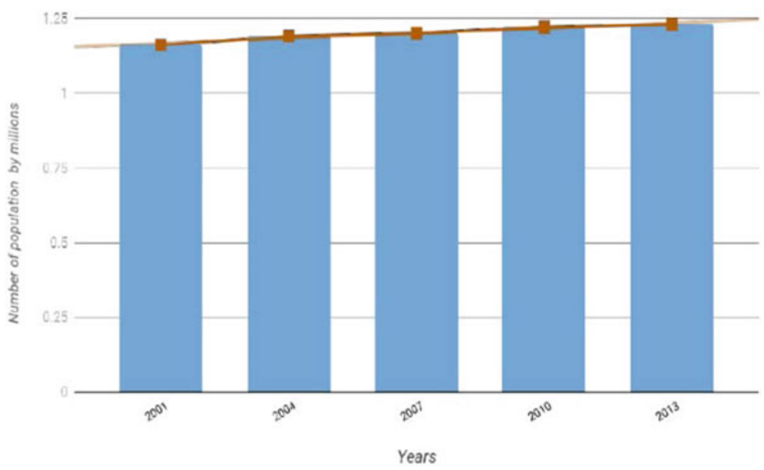


Fig. 1 Death by road accident reported

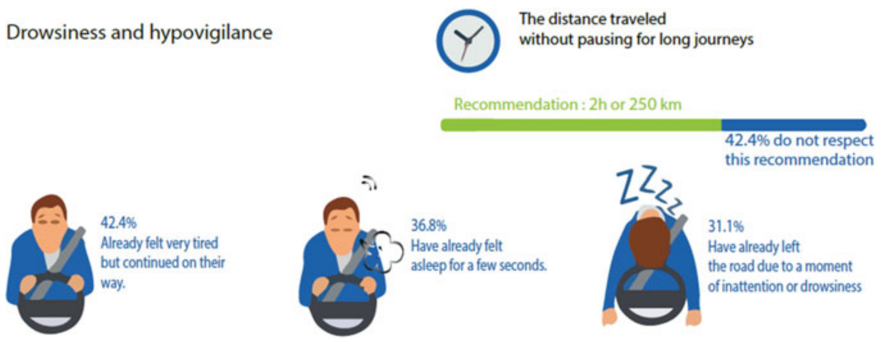


Fig. 2 In the Indian population, the prevalent risk factors for sleepy driving were investigated

Table 1 Hypermeters for training experiment

Hybrid CNN Hypermeters	
Solver_Type	SGD
Learning_Late	0.001
Momentum_Value	0.80
Batch_Size	50
Dropout_Value	0.03

the lips and eyes in the simplest way feasible. There are three main types of sleepiness levels based on NSF symptoms (Table 1). An opening eye without yawning can be defined as a normal driver with no tiredness observed, as illustrated in Table 1. Frequent blinking and yawning, on the other hand, may indicate a less tired driver. Closed eyes for more than 1.5 s cause the most severe drowsiness. The rest of the chapter is structured as follows: Sect. 2 presented a similar study and its implementations. Section 3 provides more details of the methodology of transfer learning algorithms and their approaches. Section 4 provides results and discussion. Section 5 provides the conclusion.

2 Literature Review

In this section, we'll go through some of the prior approaches to eyesight drowsiness detection that the chapter has utilized, as well as their shortcomings. Because eyelid closure is thought to be the most reliable sign of tiredness [11, 12], many of the technologies developed for driving drowsiness appear to rely on it [13]. Drowsiness has been detected using a variety of methods in the past. Some employ ordinary cameras [14], while others employ infrared and stereo cameras [13–15]. To identify driver weariness, Horng et al. [16] use image details to locate the eyeballs and track they're via dynamically matching technique. Blinking regularity, nod-ding frequency, ocular closure duration, percent eye tracking (PERCLOS), fixed gaze, and face position are all assessed in [13]. To detect driver drowsiness, these measured characteristics are merged using a fuzzy classifier. Al-Rahayfeh and Faezipour [17] uses yawning detection to evaluate whether or not the driver is tired. A variant of the Viola-Jones method is used to detect yawn and mouth regions, and Kalman filter motion tracking is used to monitor the face. The distance between the eyelids is measured by Danisman et al. [18, 19]. To increase the accuracy with which driver fatigue frameworks are discovered, several approaches have been developed. Mardi et al. suggested an electroencephalography (EEG)-based sleepy detection model. Separated turbulence highlighting and the sign's logarithm of energy are deleted to distinguish between idleness and purpose. For order, a fictitious neuronal organization was applied, with an accuracy of 83.3%. Noori et al. suggested a model based on the integration of Driving Quality Signals, EEG, and Electrooculography to detect lethargy [20]. Using differences in the rate at which the eyes squint, Danisman et al.

developed a technique for detecting laziness. The facial region of the photos was classified using the Viola-Jones recognition computation. The location of the understudies was then determined using a neural organization-based eye finder. If the number of flickers increased with each squint, it was established that the driver was tired. Abtahi et al. designed a yawning-based technique for detecting sluggishness. This method starts with identifying the face and then separating the eye and mouth districts. They determined that a huge mouth opening causes the mouth to open. A yawn can be seen on the face with the widest openness [21]. Dwivedi et al. employ CNNs to build a model for evaluating the language. Inert highlights were captured using convolutional neural organization, followed by a SoftMax layer for characterization, yielding a precision of 78 percent. Alshaqaqi et al. presented a Progressed Driver Assistance System to prevent roadway mishaps caused by slow drivers [22–25]. To determine PERCLOS for determination, a computation is proposed here to identify, follow, and study the face and eyes. After identifying the face, the eye region was determined, and the eye condition was assessed using the Hough adjustment for circles (HTC) technique [26–28]. It is stated that an eye is fatigued if it is closed for longer than 5 s. Learning is provided by three well-known organizations: Alex Net, VGG-FaceNet, and FlowImageNet. This study employed the NTHU driver tiredness video dataset, and the accuracy was around 73 percent. Tadesse et al. devised a method for identifying driver tiredness using a Hidden Markov Model. Viola Jones' estimate was used to extract the face districts in this study. Gabor wavelet decay was used to extract the features in the facial districts. The Adaboost learning equation was used to choose the highlights. This is a useful technique for depleted or stiff articulation [29]. Said et al. developed a forehead driver national language. The system identifies the vehicle's speech in this case and sounds a warning to inform him. The Viola-Jones model was utilized to determine the facial area and ocular district in this study. It had the reliability of 82 percent in interior temperatures tests and 72.8 percent in outdoor temperature tests. Picot et al. used both visual movement and cognitive actions to study driver tiredness. A single channel EEG was used to track the cerebrum's activity. To track the visual motion, squinting and representation are utilized [30]. EOG is used to eliminate squinting lights. Combining these two highlights with fluffy logic, an EOG-based finder was constructed. When tested on a dataset of twenty individual drivers, the accuracy of this study was 80.6 percent. Mandal et al. devised a dream-based approach for diagnosing fatigue in truck drivers. For head-shoulder location and driver identification, a HOG and SVM are used separately in this chapter [31]. They used OpenCV face identifier for face identification and OpenCV eye finder for eye location while identifying a motorist. The ghost is dissipating. To familiarize oneself with the eye form, we employed embedding, and to test eye transparency, we used another technique.

3 Materials and Methods

This chapter outlines a strategy for designing and developing a sleepiness detection system that is accurate, cost-effective, and reliable in real-world driving situations. The goal of the study was to create a reliable algorithm based on a resource-efficient deep learning architecture. In brief, our fundamental goal was to create a system that took use of convolutional neural networks' unrivaled accuracies in computer vision applications while still being computationally resource-efficient enough to be deployed on lower-cost embedded devices. We approached sleepiness detection as an object recognition challenge to reach this goal of constructing an efficient, asset, and expense drowsiness detection system. We trained it to recognize human faces, both open and closed, for our drowsiness detection task. The open and closed eyes were viewed as two distinct objects. Assuming that this task will be completed solely under daytime situations, the incoming video stream was acquired from a regular camera, and the training dataset was compiled accordingly, as discussed later along in this chapter. We utilize a different algorithm to decide if the driver is drowsy or not drowsy based on these detections during a particular period (Fig. 3).

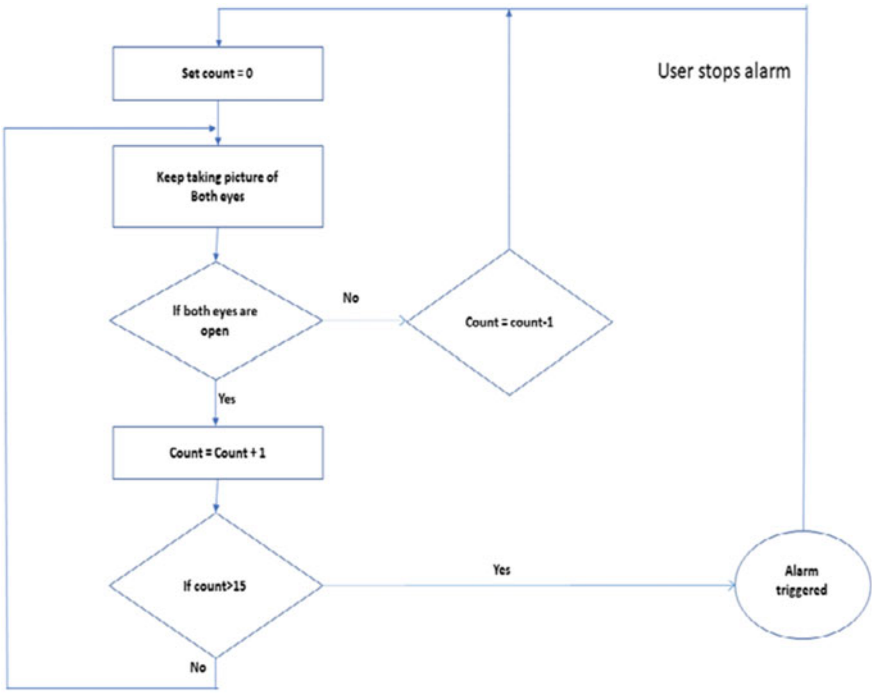


Fig. 3 Block diagram of proposed drowsiness detection algorithm

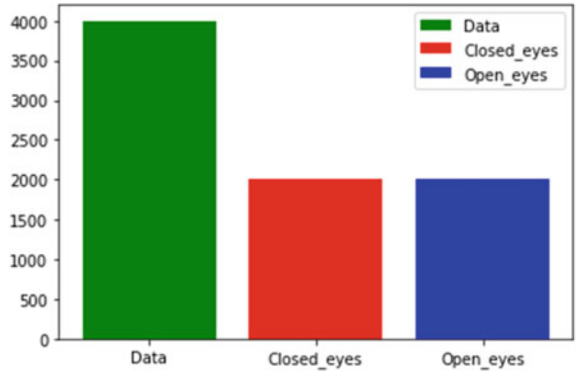


Fig. 4 Data distribution in both class

3.1 *Dataset Selection*

Because we apply an additional optimization technique in our CNN model, our suggested methodology differs significantly from past approaches to tackling the problem of drowsiness detection. We needed tagged photos of human faces with both eyes open and closed for our task. Our collection is made up of photos from a few publicly available datasets from reputable organizations. We also gathered information from various stock picture websites. The datasets and photos that were used to generate our custom dataset are listed below. We have collected the data from one famous machine learning repository named Kaggle. Our using dataset name is "Drowsiness Detection Dataset". The dataset contains two classes one is eye close another class is eye open. The total number of images is 4000 and both class has an equal number of 2000 images. Our target is the detection that driver's eye is open or close. Below we show the graph of the total image and per class image (Fig. 4).

3.2 *Feature Extraction*

Facial landmarks are used to identify and classify important facial features including the eyes, eyebrows, nose, mouth, and jawline. The position of 68 coordinates (x, y) corresponds to the driver's facial anatomy. Only the eye is used in this study to detect driving tiredness. To proceed, as stated in [32], ensembles neural networks for face detection are employed to detect the height and width of the eyes. To do so, the face must first be detected to obtain the face feature vector. Face cascade was chosen because it is superior in respect of recognition, detection, and accuracy to other approaches [33]. The left eye area (ABCD bounding box) is expanded after collecting both eye regions from real-time video. This approach is used to fit the CNN model's picture input layer for training, which is set to 24×24 pixels. The following formula is used to compute these coordinators:

$$A = \left(\frac{x_1 + x_2 - 24}{2}, \max(y_1, y_2, y_3) - \frac{x_1 + x_2 - 24}{2} \right) \tag{1}$$

$$B = \left(\frac{x_1 + x_2 + 24}{2}, \max(y_1, y_2, y_3) - \frac{x_1 + x_2 + 24}{2} \right) \tag{2}$$

Similarly, calibrated D and C coordinates are determined in the same way as A and B, with min (y4, y5, y6) and min (y4, y5, y6), respectively (y1, y2, y3).

3.3 Image Accusation

cvCaptureFromCAM assigns a capacity and uses the CvCapture framework to analyze a video transmission from the camera. The camera that will be utilized will need to be registered. If only one camera is accessible, or if it is being utilized in any case, one can be shifted. cvSetCaptureProperty, for example, sets camera properties. Using the CV.

CAP PROP FORMAT work, which returns-1, we may set length, stature characteristics, and retrieve outline. cvQueryFrame() decodes and returns a frame from a camera or video recording. With this capacity, the Grab Picture and Retrieval Frame are integrated into a single call. It is not proper to deliver the returned photograph.

3.4 Facial Detection

CvArr's grayscale image is a grayscale image. The capabilities will be determined by the location of a particular area of interest (ROI). In this vein, one technique to speed up face identification is to use ROI to decrease image size limits. The Haar highlight course was jam-packed with cvLoad() in the face identify code to generate the classifier course. In the face discovery code, the capacity contention is an OpenCV calculation work buffer that is created with cvCreateMemStorage(0) and then cleaned for reuse with cvClearMemStorage(0) (storage). The cvHaarDetectObjects() function looks for faces at all scales in the information image.

3.5 Create a Region of Interest in the Image

It adjusts the picture's ROI appropriately. The simple rectangular zone must be positioned within the image. After that, the objective image must be created. The widths of the ROI will be returned by cvGetSize. cvCopy is used to copy the image. The Topic Of Study will be restored with cvReset. We selected a few pixels from the leftmost part of a forehead to several pixels from the middle to half of its height. The distance between the district and the face is the same. The rectangular area is now used to attract attention.

3.6 Build Model

The following architecture was presented for a hybrid CNN model. The network design consists of three Convolution layers, each having a Max Pooling of 2 × 2 pools to ensure that data points are not exaggerated. After each of the convolution layers, the nonlinear function "Relu" was applied. The output of the convolution layers is transferred to a fully connected layer (FC) with a neuron output layer, and with a sigmoid activation, binary classification is established for Normal or Abnormal scans. The "Adam" optimizer has been utilized as the optimization approach throughout the model training.

I. *Convolutional Layer*

The convolution method is a technique for representing larger images i.e., since a series of trained functions function as function detectors are more (64 × 64 pixels). More preciously, at the lth layer, we denote:

- Input: $a^{[l-1]}$ with size $(n_H^{[l-1]}, n_W^{[l-1]}, n_C^{[l-1]})$, $a^{[0]}$ being the image in the input
- Padding: $p^{[l]}$, stride: $s^{[l]}$
- The number of filters: $n_C^{[l]}$ where each K^n has the dimension: $(f^{[l]}, f^{[l]}, n_C^{[l-1]})$
- The bias of the nth convolution: $b_n^{[l]}$
- Activation function: $\Psi^{[l]}$
- Output: $a^{[l]}$ with size $(n_H^{[l]}, n_W^{[l]}, n_C^{[l]})$

The learned parameters at the lth layer are:

- Filters with $(f^{[l]}$ x $f^{[l]}$ x $n_C^{[l-1]})$ x $n_C^{[l]}$
- Bias with (1 × 1 × 1) x $n_C^{[l]}$

II. *Pooling Layer*

This step enables a sub-sampling the technique that supports local space invariants to minimize the initial broad dimensions of image depiction. This layer then applies a l_2 pooling function so over capability without conflicting temporal frames (i.e. pooling kernel). To optimize the learning of invariants in each window, L2 pooling is used.

- Input: $a^{[l-1]}$ with size $(n_H^{[l-1]}, n_W^{[l-1]}, n_C^{[l-1]})$, $a^{[0]}$ being the image in the input
- Padding: $p^{[l]}$ (rarely used), stride: $s^{[l]}$
- Size of the pooling filter: $f^{[l]}$
- Pooling function: $\Phi^{[l]}$

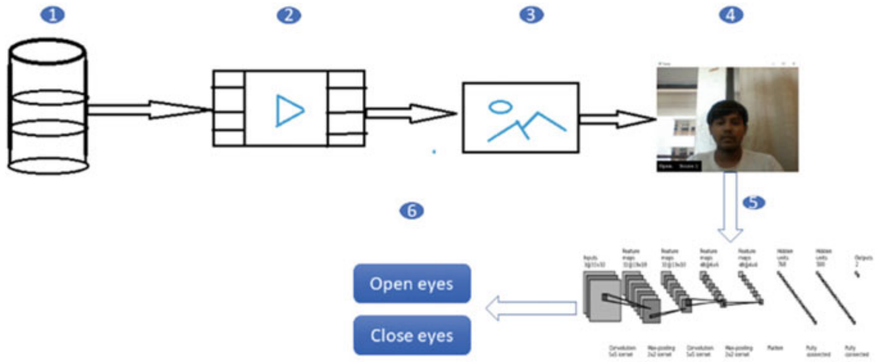


Fig. 5 An outline of the proposed CNN model

- Output: $a^{[l]}$ with size $(n_H^{[l]}, n_W^{[l]}, n_C^{[l]} = n_C^{[l-1]})$
  Where,

n_h the size of Height
n_w the size of Weight
n_c the size of Channels

III. *Fully Connected Layer*

Typical applications for this layer includes the top layer of a CNN architecture Capturing dynamic high-level interactions. Spatial knowledge is skipped in this stage to learn the association between various sites. So, the output of the pooling layer is the input of a completely connected layer that blends it into a functional vector. This is like a popular neural sensor.

IV. *Classification Layer*

In both of the two groups(Open or Close) this final layer is fully connected with a neuron-enabled sigmoid (Fig. 5).

The multi-layer structure eliminates the data's complexity as we progress from one layer to the next. These 3D ConvNets layers apply a filter to the video frame, scanning a limited pixel count at a time and constructing a feature map that forecasts which class each feature belongs to. We start with a 32 × 32 pixel width at the very first layer's entrance. To allow it to have a standard the chosen area of the picture and foresee its class, each passing to the next layer 3D ConvNets multiplies the element digitized by the model by 2, giving 256 × 256 pixels for the final layers 3D ConvNets; this enhancement of the filtration zone improves the precision of the prediction. The data for each feature gathered in the 3D ConvNets layers is then reduced in size at each pooling layer while vital information is retained. After the feature extraction with the max-pooling tier and the filter step 3D ConvNets, the flatten step includes the results of the previous layers, flattens them, and turns them into a single vector that can be used as an input for the next phase. Because of the nature of the photos, which have a gray background, we utilized max-pooling as a reduction method. To anticipate the correct label, the fully—connected continuing to be using input from the characteristic analysis and adjust weights. Finally, we come to the layer of the Softmax activation, which gives us the entry sequence's final class. It's a binary classification in our instance.

4 Result and Discussion

We report the outcomes of our model's development under a variety of measurements and presentations in this section. Thus, we can see that a designed to look on the 3D ConvNets model delivers good results compared to sequential solutions, with an acceptability rate of 97 percent and an error rate of 5.00 percent over 100 epochs. Other models were utilized to augment the result tables for this. LSTMs, LRCNs, VGG16, InceptionV3, and MLPs are all present (Table 2).

Table 2 Comparison the accuracy, validation, test of different model w.r.t number of epochs

Name of model	Epochs	Accuracy (%)	Validate (%)	Test (%)
Proposed Model	3	99.75	99.47	92.34
	5	88.45	84.24	79.32
	10	88.34	81.23	80.24
LSTMs [34]	3	92.45	90.04	80.36
	5	93.58	82.44	81.36
	10	92.73	81.23	79.23
LRCNs [35]	3	83.05	80.80	82.35
	5	83.24	82.45	79.28
	10	83.04	81.25	79.10
VGG16 [35]	3	80.64	82.63	78.04
	5	83.25	81.23	74.80
	10	81.12	82.34	79.44
Inception V3 [36]	3	91.18	90.45	82.21
	5	90.72	90.34	85.23
	10	90.84	90.10	85.78
MLP [36]	3	71.71	73.17	60.93
	5	71.33	73.04	60.97
	10	71.18	72.2	60.7

4.1 Accuracy Results

The accuracy/validation score and training/validation loss result of the 3D ConvNets architecture is displayed in the graph below. As illustrated, the acceptance rate rises quickly in the first iteration before leveling off near the end of the learning process. However, because this architecture requires more memory, it takes longer to complete the learning phase, which varies depending on the number of layers used in the 3D ConvNets architecture and the size of the dataset (Fig. 6).

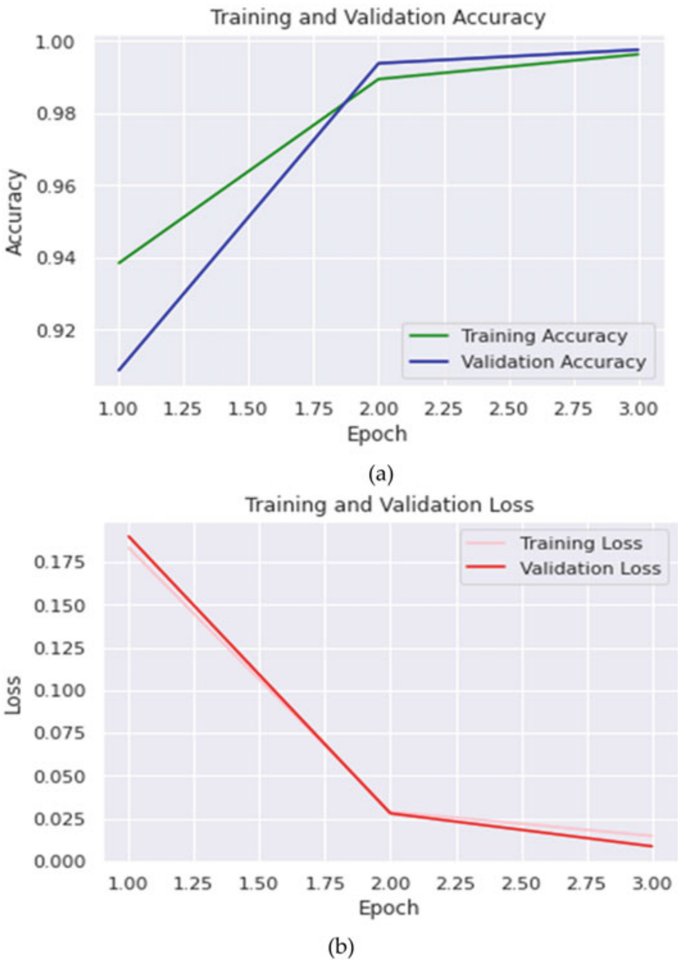


Fig. 6 Training/validation accuracy (**a**); training/validation loss (**b**)

Table 3 F1 score experimental result

Name of model	Epochs	Precision (%)	Recall (%)	F1 score (%)
Proposed model	3	76	97	89
	5	74	94	82
	10	73	94	84
LSTMs [34]	3	84	87	75
	5	84	78	63
	10	84	84	79
LRCNs [35]	3	75	78	84
	5	80	79	82
	10	75	67	84
VGG16 [35]	3	75	76	80
	5	78	75	83
	10	74	67	80
Inception V3 [36]	3	72	76	73
	5	74	82	79
	10	72	85	82
MLP [36]	3	60	100	75
	5	57	100	75
	10	67	100	75

4.2 Performance Measurement

A test phase was performed out together with information not in the calibration and testing phases to assess the effectiveness of our training, and the findings produced in the test phase are highly positive. The F1 score is the sum of precision of a test that takes into account both the precision p and the recall of a test to generate the score. The table shows an F1 score analysis of our model performance (Table 3).

4.3 Experimental Screenshot

See Figs. 7 and 8.

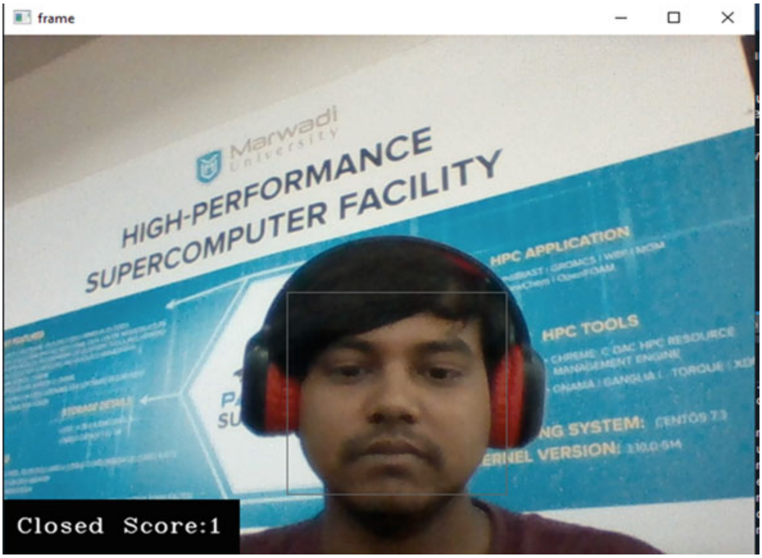


Fig. 7 Open eyes

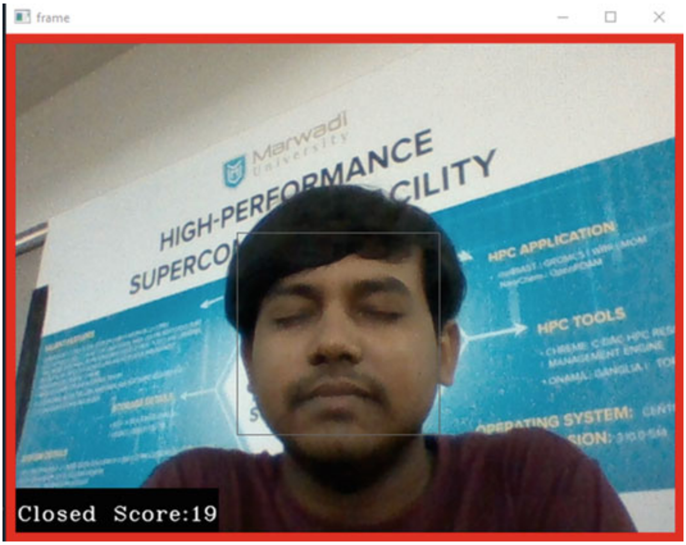


Fig. 8 Close eyes

5 Conclusion and Future Work

Companies designing future Smart City innovations based on AI systems (as well as national and local governments acquiring these other techniques for everyone's cities) will need to think about how to explore the existing monitoring mechanisms that govern the development and implementation of AI systems. In this chapter, we show how deep learning multi-layer architectures CNN employing 3DConvNets, trained on a large size video dataset, can be used to handle sequential issues like the one discussed in this chapter, namely, sleepiness detection and prevention. The purpose of this project was to develop a neural network architecture for a low-cost, portable tiredness monitoring service for regular drivers. On all data used, the ConvNet 3D architecture achieved an accuracy of about 99.45%. To improve these results, even more, a more personalized data collection that is more suitable to the subject of drowsiness in an environment similar to what the driver could experience is required. Our chapter, on the other hand, was based on the driver's conduct over time, as well as a change in the driver's posture. When the driver is tired and does not change his position, this activity is limited. Although our system cannot forecast this specific scenario, it can be improved by combining it with data on the driver's physiology.

Infrared cameras could be utilized in the future to capture driver behavior in low-light situations. Furthermore, a simple heart rate sensor and image can be examined as part of a bidirectional deep learning approach, and more modern model compressing and information extraction methods can be used to reduce runtime even further.

References

1. Taylor C (2020) Drowsy driving statistics. https://www.thezebra.com/chapter/drowsy-driving-statistics/
2. NSF (2020) Warning Signs. https://drowsydriving.org/about/warningsigns/
3. Wang T, Shi P (2005) Yawning detection for determining driver drowsiness. In: Proceedings of IEEE international workshop
4. Lu Y, Wang Z (2007) Detecting driver yawning in successive images. In: 1st International conference on bioinformatics and biomedical engineering
5. Anizy GJ, Nordin MJ, Razooq MM (2015) Automatic driver drowsiness detection using Haar algorithm and support vector machine techniques. Asian J Appl Sci Papers 8(2):149–157
6. Facts and Stats : Drowsy Driving—Stay Alert, Arrive Alive. http://drowsydriving.org/about/facts-and-stats/.
7. Saini V, Saini R (2014) Driver drowsiness detection system and techniques : a review. Int J Comput Sci Inf Technol 5:4245–4249
8. Bhatt GH, Patel PG, Trivedi PP, Patel PG (2017) Various methods for driver drowsiness detection : an overview. Int J Comput Sci Eng 9:70–74
9. Using S, Eog E (2005) Development of vehicle driver drowsiness detection system using electrooculogram (EOG). In: 1st International conference on computers, communications, and signal processing with special track on biomedical engineering (CCSP), Kuala Lumpur, Malaysia, pp 165–168

10. Takei Y, Furukawa Y (2005) Estimate of driver's fatigue through steering motion. IEEE Int Conf Syst Man Cybern 2:1–6
11. Borghini G, Astolfi L, Vecchiato G, Mattia D, Babiloni F (2014) Measuring neurophysiological signals in aircraft pilots and car drivers for the assessment of mental workload, fatigue, and drowsiness. Neurosci Biobehav Rev 44:58–75
12. Mu Z, Hu J, Min J (2017) Driver fatigue detection system using electroencephalography signals based on combined entropy features. Appl Sci 7:150
13. Zhang X, Li J, Liu Y, Zhang Z, Wang Z, Luo D, Zhou X, Zhu M, Salman W, Hu G et al (2017) Design of a fatigue detection system for high-speed trains based on driver vigilance using a wireless wearable EEG. Sensors 17:486
14. Chaudhuri A, Routray A (2019) Driver fatigue detection through chaotic entropy analysis of cortical sources obtained from scalp EEG signals. IEEE Trans Intell Transp Syst
15. Masson Q, Verly J, Van Droogenbroeck M (2018) Multi-timescale drowsiness characterization based on a video of a driver's face. Sensors 18:2801
16. Mandal B, Li L, Wang GS, Lin J (2017) Towards detection of bus driver fatigue based on robust visual analysis of eye state. IEEE Trans Intell Transp Syst 18:545–557
17. Al-Rahayfeh A, Faezipour M (2013) Eye tracking, and head movement detection: a state-of-art survey. IEEE J Transl Eng Health Med 1:2100212
18. Kurylyak Y, Lamonaca F, Mirabelli G (2012) Detection of the eye blink for human's fatigue monitoring. In: Proceedings of the medical measurements and applications proceedings (MeMeA), Budapest, Hungary, 18–19 May 2012, pp 1–4
19. Amodio A, Ermidoro M, Maggi D, Formentin S, Savaresi SM (2018) Automatic detection of driver impairment based on pupillary light reflex. IEEE Trans Intell Transp Syst 1–11. https://doi.org/10.1109/tits.2018.2871262
20. Yang JH, Mao ZH, Tijerina L, Pilutti T, Coughlin JF, Feron E (2009) Detection of driver fatigue caused by sleep deprivation. IEEE Trans Syst Man Cybern Part A Syst Hum 39(4):694–705. https://doi.org/10.1109/tsmca.2009.2018634
21. Hu S, Zheng G (2009) Driver drowsiness detection with eyelid-related parameters by support vector machine. Expert Syst Appl 36(4):7651–7658. https://doi.org/10.1016/j.eswa.2008.09.030
22. Banerjee A et al (2022) Construction of effective wireless sensor network for smart communication using modified ant colony optimization technique. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_22
23. Bodapati S, Bandarupally H, Shaw RN, Ghosh A (2021) Comparison and analysis of RNN-LSTMs and CNNs for social reviews classification. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_4
24. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Smart luminaires for commercial building by application of daylight harvesting systems. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_24
25. Mandal S, Biswas S, Balas VE, Shaw RN, Ghosh A (2021) Lyft 3D object detection for autonomous vehicles. Artif Intell Fut Gener Robot 119–136. https://doi.org/10.1016/B978-0-323-85498-6.00003-4
26. Soni A, Dharmacharya D, Pal A, Srivastava VK, Shaw RN, Ghosh A (2021) Design of a machine learning-based self-driving car. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_11
27. Mandal S, Mones SMB, Das A, Balas VE, Shaw RN, Ghosh A (2021) Single shot detection for detecting real-time flying objects for unmanned aerial vehicle. Artif Intell Fut Gener Robot 37–53. https://doi.org/10.1016/B978-0-323-85498-6.00005-8
28. Gautam J, Atrey M, Malsa N, Balyan A, Shaw RN, Ghosh A (2021) Twitter data sentiment analysis using naive bayes classifier and generation of heat map for analyzing intensity

geographically. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_10
29. Biswas S, Bianchini M, Shaw RN, Ghosh A (2021) Prediction of traffic movement for autonomous vehicles. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_12
30. Rawat R, Rajawat AS, Mahor V, Shaw RN, Ghosh A (2021) Surveillance robot in cyber intelligence for vulnerability detection. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_9
31. Amritha Ashok K, Savy A, Shijoh V, Shaw RN, Ghosh A (2021) Hospital assistance robots control strategy and machine learning technology. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_3
32. Sagonas C, Antinakos E, Tzimiropoulos G, Zafeiriou S, Pantic M (2016) 300 faces in-the-wild challenge: database and results. Image Vision Comput (47):3–18
33. Mael F (2020) A guide to face detection in python. https://towardsdatascience.com/a-guide-to-face-detection-inpython-3eab0f6b9fc1
34. Srivastava N, Mansimov E, Salakhudinov R (2015) Unsupervised learning of video representations using LSTMS. In: Proceedings of the international conference on machine learning, Lille, France, 6–11 July 2015, pp 843–852
35. Donahue J, Anne Hendricks L, Guadarrama S, Rohrbach M, Venugopalan S, Saenko K, Darrell T (2015) Long-term recurrent convolutional networks for visual recognition and description. In: Proceedings of the IEEE conference on computer vision and pattern recognition, Boston, MA, USA, 7–12 June 2015, pp 2625–2634
36. Kumar PJ (2018) Multilayer perceptron neural network-based immersive VR system for cognitive computer gaming. In: Progress in Advanced Computing and Intelligent Engineering, Springer, Berlin/Heidelberg, Germany, 2018, pp 91–102

Traffic Control System for Smart City Using Image Processing

Vedansh Bhardwaj, Yaswanth Rasamsetti, and Vipina Valsan

Abstract Due to the quickly changing population with the economic development of the country, traffic congestion has come out as a serious threat to society. Since the present traffic system is only predetermined time-based traffic control, it's high time to come out with a self-adaptive system for better traffic administration. This chapter represents a smart traffic control technique for smart cities that can be implemented by using image processing. A web camera is positioned on a traffic signal to seize the photo sequences. An empty road image is about a reference photograph and the real-time traffic images are matched with the usage of image matching. For this purpose, edge detection is used and a percentage matching happens between a reference image and a real-time traffic image, the traffic light time allocation can be done with percentage image matching. The results obtained in the above processes will help in reducing delay time at the traffic lane.

Keywords Traffic management · Image processing · Self-adaptive · Edge detection · Image matching

1 Introduction

In today's world, traffic jams have become a really frantic activity due to uncontrolled growth in population. Every day, the number of cars on the road rises significantly. Fast transportation systems and rapid transit systems are important for the economic development of any nation. An in-depth study has been finished on the traffic control system and a big variety of articles and study papers have been posted on this subject matter for the last couple of decades. But most of the systems are inductive loop detectors, infrared and radar sensors which offer very limited traffic data and they're a concern to excessive failure rate while installed on street surfaces. For road use

V. Bhardwaj (✉) · Y. Rasamsetti · V. Valsan
Department of Electrical and Electronics Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, India

V. Valsan
e-mail: deepthi@am.amrita.edu

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_6

and traffic management, automatic traffic monitoring and surveillance are important. Researchers have suggested several solutions to cope with this problem. There are some technologies which are in place to detect the traffic and control it.

1.1 Manual Control

In Manual Controlling of traffic, a Traffic Police is hired and allotted a particular area to handle the traffic congestion. They will control the traffic with the help of whistles and signboards. The disadvantage of this method is that it becomes difficult to handle heavy traffic and requires more manpower.

1.2 Automatic Control

Controlling Traffic Signals with the help of Timers and Electrical Sensors comes below Automatic Control. A mathematical value is sent into the timer at each segment of the traffic light for Timer Based Control. Based on the timer value, Traffic lights will operate in ON and OFF conditions. In the technique of the usage of electric sensors, the sensors will take a look at the availability of vehicles in a specific lane and will operate traffic lights between OFF and ON. The drawback of each of those techniques is that extra time is being wasted on an empty road. By regulating traffic lights with the aid of image processing, we can overcome those limitations.

1.3 Need for Image Processing

To technique, the hassle of Traffic congestion, Image Processing is a pleasant idea. The cars are detected through the System with the assistance of snapshots. By using image processing methods, these snapshots are processed. Here, the cars are detected through thinking about the captured snapshots as opposed to the usage of timers or digital sensors which can be located on the lane. A web camera is located on the site visitors mild which captures snapshots of the street via which the automobile matter is predicted and site visitors are controlled. Using picture processing in site visitors management is determined to be a higher method than the prevailing techniques. It allows lower site visitors congestion with no wastage of time because of displaying inexperienced indicators on an empty street with no cars. Nowadays it's also being utilized in automated site visitor tracking structures to manipulate the site visitors. The implementation of a picture processing is needed a set of rules in real-time site visitors mild management if we want to manage the traffic light efficiently [1–5]. The snapshots of the street on which we need to manipulate the traffic light will be recorded by a web camera positioned at every degree of a traffic lane. Then the captured snapshots have successively matched a reference image that is an empty street image with the use of image matching. The site visitors are ruled through the proportion of matching. The key factor of the paper is the method that is used for picture comparison. The authors have used picture matching strategies. A system that estimates the scale of site visitors on highways through the usage of picture processing and as a result, a message is proven to tell the number of motors on the highway. This venture has been carried out through the usage of the Matlab software program and its objectives to do away with heavy site visitors on highways [6–10]. A technique to cope with site visitors' congestion, the usage of picture processing is shown in ref [3]. The video of a lane is recorded and extracted into frames. Then Image processing strategies are done at the captured body and the reference picture. Then the timer for the lane is allotted primarily based totally on the proportion of matching in each of the snapshots. The need for a sensible site visitor's machine and the abnormal manner of implementation with embedded machine tools is shown in ref [4]. It is carried out the usage of item counting techniques and detection of emergency cars concurrently thereby managing the site visitors indicators primarily based totally on the concern outcome [11–15]. In [5] the idea of picture processing for the street site visitor management is shown. The system makes use of a canny area detection method for figuring out the density of the site visitors. Simulation results are used to demonstrate how the canny area detection strategy has greater effects on the estimation of site visitor parameters relative to other area detection strategies [16–18].

2 Proposed System Description

In today's life, Traffic jams have become a main problem which we are facing in everyday life. The major cause is old technique is used in traffic light' signals. We want an advanced technology and smart traffic control system to manipulate the traffic light in an efficient manner [19–21]. So This system proposed photograph processing based totally smart traffic control to manipulate the system to keep away from lengthy delays on-traffic' lanes. This system is carried out in MATLAB 2018a software program via means of the usage of image processing techniques. A web camera is located on every degree of a traffic signal, a good way to capture images in a sequence.

First, the web camera will capture an image of an empty lane, a good way to be a reference photograph, and a real-time image of a traffic signal lane may be captured for matching with the reference image. After capturing pictures, the subsequent 4 steps to be followed:

1. RGB to Gray Conversion.
2. Resizing of an image.
3. Image Enhancement.
4. Edge Detection.

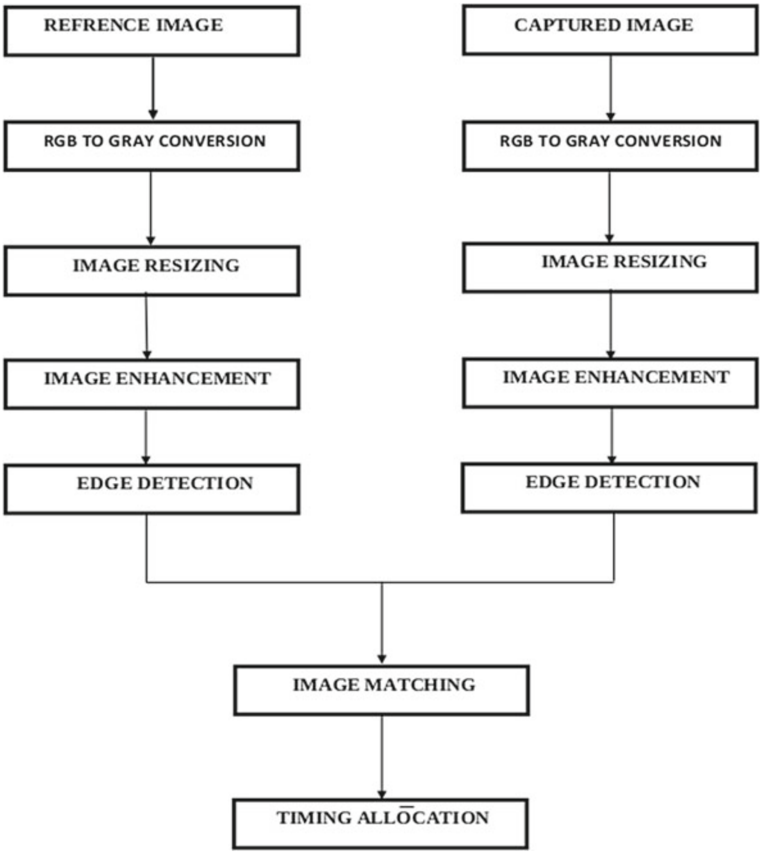


Fig. 1 Block diagram

Then the images captured have successively combined the use of image with a reference photo that is an empty road image. The traffic is ruled consistent with the share of matching and time may be allotted on the idea of the above photo-matching results (Fig. 1).

3 Introduction to Image Processing

Image processing is a type of signal processing in which images or video images are the input. Each image and some of the capabilities or parameters relevant to the image may be the output of image processing. Many image processing techniques include the use of traditional signal processing techniques and the treatment of the image as a two-dimensional signal. Image processing is a way of enhancing raw images captured in ordinary life through cameras/sensors mounted on nearby probes, airplanes, and satellites or snap shots. A photo is a rectangular object with a photo. The processing of images presents photo rendering problems, compression techniques, and extreme problem operations that may be performed on the photo data. Image enhancement activities are the operations that come under image processing, which include blurring, brightening, enhancement of sections, etc.

3.1 Image Acquisition

In general, an image is a 2D f(x, y) function (where x and y are axes coordinates). The image's amplitude at a particular point implies that f is referred to as the image's intensity. At that point, it is also called the gray stage of the image. To form a digital image, we have to convert the x and y values to finite discrete values. The input image is a resource taken from the store database and the database of forces. To engineer it through a digital computer, it is essential to transform the analog image to a digital image. Each cell in a digital image has a finite value and that cell is known as a pixel (Fig. 2).

MATLAB Command for reading an image.

Imread ("original.png").

Fig. 2 Input image

3.2 Formation of Image

As the values of the images are proportional to the energy radiated with the aid of a physical source, we have a few conditions for creating an image f(x, y). So f(x, y) must be infinite and non-zero.

i.e., $0 < f(x, y) < \infty$.

3.3 Image Resizing/Rescaling

In all digital images, image scaling happens in certain ranges, whether or not it is in Bayer demosaicing or photograph enlargement or no longer—the time you rescale an image graph from one pixel grid to another, this happens. When you want to increase or decrease the entire amount of pixels, image resizing is critical. Even if the same image graph is resized, depending on the algorithm, the end result will differ significantly. Because of some of the motives, photos are resized, but one in each of them may be very vital in our project. Each web camera has its preference, so while a system is built for a few digital camera specs, another digital camera relying on specification similarities will not operate successfully. So it's far more important to make the decision consistent for the software and for this reason carry out picture graph resizing (Figs. 3 and 4).

Fig. 3 Original image

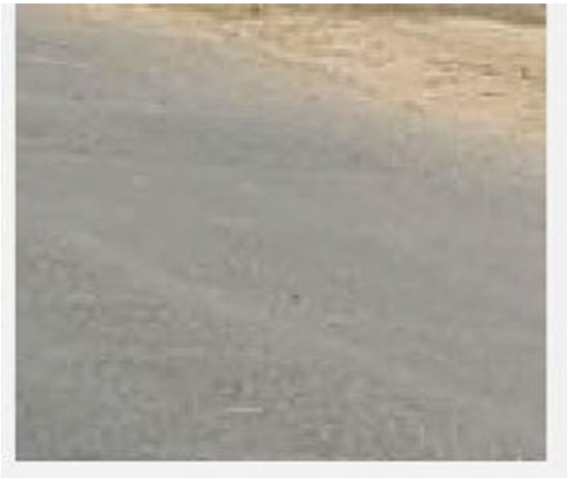


Fig. 4 Resize/crop image

3.4 RGB to Grayscale Conversion

Humans understand radiation through wavelength-touchy sensory cells referred to as cones. There are 3 different kinds of cones, each of which has an extraordinary sensitivity to various wavelengths of electromagnetic radiation (light). One cone is especially susceptible to red, one to green, and one to blue light. We are able to produce almost any observable radiation by omitting a small mixture of those 3 colors (red, green, and blue) and stimulating the 3 types of cones at will for this purpose. The primary explanation why color photographs are routinely stored as 3 separate matrices of photographs; one matrix stores the amount of red (R) in each pixel, in another the amount of green (G) and the amount of blue (B) in third matrix. As saved in the RGB format, we call such color photographs. However, we no longer discern how often we emit different colors in grayscale images, we omit the equivalent amount in each channel. For each pixel, we might be in a position to discern the entire amount of light emitted; little light provides grayscale pixels and plenty of light is viewed as bright pixels. We don't want to forget the RGB values for each pixel when converting an RGB picture to grayscale and make a single fee representing the brightness of that pixel as output. One of the way is by calculating the mean of each channel's i.e. $(R + B + C)/3$. However, the approach should take into account a weighted average, e.g.: 0.3R 0.59G 0.11B, since perceived brightness is routinely controlled by means of the green variable, an extraordinary, more "human-oriented" approach (Figs. 5 and 6).

MATLAB Command for RGB conversion an image.

x = rgb2gray("original.png").

Fig. 5 Original image

Fig. 6 RGB to gray

3.5 Image Enhancement

Image Enhancement is the method of improving digital snapshots in order to be more suitable for demonstration or additional study of the consequences. You might, for example, get rid of noise, so you can make it less difficult to choose the characteristics of the important thing. In bad snap shots assessment, the close characters merge while binarizing. We want to minimize the unfolding of the characters earlier than using the threshold of the picture of the word. We therefore implement "POWER-LAW TRANSFORMATION" so that the evaluation of the characters can be increased and greater segmentation can be permitted. The fundamental type of transformation of power-law is

$$S = c\gamma^{\gamma}$$

where r and S, respectively, are the input and output intensities; c and γ are non-negative constants (c not equal to zero). γ values map a small range of dark input values into a much broader range of output values. Conversely, this is also sufficient for better values of input levels. These also are known as gamma correction because of the exponent inside the strength power-law equation. In our experiment, the spectrum from 1 to 5 varies with gamma. If c is not equal to '1' then scaling will alter the dynamic range of the pixel values remarkably. Therefore, after power-law transformation, we set the values of $c = 1$. To stay away from any other stage of rescaling. With $\gamma = 1$, if the transformed power-law image is passed via binarization, there may be no variance inside the give-up leading to simple binarization evaluation. If $\gamma > 1$, there may be a variant within the histogram graph, since there may be a boom of samples within the containers in the direction of zero gray expense. Gamma correction is important if an image is seen (Figs. 7 and 8).

Fig. 7 Original image

Fig. 8 Power-law transformation image

3.6 Edge Detection

Edge detection is the option for a difficult and rapid numerical method that recognizes elements in a virtual image in which the brightness of the photograph alter sharply or, in general, means that it has noise. In general, the elements where photographic brightness shifts clearly are properly prepared right into a hard and fast bent line segment called edges. The same difficulty of detecting noise within the 1 dimensional signal is referred to as phase detection, alternative detection is called the difficulty of identifying signal discontinuities over time. It was concluded that the Canny Edge Detector approach is the most powerful one after testing various edge detection algorithms. For our suggested prototype, we use the Canny as a Edge Detection method:

A. The Canny Edge Detector is known as the same set of rules for detection within the industry. As follows, the steps inside the Canny Edge Detector are

1. Smooth out the picture with a Gaussian dimension. The estimation of a dimensional Gaussian is expensive in maximum situations, so it is approximate in the approach manner of 1D Gaussians, one within the x-direction and the alternative y-direction.
2. Take the image's gradient. This illustrates pressure shifts, showing the presence of edges. This really provides results, with the gradient within the x-direction and the gradient within the y-direction.
3. Non-maximal suppression. Edges will emerge from variables in which it is necessary to suppress the gradient at most. The significance and direction of the gradient are computed at each pixel in order to do this. Then take a look at

Fig. 9 Original image

how the significance of the gradient is more distant from one pixel in either of the positive or negative directions perpendicular to the gradient for each pixel. If there is no more than one pixel, suppress it.

4. Edge Thresholding: The thresholding technique used by the Canny is called "hysteresis." Each excessive threshold and a small threshold are used. If a pixel has a price higher than the excessive threshold, it can be taken as a pixel of the field. If a pixel has a price higher than the minimum threshold and is an area pixel's neighbor, it is also set as an area pixel. If a pixel has a price above the minimum threshold, but is not an area pixel neighbor. It cannot be set as a pixel of the field. If a pixel has a price below the low threshold, it is not set as a pixel region in any way (Figs. 9 and 10).

3.7 Image Matching

Recognition techniques primarily based totally on matching constitute every magnificence with the aid of using a prototype sample vector. The elegance closest to the predefined metric is assigned to an arbitrary pattern. The simplest technique is the least distance classifier, which, as its name suggests, measures the (Euclidean) distance of many of the unknown vectors and each of the prototype vectors. It selects the minimum distance in order to make a decision. There is an alternate method primarily based solely on similarities, which is very intuitive and can be formulated immediately in phrases of pictures. We have used a fully high-quality approach to image matching. Comparison of a reference image with a valuable pixel resource

Fig. 10 Edge detection

to a real-time image pixel. Although there are some hazards associated with fully matching pixel-based images, It is one of the first-rate techniques of the set of rules used in the choice-making venture. The real image is stored in the matrix in reminiscence, and the real-time image is also transformed within the chosen matrix. Their pixel values within the matrix need to be the same for the images to be identical. In pixel matching, this is the most important fact used. The counter used to calculate the vast type of pixel mismatch is provided at once whether there may be any mismatch in the pixel value. The number of matches is eventually expressed as

$$\%\text{matching} = (\text{No of pixels matched successfully/Total No of pixels}) * 100$$

4 Implementation Algorithm

The following steps are part of the algorithm of this block diagram:

1. We have a reference image, and using a web camera mounted at the junction, the images to be matched are continually captured.
2. The pre-processing of the captured images is done according to the following steps:

   a. Images are resized to three hundred x three hundred pixels;
   b. The resized images are then transformed from RGB to gray.

Fig. 11 Time allocation table

Percentage Matching	Time allocation for Green Light
0 - 30%	60 seconds
30 - 50%	40 seconds
50 - 70%	30 seconds
70 - 90%	20 seconds
90 - 100%	10 seconds

3. The use of the canny side detection technique has been carried out by Edge detection of pre-processed images.
4. The output images of the previous phase matched the use of the technique of pixel to pixel matching.
5. Every reference and real-time image are matched after the edge detection phase, and traffic lights can be managed based more on a percentage of matching (Fig. 11).

5 Experimental Results

Experiments are completed and rely on the traffic density on the road, from which we obtain the following result concerning the time allocation of numerous traffic lights.

Figure 12 shows the empty lane image which is a reference image for comparison between different lanes. Figure 13 shows the real-time capture image of traffic which will be compared with the reference image of the lane.

Figure 14 shows the result of various methods involved in image processing. It shows a comparison between captured reference and real time captured images in which the original image is converted to gray scale images which is followed by image enhancement an edge detection.

Figure 15 shows the result of percentage match on the basis of which time will be allocated for different lanes.

6 Conclusion

"Image Processing Based Smart Traffic Control for Smart City" is the technique that we have approached that minimizes all the constraints of the previous techniques implemented for reduction in traffic congestion. In Automatic traffic which uses a

Fig. 12 Reference image

Fig. 13 Capture image

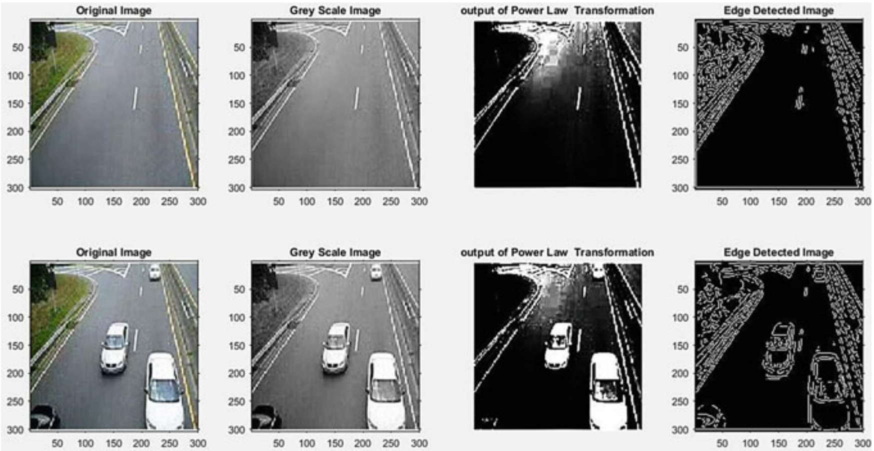
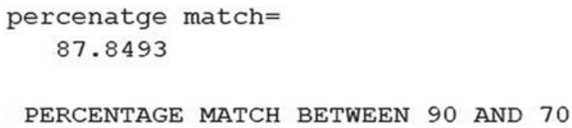


Fig. 14 Output of edge detection technique

Fig. 15 Percentage match of the reference image and captured image



fixed time-based technique in which time is wasted on empty roads also. The Image processing technique eliminates the issue of the existing system. It was observed that the Canny Edge detection technique gave a better result. This chapter suggests that image processing is a greater green technique for traffic control systems in comparison to conventional techniques. The use of this technique gets rid of the want for added hardware which includes sound sensors and loop detectors. This will remove the excess time wasted in the traditional traffic system. The main advantage is the variation of signal time which is allocated based on traffic density with the help of image match percentage. The exactness within side the time allocation depends upon the position even as going through the street each time.

7 Future Work

The main focus will be to implement emergency vehicle detection and emergency situations like accidents in which control will be given to traffic police. Also, the Foggy weather condition situation also will be taken under consideration to capture clear images under foggy weather. For real-time practical situations, the execution is done through hardware implementation.

References

1. Chandrasekhar M, Saikrishna C, Chakradhar B, Phaneendra Kumar P, Sasanka C (2013) Traffic control using digital image processing. IJAEEE 2(5):2278–8948
2. Thakkar C, Patil R (2017) Smart traffic control system based on image processing. Int J Res Appl Sci Eng Technol (IJRASET) 5(VIII). ISSN: 2321-9653
3. Kaur G, Sharma S (2017) Traffic management using digital image processing. IJCST 8(2)
4. Parthasarathi V, Surya M, Akshay BK, Siva M, Vasudevan SK (2015) Smart control of traffic signal system using image processing. Indian J Sci Technol 8
5. Singh Gosain A, Sivraj P (2013) Image processing technique used in real-time traffic light controlling. In: 4th International conference, confluence 2013: the next generation information technology summit on the theme: mega trends of IT
6. Sarath S, Chinnu R, Gopika PS (2016) Real-time smart traffic control system using dynamic background. In: International conference on computing paradigms (ICCP 2016) (International Journal of Control Theory and Applications), vol 9. International Science Press, Serials Publications, pp 4249–4255
7. Palimkar P, Shaw RN, Ghosh A (2022) Machine learning technique to prognosis diabetes disease: random forest classifier approach. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_19
8. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Multi-objective fuzzy-swarm optimizer for data partitioning. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_25
9. Garg C, Namdeo A, Singhal A, Singh P, Shaw RN, Ghosh A (2022) Adaptive fuzzy logic models for the prediction of compressive strength of sustainable concrete. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_47
10. Latha M, Poojith A, Reddy BV, Amarnath G, Kumar V (2014) Image processing in agriculture. Int J Innov Res Electr ,Electron Instrum Control Eng 2(6)
11. Palimkar P, Bajaj V, Mal AK, Shaw RN, Ghosh A (2022) Unique action identifier by using magnetometer, accelerometer and gyroscope: KNN approach. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_48
12. Rajawat AS, Rawat R, Barhanpurkar K, Shaw RN, Ghosh A (2021) Robotic process automation with increasing productivity and improving product quality using artificial intelligence and machine learning. Artif Intell Fut Gener Robot 1–13. https://doi.org/10.1016/B978-0-323-85498-6.00007-1
13. Choukekar GR, Bhosale A (2018) Density based smart traffic light control system and emergency vehicle detection based on image processing. IRJET 05(04). e-ISSN: 2395-0056
14. Mandal S, Mones SMB, Das A, Balas VE, Shaw RN, Ghosh A (2021) Single shot detection for detecting real-time flying objects for unmanned aerial vehicle. Artif Intell Fut Gener Robot 37–53. https://doi.org/10.1016/B978-0-323-85498-6.00005-8
15. Prakash D, Sandhya Devi B, Naveen Kumar R, Thiyagarajan S, Shabarinath P (2017) Density based traffic light control system using image processing. Int J Adv Res Electr Electron Instr Eng 6(3)
16. Singh P, Bhardwaj S, Dixit S, Shaw RN, Ghosh A (2021) Development of prediction models to determine compressive strength and workability of sustainable concrete with ANN. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_59

17. Soni A, Dharmacharya D, Pal A, Srivastava VK, Shaw RN, Ghosh A (2021) Design of a machine learning-based self-driving car. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_11
18. Biswas S, Bianchini M, Shaw RN, Ghosh A (2021) Prediction of traffic movement for autonomous vehicles. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_12
19. Majumder K, Chakrabarti K, Shaw RN, Ghosh A (2021) Genetic algorithm-based two-tiered load balancing scheme for cloud data centers. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_1
20. Maddikonda SS, Shanmugha Sundaram GA (2014) SAR image processing using GPU. In: 2014 International conference on communications and signal processing (ICCSP), Melmaruvathur
21. Neha R, Nithin S (2018) Comparative analysis of image processing algorithms for face recognition. In: 2018 International conference on inventive research in computing applications (ICIRCA)

Visual Perception for Smart City Defense Administration and Intelligent Premonition Framework Based on DNN

Debosmit Neogi, Nataraj Das, and Suman Deb

Abstract A detailed methodology of object detection in a smart city setting has been illustrated in this chapter. The presented methodology focuses on intelligent uses of machine learning and deep learning algorithms for the effective extraction of the desired ROI from a challenging backdrop. This chapter encompasses a Convolutional Neural Network (CNN)-based architecture and a Faster RCNN-based approach and holistic comparisons are being made between the results obtained from the different approaches. The problem that has been tried to address through this work is the lack of robust algorithms that can detect occluded objects effectively, which may commonly occur in a smart city. So, the primary focus of this work is to devise a methodology that can detect even minute objects camouflaged in a city crowd, which are prevalent in smart cities across India. This work is believed to be beneficial in various sectors, even in the military, to help them with reconnaissance tasks. Further, the proposed methodology is equipped with an alarm system that warns against plausible security breaches and intrusion. This mechanism enhances the security of a smart city using IoT techniques. The entire methodology described in the chapter can be deployed without the use of any additional hardware. Overall, the proposed framework is robust, effective and viable for multi-facet uses in the future and can be effectively deployed in large distributed systems across smart cities of India.

Keywords Alerting framework · Defense · CNN · Faster RCNN · Smart city · Motional feedback · Object detection · ROI · Smart city

1 Introduction

Object detection and stratification always have been an important task. This is due to the vast array of real-life situations where object detection plays an important role. This task becomes even more daunting when the object is camouflaged with its background, making the detection task even more difficult and challenging. The problem addressed in this work is believed to prove extremely valuable when ROI is

D. Neogi · N. Das · S. Deb (✉)
Deptartment of Computer Science and Engineering, NIT Agartala, Agartala, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_7

perfectly hidden. Such scenarios include army reconnaissance tasks, wildlife census, etc.

In the military, it is very important to track the movements of people. Even small negligence can prove to be deadly. The Indian army usually operates in challenging battle field conditions, usually covered with dense forest. In such a situation, where visibility is extremely low and enemies can easily camouflage in the dense backdrop, the proposed methodology can work very well. The proposed framework is specially built to extract and detect ROI.

The most important scenario where the methodology is tested is urban defense. With the growing urbanization and development of smart cities, there has been a steady surge in crime rates. Theft and burglary in houses are very common. This architecture can resolve this issue to a great extent and help in making a better defense system for houses and smart cities in general. The described framework can very well be deployed in houses which helps in enhancing securities.

We have implemented a novel idea of the alarm system in this methodology. The alarm system uses simple conditional statements and based on that, the alarm rings. This technology was built keeping in mind the use case of the methodology in case of theft and burglary in houses and also in military settings. If our system detects any object in the wild, the alarm raises an alert signal against a potential security breach. This can be very beneficial as it alarms the people during the night and helps in securing the apartments, which are very common in smart cities. With the rapid transformation of smart cities, there is an associated growth of shopping malls, amusement parks and most importantly banks and ATMs. The defense mechanism proposed here can add an extra layer of security in these public places, thus boosting the security by keeping the intruders at bay. Figure 1 describes a potential security issue in banks across smart cities. The incorporation of our framework ensures an extra protective layer with its alarming mechanism giving time to security officials to react and respond to the situation swiftly.

Fig. 1 Bank defense system

The whole architecture is light and is computationally inexpensive. In addition to that, any requirement of additional hardware has been completely removed. Only a high-resolution camera is a prerequisite for the smooth working of the model. The architecture has been tested upon various parameters, and it fares well against other frameworks.

2 Literature Review

A number of researches have been done in the past that made use of several techniques and algorithms in order to build an intelligent and smart surveillance system for the military: [1] used sensors for collecting intelligence for the army, and [1] used several distributed, wireless communicating smart sensors for surveillance, information collection and reconnaissance system. However, the above-stated researches are involved with a high budget as a result of the costly sensors and hardware for achieving the desired output. To this contrast, the stated methodology is believed to be quite economical as it strongly eliminates the use of costly sensors to conduct surveillance; [2] also worked on a similar theme but used a high-resolution camera. Numerous algorithms and techniques were used by researchers for object detection problems. For instance, among recent works, [3] proposed an algorithm that is capable of detecting entities from an unknown environment; [4] have been referred as they contributed significantly toward deep neural approach toward the detection of physical entities. Reference [5] deployed a multi-scale CNN approach for the detection of entities. Last but not the least, [6] have contributed toward the detection algorithm.

Several researchers have worked on camouflaged object detection. Reference [7] used trans-former networks in their approach. Reference [8] used a video-based input detection mechanism for object detection. A group of researchers [9] have worked on multiple object detection. All their results have been nicely covered in our proposed methodology. Reference [10] worked on creating an alarm system to prevent accidents. Our proposed framework utilizes a similar theme and leverages it along with the object detection mechanism.

3 Dataset and Feature Engineering

For the purpose of training the faster RCNN model, Open Image Dataset (OID) v4 has been taken as the dataset. It can be further used to create a custom dataset that detects classes of our choice. This dataset contains sufficient labeled and annotated images in the training and validation sets for custom classes. The entire dataset is cleaned and preprocessed before training the faster RCNN model. The CNN model was trained on a dataset that contains 75,000 images of trucks which were to make sure the model works perfectly. d Prior to feeding the dataset to the model, a number of feature engineering is applied in order to shape the data for training purposes. All the images were subjected to pixel adjustment of 90 × 90 pixels. The images were then scaled as well as cleaned. Finally a matrix of 24,300 × 75,000 pixels values obtained. The images assumed to be 3 channel RGB that are finally transformed to a comma-separated value(CSV) file and was used as independent training values for feeding the model.

A similar approach was leveraged to train the model on a gun dataset. The dataset contains 10,000 images of guns. Again, feature engineering is applied to the dataset in order to create total features of 90 × 90, resulting in a matrix of 24,300 × 10,000 dimensions. Both the above datasets are concatenated in order to create a single data file. Even this dataset was subjected to several cleaning and preprocessing stages before making it suitable for training.

4 Synopsis of Proposed Methodology

The proposed methodology is the sequential implementation of a CNN-based and a faster RCNN-based model. The very first step is to apprehend optical feedback. A video is a sequence of images being played with an fps of 60 or more. Considering this fact, we have segmented the video into frames that are images and used that image for further analysis. In light of that purpose, we divided the obtained feedback into two frames at a time.

But before doing any further steps, detection of movement is required. To achieve this, a series of actions is performed to detect movement by calculating the absolute difference between 2 successive frames from the camera feedback. Such difference between frames within a fraction of a second was capable of detecting the very minute and trivial movements. Upon receiving the object in motion, certain morphological transformations are applied such as thresholding and Gaussian blur to achieve a robust and effective visual in order to draw out the contours around the moving entities. Depending upon the area of the captured object, contours are drawn around the object in order to extract the ROI.

Then the detected ROI is first passed through a series of convolution layers, max-pool and activation layers. In the next model, the ROI is passed through a whole faster RCNN-based architecture for stratification. The result obtained is further used for analysis and result validation. Figure 2 depicts the entire methodology of the proposed research work.

5 Classification of Extracted ROI

Classification of ROI is the most important step in the entire pipeline. This step has to be accurate and precise. This step ensures the overall viability of the entire framework. Latest deep learning and state-of-the-art algorithms have been used to

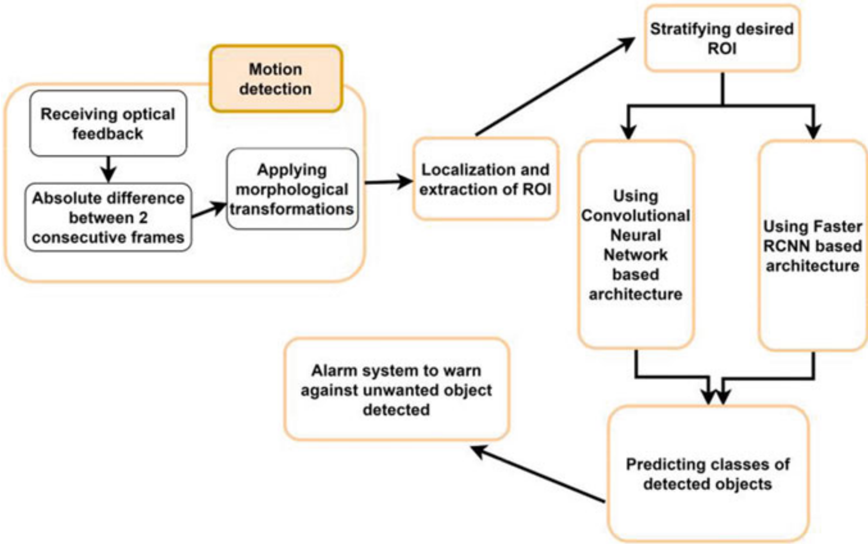


Fig. 2 An overview of the working framework

ensure maximum accuracy such that the framework works well in solving smart city security problems.

5.1 CNN

The very fast stratification of extracted ROI was done through convolution of the image and using artificial neural networks alongside in order to stratify the ROI [11]. To be precise, convolutional neural networks were deployed in order to obtain the desired output. The data feature points were plotted in order to determine the scaling of the issues as well as to draw an initial point of view regarding the classification report.

Figure 3 clearly depicts [12] how well a classification algorithm will perform in order to draw the desired classification report. The desired ROIs are then convoluted with a kernel of specific dimension and value. Since the extracted ROIs were RGB images, they were having a dimension of 3 units. Thus, it was required to perform 2D convolution in order to obtain the feature map. In total, 32 filters were deployed with 3×3 kernel size. Deployment was accompanied by the ReLU activation function. After that, maximum pooling operation was deployed on the earlier created feature map. In order to perform the max-pooling operation, another kernel of size 2×2 was taken into consideration. Finally, the flatten layer was introduced in order to push all the features. The architecture of the classification neurons was considered to be a sequential one and dense network distribution. A total of 6000 neural hidden

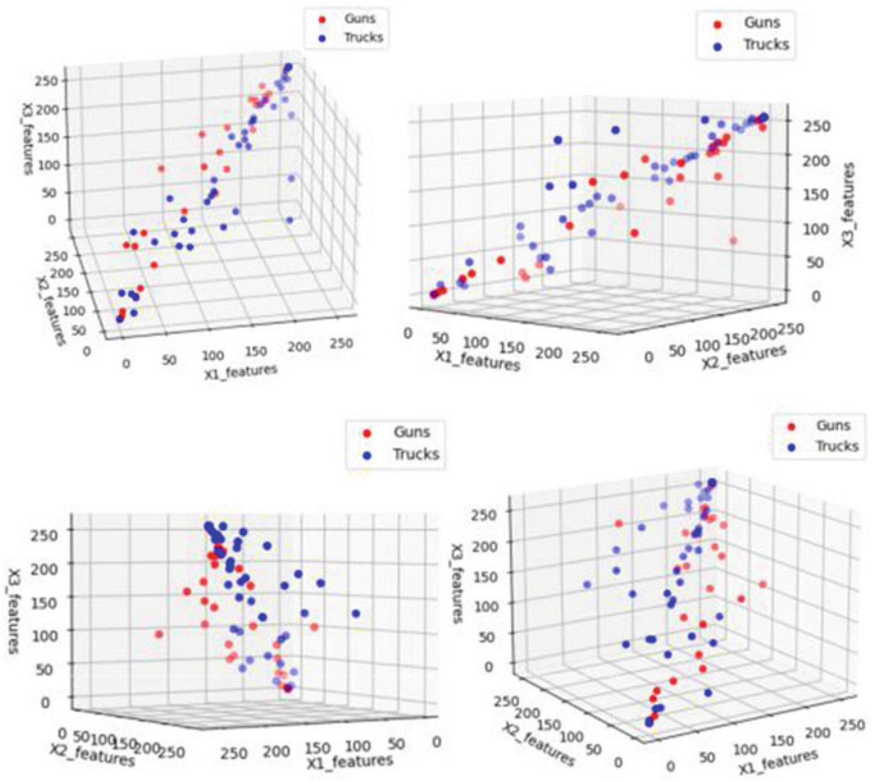


Fig. 3 Feature plot of the data points

layers were created with ReLU as an activation function. The final output layer was designed corresponding to the number of classification targets with Sigmoid as the activation function. Finally, the neural model was compiled with Adam optimizer [13, 14] instead of traditional SGD [15, 16]; Sparse categorical cross entropy as the loss and accuracy as the metrics.

Figure 4 gives a visual of the entire process that has been carried out in order to obtain the desired stratified classes.

5.2 Faster RCNN

Faster RCNN [17] is the most effective and robust model when compared to RCNN or fast RCNN. This is because it solves all the bottlenecks of the Fast RCNN model [18]. There are 2 paramount steps that describe the entire algorithm of Faster RCNN: Region Proposal Network and Fast RCNN as detector algorithm. The first step of the architecture is to feed our image input into the Convolutional Neural Network.

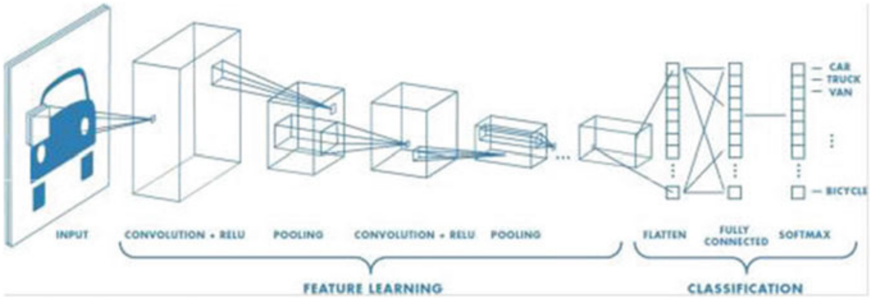


Fig. 4 Algorithmic stratification strategy: CNN

The image size has been resized to 100 × 100 pixels. We have tested our model with 2 different stride values. First, we have set a stride value of 1 both vertically and horizontally. The model is first built upon the ResNet model. But later, VGG-16 was introduced which ultimately gave a better result. There are 4 max-pooling layers in the VGG-16 architecture [19]. Similarly, a stride value of 2 has been considered to test the maximum potential of the detection algorithm. As mentioned earlier, $2^4 = 16$. This means that upon moving a unit step in the feature map, a total of 16 pixels are traversed in input. Another important factor contributing toward this result is the selection of appropriate anchors of various aspect ratios. For this research, a set of aspect ratio values of 1:1, 1:2 and 2:1 have been leveraged (Fig. 5).

Training and loss function

The loss function implemented in this proposed methodology, as mentioned by [17], is

$$L_i(\{p_i\}, \{t_i\}) = 1/N_{cls}\left(\sum L_i(p_i, p_i^*)\right) \tag{1}$$

$$L_i(\{p_i\}, \{t_i\}) = L_i(\{p_i\}, \{t_i\}) + \lambda / N_{reg}\left(\Sigma_i p_i^* L_{reg}(t_i, t_i^*)\right) \tag{2}$$

6 Viable Result Analysis

The proposed methodology has been put through numerous critical analyzing factors and depending on the feedback, the framework has been reconfigured in order to achieve the best possible outcome.

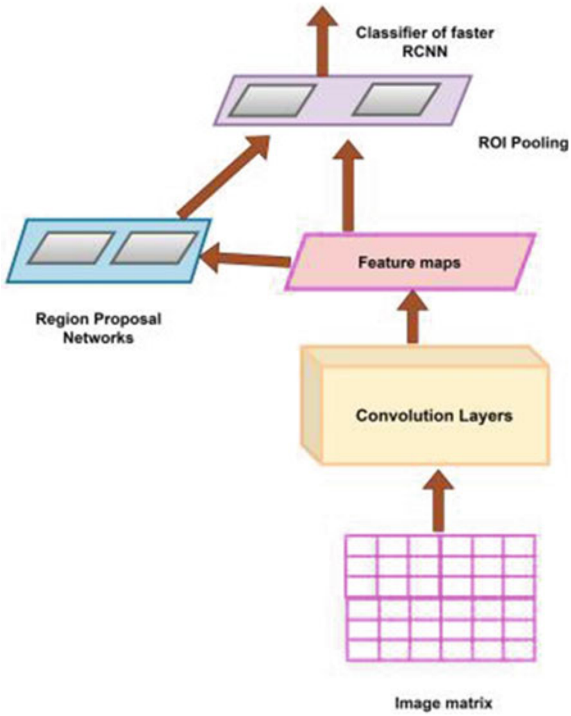


Fig. 5 Algorithmic stratification strategy: faster RCNN

6.1 Alerting for Engagement

During warfare, situations arise where stealth movements occur, which sometimes create a lot of casualties as the oppositions manage to come very close to the operating base [20]. The proposed method also deploys an alarming system that starts ringing as soon as there is some motion on the optical feedback. The algorithm that is used is quite simple which is a rule-based one.

$$Alert\_System = 1;\ \text{if absdiff}_{\text{i}}(\text{f}_{\text{i}} -- \text{f}_{\text{i+1}})\,! = 0$$

$$Alert\_System = 0;\ \text{if absdiff}_{\text{i}}(\text{f}_{\text{i}} -- \text{f}_{\text{i+1}}) = 0$$

In the above equation, 1 and 0 refer to the logical on and off for the alarm system. Thus, whenever the absolute difference between the frames returns zero, the alert system remains off, but as soon as the return type is not false, i.e. true, the alarm turns on. The deployment of the above algorithm makes the alert system highly robust and precise. However, the problem of alerting against noises was solved using a real ratio of detected motional entities based on their distance from the camera.

6.2 Performance Analysis of CNN Model

In order to analyze the result of the proposed framework [21], it was necessary to tune the parameters of the first classification algorithm, i.e. the CNN. The significant hyper-parameters were tuned through hyper-tuning functions. Ultimately, the following parameters were obtained:

Parameter	Value
Model	Sequential
Architecture	Dense
Convolution	2D
Filters	32
Kernel	3×3
Stride	32
Pool size	MAX, 3X3
Dropout	0.3
Optimizer	Adam
Loss	S.C.Cr.E
Accuracy	98.7
Loss	2.19

The ReLU function played a vital role as an activation function in both feature map creation as well as in hidden neural layers. Finally, the ROC and AUC of the CNN algorithm were determined and plotted.

Figure 6 depicts the performance of the CNN algorithm in obtaining the stratified ROI.

The precision, robustness and result analysis are carried out by creating a confusion matrix [22].

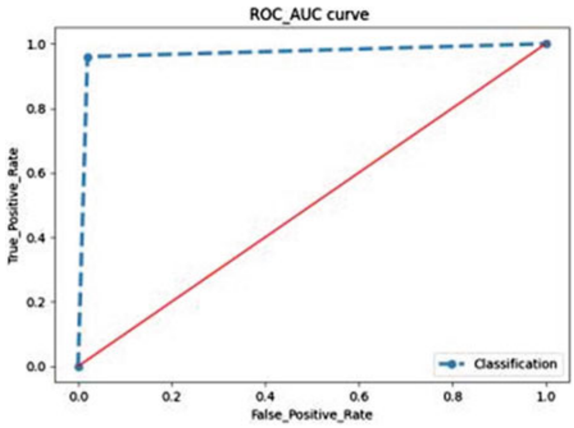


Fig. 6 ROC and AUC for CNN

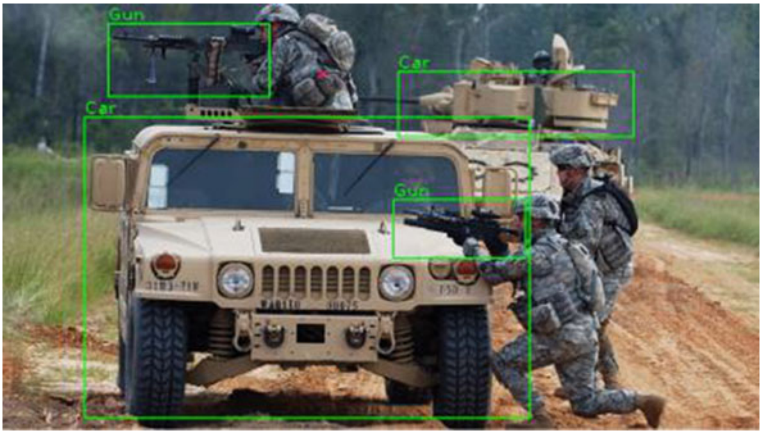


Fig. 7 Classification of extracted ROI using CNN model (Deadlock 1983)

$$A = \begin{bmatrix} 48 & 2 \\ 1 & 49 \end{bmatrix}$$

In the above matrix 6.2 A, the columns are the predicted dataset and rows are the actual ones. Here, the first and second columns represent the gun and truck datasets, respectively. Likewise, the first row represents the actual class of guns and the second row represents trucks. Several parameters have been used to validate the performance of the model [23]. Applying those parameters to the matrix 6.2 A, we have values as the following.

Thus, an average F1 score of 0.97 has been recorded [24]. The model is gives high accuracy of classification. Figure 7 talks about the visual of the physical output of the model. The model gives correct prediction in the image taken in foggy conditions with reduced visibility.

6.3 *Performance Analysis of Faster RCNN Model*

The model works well when tested under different conditions (Fig. 8). In Fig. 9, the performance of the model is shown. The model does extremely well in detecting the "person" in camouflage in both scenarios. It is equally capable of detecting birds and animals in challenging situations. The model detects a cat from a dark environment and classifies it correctly with a confidence score of 68.75%. It even does well to detect the precise ROI of a parrot in green surroundings and classifies it correctly with a confidence score of 69.92%.

Further, to improve the performance of the proposals generated by the network, we label anchor targets as either 0 or 1. Considering the scenario where anchor's and ground truth's IOU 0.7, the anchor has been labeled as 1. In the proposed

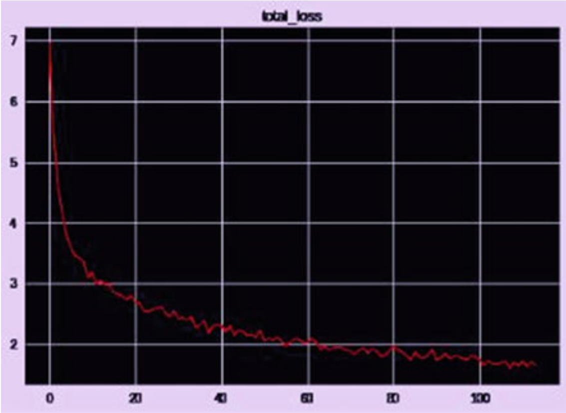


Fig. 8 Epochs versus net loss for faster RCNN training

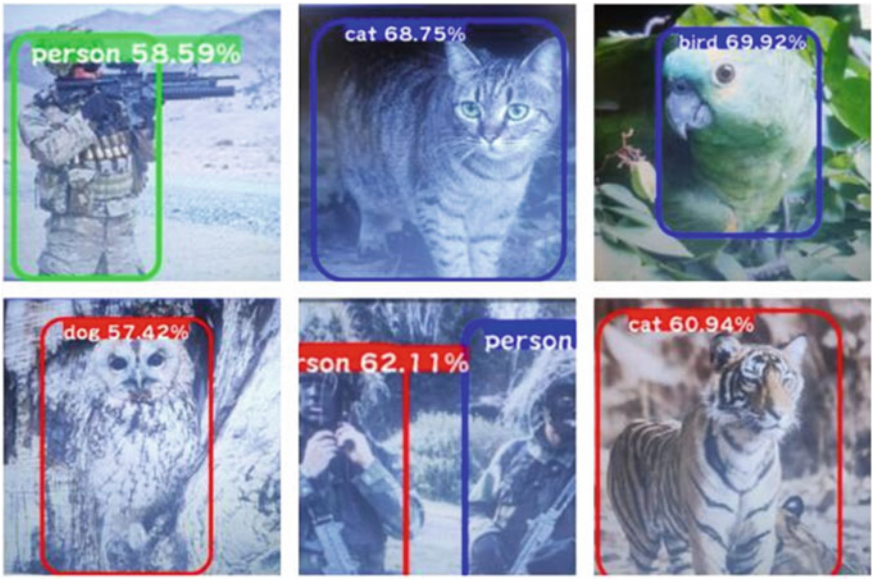


Fig. 9 Object detection using faster RCNN in different conditions (https://unsplash.com/)

methodology, for the object detector network, Binary Cross Entropy [25] has been implemented to calculate the net loss.

The Maximum Average Precision (mAP @ 0.5) and overall mAP score achieved after training the Faster RCNN model on OID v4 were approximately 43.5 and 75%, respectively. The score achieved is quite extraordinary given the challenging conditions on which the model was tested. The initial learning rate (alpha) was set as 0.05 which was tuned over the course of training.

7 Conclusion

In line with the objective of the proposed methodology, a robust object detection and classification algorithm has been achieved. Both CNN-based architecture and Faster RCNN-based models work extremely well when tested in different conditions. The Faster RCNN-based model works particularly well in testing and difficult situations such as low light and objects in camouflage. Both the models have been greatly modified from their respective vanilla architecture, to achieve a state of robustness.

There were some shortcomings too in this methodology. In Fig. 9, the framework misclassified the "owl" and the "tiger" as a dog and a cat, respectively. Although the framework did extremely well in extracting the desired ROI from heavy camouflage, the classification was wrong. This can be solved by taking a stronger dataset to train the models. In the rest of all other cases, the model did a good job in extracting the desired ROI and correctly classifying them. The alerting methodology executed with the rule-based algorithm worked with high precision and robustness. However, an initial problem was encountered, which was unnecessary alerting for minute movements of trees birds, etc. in the optical feedback. This problem was solved by adjusting the contour area on the basis of a specific distance from the camera, keeping in mind the purpose it serves. Maintaining the contour area reduces the unnecessary detection of noise and latent vectors, thus contributing toward its viability.

The main objective of enhancing the security of smart cities by acting as a defensive mechanism has been achieved. The system is tested on different grounds and it has returned high accuracy. The viability of the framework comes from the fact that it has been tested in crowded places. This is a very important aspect as smart cities are usually very crowded due to available job opportunities and promising quality of life. In short, it can be rightly concluded that the proposed framework works with high precision and robustness. The computational power is low and also eliminates all hardware dependencies. The proposed framework, thus, can be deployed in real life in developing and developed smart cities of India such as Agartala, Silchar, Durgapur, Indore and Varanasi. This framework along with minute modifications can be an effective tool in solving a large array of security problems in smart cities that can be classified as detection-related conundrums.

References

1. Astapov S, Preden J-S, Ehala J, Riid A (2014) Object detection for military surveillance using distributed multimodal smart sensors. 08
2. Rajjak SSA, Kureshi AK (2019) Recent advances in object de-tection and tracking for high resolution video: overview and state-of-the-art. In: 2019 5th International conference on computing, communication, control and automation (ICCUBEA), pp 1–9
3. Prasad S, Sinha S (2011) Real-time object detection and tracking in an unknown environment. In: 2011 World congress on information and communication technologies, pp 1056–1061
4. Zhong-Qiu Zhao SX, Zheng P, Wu X. Object detection with deep learning: a review. Neural networks and learning systems

5. Chen Z, Gao L, Cao D (2020) An improved object detection algorithm based on multi-scaled and deformable convolutional neural networks. Hum Cent Comput Inf Sci 10:14
6. Sharma K, Thakur N (2017) A review and an approach for object detection in images. Int J Comput Vis Robot 7:196
7. Mao Y, Zhang J, Wan Z, Dai Y, Li A, Lv Y, Tian X, Fan D-P, Barnes N (2021) Transformer transforms salient object detection and camou aged object detection
8. Mukherjee S (2021) Object detection, pp 159–170
9. Singh A, Kumar T (2021) Multiple object detection, pp 659–664
10. Dr Maturkar, Dudhe K, Roy K (2021) Accident identication and alerting system. Int J Adv Res Sci Commun Technol 766–774
11. Albawi S, Mohammed TA, Al-Zawi S (2017) Understanding of a convolutional neural network, pp 1–6
12. Guyon AEI (2003) An introduction to variable and feature selection. J Mach Learn Res 3(2003):1157–1182
13. Kingma D, Ba J (2014) Adam: A method for stochastic optimization. In: International conference on learning representations
14. Kingma DP, Ba J (2017) Adam: A method for stochastic optimization
15. Wang Y, Zhou P, Zhong W (2018) An optimization strategy based on hybrid algorithm of Adam and sgd. MATEC Web Conf 232:03007
16. Ruder S (2016) An overview of gradient descent optimization algorithms. CoRR, abs/1609.04747
17. Ren RGS, He K, Sun J (2015) Faster r-cnn: towards real-time object detec-tion with region proposal networks. In: Advances in neural information processing systems, pp 91–99
18. Girshick R (2015) Fast r-cnn. arXiv:1504.08083
19. Simonyan K, Zisserman A (2015) Very deep convolutional networks for large-scale image recognition
20. Sarkar P, Singh A, Md Islam (2019) Emergency alert system for women's safety. IJIREEICE 7:53–55
21. Humaidi AJ, Al-Dujaili A, Duan Y, Al-Shamma O, Santa-mara J, Fadhel MA, Al-Amidie M, Farhan L, Alzubaidi L, Zhang J (2021) Review of deep learning: concepts, cnn architectures, challenges, applications, future directions
22. Susmaga R (2004) Confusion matrix visualization. In: Mieczys law A Klopotek, Slawomir T Wierzchon, Trojanowski K (eds) Intelligent information processing and web mining, pp 107–116. Springer, Berlin Heidelberg
23. Pianosi F, Beven K, Freer J, Hall JW, Rougier J, Stephenson DB, Wagener T (2016) Sensitivity analysis of environmental models: a systematic review with practical work ow. Environ Model Softw , 79:214–232
24. Sokolova M, Japkowicz N, Szpakowicz S (2006) Beyond accuracy, f-score and roc: a family of discriminant measures for performance evaluation, vol 4304, pp 1015–1021
25. Ruby U, Yendapalli V (2020) Binary cross entropy with deep learning technique for image classification. Int J Adv Trends Comput Sci Eng 9:10

Application of AI/IoT for Smart Renewable Energy Management in Smart Cities

Pradeep Bedi, S. B. Goyal, Anand Singh Rajawat, Rabindra Nath Shaw, and Ankush Ghosh

Abstract A city is considered to be smart when the application of Artificial Intelligence (AI) and the Internet of Things (IoT) is integrated with it. This enables the collection of data from people, devices, and buildings, then analyses are performed to optimize control over infrastructure, traffic, energy, etc. A smart city is a collective framework with the integration of Information and Communication Technologies (ICT) and Cloud that makes interaction easily with one another. In this chapter, smart energy infrastructure is studied to monitor energy utilization in the city and to reduce costs and carbon emissions. Energy usage has recently shifted focus to renewable energy sources with minimal carbon emissions, emphasizing the necessity for ongoing environmental and human health preservation. Renewable energy is becoming more abundant, and the issue is to recognize and understand it in meeting the increasing demand for clean, affordable energy. Customers, distributors, and government bodies are all concerned about cost and the climate. Artificial intelligence proclaimed a new age in technology as well as in sustainable development. So, in this chapter, an implication of AI is presented and analyzed for RE research in smart environments. Along with that, an analytical study is also presented with the application of AI or IoT for smart energy management for smart cities. The main aim is to focus on and explore the efficiency level of ML/IoT techniques. This work will

P. Bedi
Computer Science and Engineering, KCC Institute of Technology and Management, Greater Noida, Uttar Pradesh, India

S. B. Goyal
City University, Petaling Jaya, Malaysia

A. S. Rajawat
Department of Computer Science Engineering, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, India

R. N. Shaw
Department of Electrical, Electronics and Communication Engineering, Galgotias University, Greater Noida, India
e-mail: r.n.s@ieee.org

A. Ghosh (✉)
School of Engineering and Applied Sciences, The Neotia University, Sarisha, West Bengal, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_8

also provide an in-depth analysis of innovative development, deployment, analysis, and management of smart energy in smart cities.

Keywords Smart cities · Renewable energy · Smart grids · Artificial intelligence (AI) · Machine learning (ML) · Internet of Things (IoT)

1 Introduction

Currently, the world is undergoing rapid urbanization that would increase the demand for energy and consumption. With increased consumption, the carbon emission also increases. As can be observed worldwide, urban areas emit about 50–60% of total greenhouse gas (GHGs). With the increasing population in an urban area, there is an increase in demand for energy consumption day by day that subsequently increases the GHG emissions. Consequently, there arises a major issue for managing and reducing carbon emission and needs to be managed. This problem is directed toward the solution of smart energy management (SEM). This principle redirected the energy management toward green and clean energy management and the development of sustainable policies to manage urban energy demand and reduce future carbon emissions [1].

To build an efficient SEM, first of all, it is required to understand the concept of energy management and then its integration with smart cities [2]. Planning and controlling of energy demand, supply, and consumption are considered to be efficient energy management with an aim to maximizing productivity and reduction in carbon emission and energy costs. In easy terms, energy management means "saving of energy". Smart cities are a complex task that covers a wide application, as mentioned in Fig. 1. SEM is integrated into different sectors such as buildings, water management, waste management, and transportation. According to different studies [1–5], different SEM challenges can be identified that hinder the adoption of SEM.

Smart energy management (SEM) is considered to be the most challenging area for future smart cities. The related critical issues are designing of networks and topology, and computational tasks integrated with artificial intelligence (AI) or machine learning (ML). In the context of smart energy management, renewable energy (RE) is considered to be a future energy source. Therefore, there is a need to investigate the benefits of renewable energy (RE) for the development of energy-optimized smart cities. For this, artificial intelligence (AI) can be used to respond to these requirements. This can be possible by the improvement in infrastructure design, production, and distribution of power in smart cities while facing challenges related to growth and resilience.

Smart grid with RE is considered to be the next-generation smart city grid that is a combination of electrical engineering and information and communication technology (ICT). Recently, it is being deployed at a rapid pace with increasing demand in a flexible, environment-friendly, robust, and cost-efficient way. Smart energy

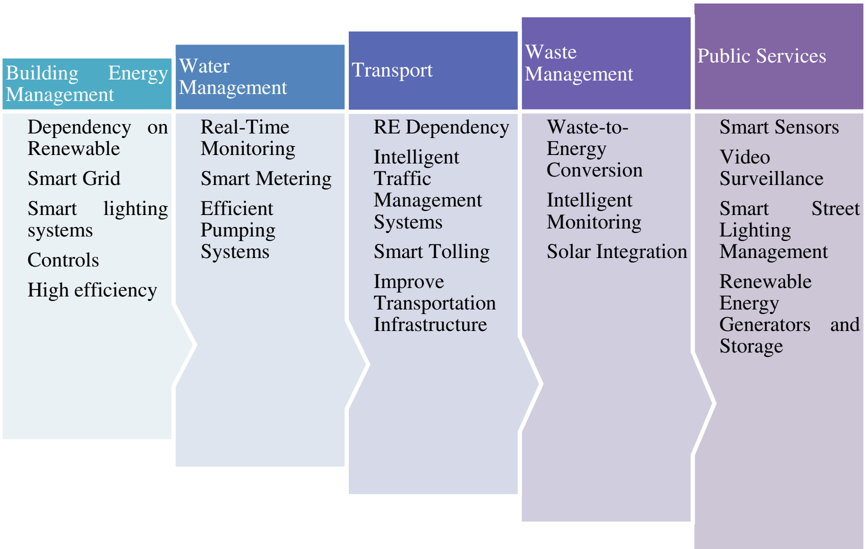


Fig. 1 SEM in different sectors

management includes deployment of smart meters, load forecasting, optimization of energy generation, etc. For example, with the deployment of a smart meter, a consumer can measure power consumption whereas, it can also enable consumers to be aware of the operation status between utility companies and consumers. The following challenges are observed in current grid systems:

- The current energy grid was not built to handle changeable sources of energy or fluctuating load-carrying capacity.
- The labor force presents unique challenges to the renewable energy industry in terms of abilities and labor shortages.
- The key to fixing the issues is not just management of generation, delivery, and storage but also the application of Artificial Intelligence at all levels of renewable energy's chain of distribution.

1.1 Key Contributions

The contribution of this chapter is illustrated as follows:

- The chapter is dedicated to describing the smart grid architecture in smart city applications. The chapter is dedicated to exploring the architectural models needed to be known during the deployment of energy management system in smart cities.

- The chapter also presented different existing research articles that have presented their efforts in deploying machine learning or artificial intelligence for smart grid architecture.
- To explore accurate and precise decision-making systems to analyze the impact of ML/AI techniques to reduce energy losses and their cost.
- The addition of artificial intelligence or Internet of Things (IoT) elements to the current study and to identify AI as a study area with a meaningful effect on smart grid quality and productivity.
- Further, this chapter has explored smart renewable energy design and management with analytical results under different machine learning algorithms for energy management in smart cities through a smart grid system.

1.2 Organization of the Chapter

The chapter is organized in sections: Sect. 2 is dedicated to showing an overview of smart cities with their architecture and applications. Section 3 presents the role of information and communication technology (ICT) while deploying smart cities. Section 4 presents the relationship between artificial intelligence application with renewable energy and its application in the smart city for energy management. Section 5 gives an overview of smart grids and their deployment architecture. Section 6 presents the contribution of machine learning and IoT in the smart grid. Section 7 describes the analytical study of the application of ML and IoT for the identification of future research directions. The last conclusion is presented in Sect. 8.

2 Overview of Smart Cities

The concept of a smart city is based on Internet of Things (IoT) [6]. Constant population expansion and modernization have heightened the need for novel approaches to modernization that have minimum impact on the ecosystem, human lifestyles, and administration**.** The early adoption of information and communication technology (ICT) in city administration sparked the notions of a digital city. Smart cities have evolved as a remedy to the issues that come with rapid urbanization and population expansion. With the advent of smart gadgets and their subsequent improvements, the concept of linking everyday things over existing networks has gained a lot of traction. The growth of traditional networks that link zillions of linked gadgets gave rise to Internet of Things (IoT) [7]. Internet of Things has been reinforced by technological improvements in ubiquitous computing (UC). Due to rapid modernization around the world, smart cities have risen to prominence in recent decades. Using ICT to run city management made cities more efficient in a variety of ways. In broad terms, a smart city is an urban ecosystem that makes use of information and communication technology (ICT) and other associated technologies to improve the effectiveness of normal city operations and the quality of services (QoS) given to city residents. Authorities have defined the smart cities' informal words, considering many features and views [3]. mart cities' informal words, taking into account many features and views [3] a smart city links physical, social, business, and ICT infrastructure to improve the city's intelligence.

A smart city links physical, social, business, and ICT infrastructure to improve the city's intelligence. A smart city, according to another conception, is a developed modern metropolis that uses ICT and other technology to enhance the standard of life. Because of its significant realistic necessity and practical foundation in a growing urbanized globe, the notion of a "smart city" has drawn expanding emphasis in both academic and industrial disciplines over the last two decades. However, because of the vulnerabilities that exist in every phase of a smart system, the design of these smart apps may pose several security [8] and privacy issues.

Numerous architectures have been devised to keep up with the advancement of smart cities. However, as far as we are aware, there is no standard IoT [9, 10] architecture. The design presented here is based on the well-known three-layer architecture and the commonly recognized architecture proposed, as the focus of this study is to outline security and privacy challenges in smart cities. The architecture can be separated into four layers, as indicated in Fig. 2; a quick overview is provided below [4].

- The lowest layer of the architecture is the observation layer, also known as the sensing layer, recognition layer, or edge layer. The perception layer is primarily responsible for collecting data from items in the real world (e.g., heterogeneous devices, WSNs, and sensors) and delivering it to the network layer for further computation.
- The network layer is the foundation of the Internet of Things architecture, and it relies on basic networks including the Internet, wireless sensor networks, and

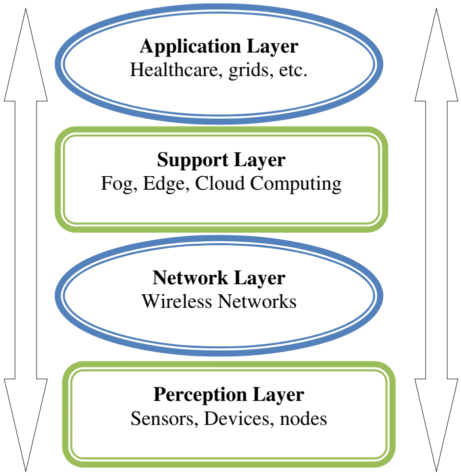


Fig. 2 The architecture of smart city

Fig. 3 Applications of smart city

communications networks. This layer's job is to link smart items, network devices, and servers while also transmitting the data gathered by the perception layer.
- The support layer, which works intimately with the application layer, uses intelligent computing approaches to support the needs of various applications (e.g., cloud computing, edge computing, and fog computing).

As the top layer, the application layer is in charge of supplying intelligent and practical services or applications to users based on their specific needs. In the following subsection, we go through everything in detail. Smart city applications are represented as in Fig. 3.

2.1 Implementation of Smart Cities

The availability of real data on urban surroundings is critical for the operation of a variety of useful applications and services. Figure 4 encapsulates a brief explanation of major smart city implementations. The range of application areas is extremely broad. For apps that allow individuals to book travel on mass transportation, for instance, actual travel data is relevant. The client might get real-time updates on when the next bus or train will arrive. Stakeholders will be able to engage in a wide range of online activities, including websites for general details, citizen services, enterprise, and tourism, all of which will be built on a single infrastructure. Urban areas are implementing online services in a variety of fields [5].

Urban areas are resource frameworks, and these services are the means through which people participate with one another inside infrastructure systems. They frequently use or transform resources, and they usually demand payment or interchange. International and local service providers both enable the management and operation of urban apps and services.

Several technology designers and service providers are extending outside identifying, planning, implementing, and distributing products for specific smart urban programs by combining them or promising to complete and manage them in favor of urban administrations or other partners. Smart urban products should be simple to

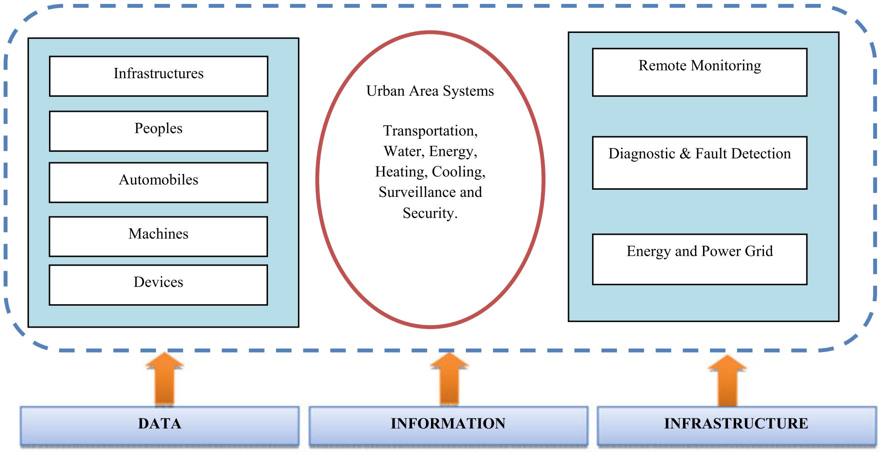


Fig. 4 Relation between ICT components with smart city components

use, effective, reactive, transparent, and environmentally friendly. People as well as other investors want high-level government services that improve and revolutionize their everyday lives. Urban areas are under pressure to improve urban strategic planning, deliver better and more effective infrastructure and operations, and do so at a cheaper cost.

2.2 *Smart Urban Area Services*

There are numerous services and apps available. Public transport, public utilities, learning training, fitness, and social welfare, and public security are among the services provided. People's daily routines, crisis response, intelligent cities, transportation, and smart purchasing are all impacted by evolving apps and services. This portfolio's technologies comprise smart grid, home automation, safety, smart buildings, faraway health and wellbeing tracking, position-aware applications, digital money, as well as other machine-to-machine (M2M) technologies for the linked metropolis. The advanced applications can provide real-time data, increase the ability to forecast and control urban movements, and perform other municipal duties.

A further technique to increase the amount of knowledge available is through social application-based cooperation and spontaneous collective experience. Through the Internet, crowdfunding portals, mash-ups, and other participative real concern methodologies, social media have provided the technical foundation for arranging collective knowledge. One other major area of application is evaluation, intellectual ability collecting, and predicting utilizing information to promote prognostic systems that allow risk modeling and integrated need for urban area resources.

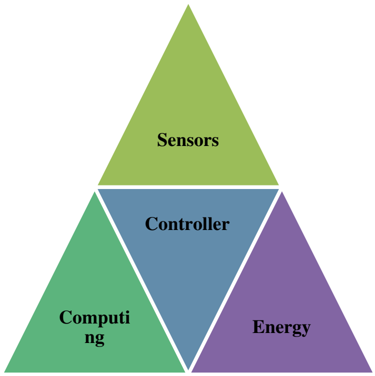
The city will perform better because of these decentralized problem-solving judgments. It is all about providing decision-makers with unified data that allows them to anticipate instead of responding to issues as they arise. As a result, numerous methods emerge, allowing urban centers to improve their problem-solving abilities.

3 Role of ICT in Building Smart City

Modern technologies are being used to enhance urban applications and services. It's transforming the way the services are delivered by merging ICTs with municipal infrastructure and altering city system solutions. From a smart urban viewpoint, smart urban services and apps are concentrating on how to design upcoming Web systems and resources. To satisfy the difficulties of advanced cities, creative web services and apps must be deployed, implemented, and approved. People working with data and understanding are particularly affected by this shift and possibility. The generation of information content is not limited to a single area, and the resulting goods are usually distributed via the Internet. Services-driven marketing infrastructure, which includes web services, the extensible markup language (XML), and mobilizing software programs, allows smart urban services to be accessed via wireless devices [11]. The business applications that are designed and run have changed dramatically, thanks to Cloud computing. Platform as a Service (PaaS) is a method of renting operating systems, memory, network bandwidth, and equipment over the Web. It's a type of Cloud computing service that includes both a solution stack and a computing environment. Access to online services does not need to own or license the software to fully utilize it [12].

Such breakthroughs have enabled the provision of more services to a wider group of people, as well as improved access to services with accompanying upgrades and advancements. These enhancements to the services have reduced operating costs and higher productivity. A person can access a variety of city services over the Internet. Relying on their user account and the accompanying security standards, the operator may deliver services to distinct user groups, each of which is defined by certain roles and permitted to engage in a variety of actions. Upcoming online services in smart urban areas will rely heavily on innovative mechanisms that involve people, corporations, and government agencies. Sustainable urban services, architectures, techniques, and ICT systems are deployed and tested before being used by end-users. Verifying cities' performance levels and improving their durability require them to become progressively able to fulfill both anticipated and unanticipated problems.

Fig. 5 Topology for sensor nodes for deployment of smart city



3.1 Wireless Communication and Associated Technologies

The goal is to put in place surveillance equipment and create a decentralized system of smart sensor nodes that can detect a variety of characteristics for better city administration. A variety of fundamental technological improvements, particularly developments in MEMS sensor technology, and novel techniques to regulate power usage has driven new progress in wireless communication. Figure 5 topology for sensor nodes for deployment of smart city system, which can sense and also the initial phases of the process, can provide versatile, cheap monitoring. Smart urban solutions based on Wireless Sensor Networks for action recognition will see a significant increment in this market [13]. The wireless sensor network (WSN) is comprised of a large number of diverse and geographically scattered independent sensors positioned inside or near the event. A wide number of "nodes" that are linked to one or more sensors and organized into a cooperative network supports the WSN. The standard sensor node topology is depicted schematically in Fig. 5.

These sensor nodes can gather and process information, and each one can sense, analyze, and transfer data about its immediate community to other nodes and processors nearby. The goal of these networks is to detect and capture physical and environmental parameters like temperature, noise, pressure, and other factors to jointly send associated data over the network to a central point. Sensor networks will give large ensembles of real-time, distant contact with the physical environment, similar to how the Web enables access to digital information from everywhere. Decentralized information from the sensor to the system becomes as important as Internet-based wireless sensor networks in enabling the building of smart cities by allowing for the collection of data that is appropriate for the purpose. Each node in the network has processing power provided by one or more configurable microcontrollers for managing node activities and processing data, ranging from a few to many hundreds or thousands. Small-format, battery-powered, sensor-enabled processors that can execute the role of sensors can now be produced at a low price, thanks to innovative technologies. These sensor nodes, which act as a method of detecting, data analysis, and communication, might be built from these small embedded systems, leveraging the concept of sensor networks built through a collective effort of a large number of nodes. Various kinds of storage, a radio (RF) transceiver for communications with an internal antenna or connectivity to a directional device, an electrical device for sensor interface, and an on-board power supply for power, are all included in this system.

Wireless Fidelity (Wi-Fi), ZigBee, IQRF, Ultra-Wide Band (UWB), and Wireless Hart are examples of sensor network communication systems. Wireless sensor networks (WSNs) are a significant technique that enables to satisfy city conditions surveillance demands, even though they have not been widely deployed on a broad scale yet. By analyzing real-time data, this model enables the efficient and accurate detection of diverse spatial occurrences, such as the issues associated with an area of high pollution intensity. Dense WSNs of nodes with monitoring capability could help with air pollution or tracking of urban areas [14].

4 Relationship Between Artificial Intelligence and Renewable Energy

Renewable energy (RE) has the potential to be a long-term solution to the world's energy needs. The potential of RE cannot be wasted due to traditional resource depletion, growing pollution, and climate change. High power and process quality are required in the generation, transmission, and distribution systems as the trend toward renewable energy growth [15]. As RE is available in remote regions instead of any conventional fossil fuel sources, this arises a challenging development and growth of technology with increased efficiency of control and technology [16]. Its main advantage is that it is independent of dependency on fossil fuels, whose prices may vary considerably. Furthermore, the fluctuation of renewable energy sources may provide a difficulty, necessitating the adoption of technologies to produce and store energy when conditions are favorable and to use it when conditions are not, precise data prediction to eliminate wasteful and inaccurate outputs. Whether isolated or not, intermittent generation of electricity is the main challenge for renewable energy grids. It has the potential to return us as backup fossil fuels if not properly controlled [17–20].

Artificial intelligence and considered it for studying and calculations that allow the perception, reasoning, and action to be perceived and defined according to its objectives. Experts believe that Artificial Intelligence can make recommendations, decisions, and predictions about a given plan of action defined by human beings and influence the real or virtual environment [20]. The grid's complexity is growing all the time; thus, AI should look into data and apply automated algorithms paired with climate prediction to maximize the return on investment in renewable energy and estimate the power consumed by all of the grid's production components. Even when the initial RE investments are high, the cost of RE mass production is very low.

The systems will use AI to gather and evaluate large amounts of information from all of the grid's key features, as well as to provide rapid judgment algorithms for the optimal resource distribution in and out of the grid. AI can detect controls for the generation of energy and regulating energy demand.

Particularly using better operation and maintenance, the following AI applications need to be focused on:

- Production of energy with application of RE.
- Stability and reliability.
- Operational stability and security.
- Demand forecasting with accuracy.
- Optimal energy generation and storage.
- Optimal design and management.

The relationship between AI applications and energy management is presented in Fig. 6.

Some applications of AI in the field of smart Energy Management are as follows.

Supply-Demand Management: Even while the increased usage of RE provides a wonderful potential for current cultures to combat resource scarcity [21], because RE is so dependent, AI can give precisely power supply in order to respond to natural oscillations, alter operations so that plans are not disturbed, and adapt to anticipated actual consumers' needs. It is expected to boost RE efficiency by automating operations, which would necessitate the employment of AI on a wide scale. The ultimate target for RE networks is to maximize production capabilities' intakes because of the volatility and associated cost of uncertainty. Artificial intelligence is being used to predict energy requirements to better respond to peaks. The energy demand and

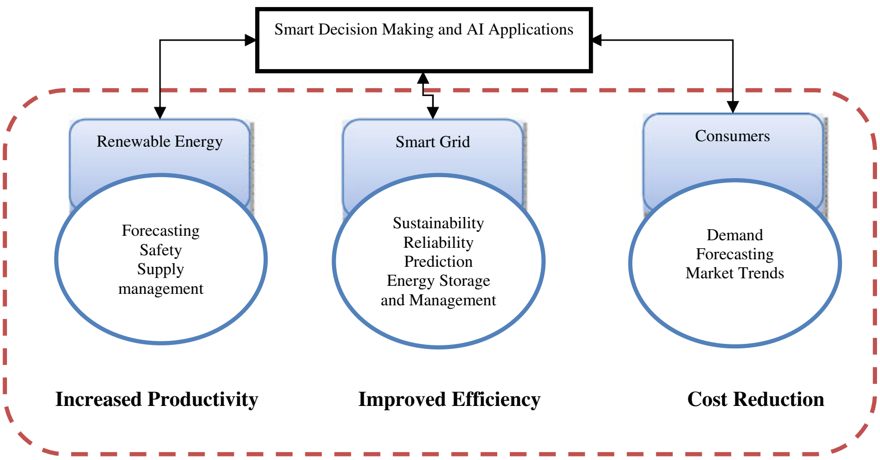


Fig. 6 Relation between AI and energy management system

energy supply of decentralized manufacturing systems (private customers generating energy from renews) which use grid power when development is below their requirements and return supplementary power to the grid when it produces more than it consumes are essential. The exchange of energy between consumers and suppliers would be continuous.

Intelligent Storage: Recent trends have shown that AI can provide optimization, even without extensive weather information on a long-term basis [21]. The inclusion of smart storage in the RE project maximizes investment revenues and enhances flexibility for changing demand and renewable inputs caused by climate circumstances. Smart storage must be fully utilized, and smart renewable energy systems must be developed. The result will affect both energy producers and consumers because they have low-cost access to energy. The improving distribution networks and storing systems are significant advantages for renewables' integration (the use of RE output in the electricity system). In addition, a useful adaptation mechanism is the ability to switch between energy sources. Storage technology can help to tackle the challenges of renewable energy volatility (mainly wind or solar) and demand cyclicality. More energy can be produced if it is not required.

Control System: AI integrated for control will help to prevent energy shortages by detecting problems early and reducing the time it takes to repair them. The control system is basically designed on alarm-based reporting, web-based interface, security keys, and backup server for unexpected cases, for authentication for users from multiple locations, and other features to be effective in these directions. The platforms required for controlling the supervised locations are referred to as centralized intelligent control. AI could help to manage this exponentially rising data by providing techniques for dealing with RE variations based on experience and forecasts. It will aid in the integration of renewable energy into the energy chain, as well as the improved utilization of the capabilities of these forms, regardless of their fluctuation.

Smart Grids or Microgrids: A microgrid can function as a "'island" as well as being connected to the grid. Microgrids are small integrated grids that are considered to be regulated systems to increase grid connections [22]. In these cases, they could also be cost-effective. In microgrids, RE can not only be used as a primary power supply but can also be used as emergency support to reduce disturbance in the event of energy shortages. As fossil fuels are becoming more and more costly and emissions, a growing trend is toward the use of standalone hybrid renewable energy systems. Renewable energy, the increased storage capacity, and interaction linkages have determined the need for much greater development of grid control and protection that provides the energy system with greater flexibility and reliability [23]. Intelligent microgrid technologies symbolize a shift away from the previous centralized energy production and delivery system and toward a new and modern network that includes decentralized energy transmission, generation, and distribution.

5 Overview of Smart Grids

For upcoming smart grid technology, there have been enough operational and analytical standardization approaches. Among all the different ideas of smart grid construction, the National Institute of Standards and Technology (NIST) smart grid theoretical framework, the IEEE 2030 guideline, and the smart grid architectural model (SGAM) are the most frequently acknowledged (Fig. 7). The SGAM is a cube-shaped framework made up of five compatibility layers (component, communication, information, function, and business). Inside of coming generations' advanced technologies, the layers considerably interweave among information and communications technologies (ICT), energy informatics, and commercial viewpoints. Domains and zones are subdivided inside each layer. Beginning with mass production, transmitting, distributing, distributed energy resources (DER), and customer premises or loads, the domains cover the entire energy conversion cycle. Processes, area, stations, function, business, and marketplace are the organization chart of power system administration that the zones are separated into. The processing zone contains the majority of mechanical energy conversion devices. The security, controlling, and surveillance systems are located in the zone of the field, while the information concentrating and functioning aggregation modules are located in the station zone. The microgrid energy and distributing administration modules are housed in the operation zone.

Every element (physical equipment, information transfer, information, program, compatibility, and limitations) must be integrated into mathematical models, and their connections must be studied. The location of zonal components is characterized based on their intended use. The processing zone houses key elements such as energy and cable exchange, loads, detectors, and actuators, whereas the field zone houses control, security, and detection systems. The station zone houses data reflectors, functional aggregators, substation mechanization and monitoring units,

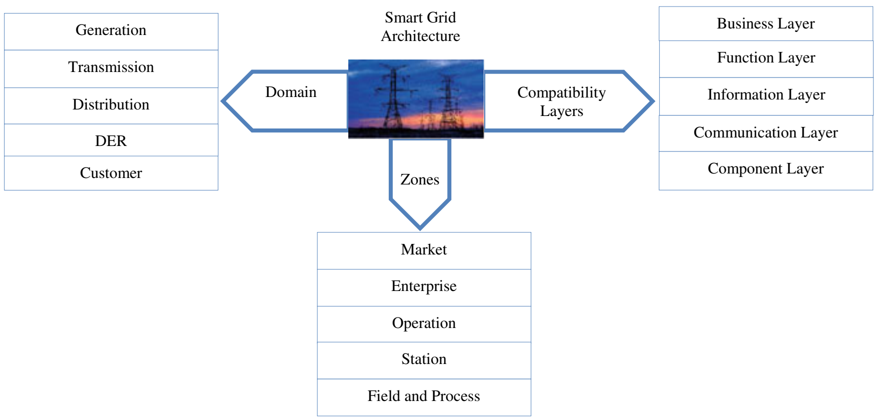


Fig. 7 Smart grid architecture models

and equipment, while the operational zone houses the microgrid's energy management and dispersal modules. Huge power systems, intermediate mechanization, and distribution channels are all described by the SGAM [24].

A smart grid ontology should include ICT algorithms as well as terminology and taxonomies for smart grid design. The ontological description acts as a central foundation for a variety of abbreviations that are used to express models in various layers. The framework will aid in the validation of various smart grid protocols, allowing for compatibility between virtualized and physical devices via globally diverse Internet of Things (IoT) or interaction taking into account faster dynamic phenomena and communication delay.

6 Smart Grid: A Perspective of Smart City with Machine Learning and IoT

Smart grids are one of the most concerning parts of the electrical transmission system. Modern power grids when integrated with the machine learning and IoTs have operational domain to control and monitor, analyze the data, service provider domain for customer management, emerging services, building, and home management, account and billing management, market domain for ancillary operations, trading and market operations as well as it has a custom domain for various service. A brief literature review related to smart grids using the machine learning and Internet of Things algorithm is presented here.

Zhuzhu Wang et al. [25] presented a lightweight secure, privacy-preserving Q-learning framework (LPSG) for developing smart grid energy management strategies that were implemented using IoTs as the world's largest Internet of Things (IoT) deployment; the smart grid substantially decreases energy dissipation for urban planning operations. The smart grid's power data comprises a significant amount of valuable data, such as shipping orders and bills. The dataset is always provided to Cloud servers in an unencrypted manner for the Q-learning-based energy plan creation, giving the intruder the chance to abuse the customer data. In order to get to the control panel, the energy the information present in the supply site in LiPSG is divided into evenly random secret shares. LiPSG's security and productivity are further demonstrated through comprehensive theoretic research and experiments. Unlike prior smart grid confidentiality and integrity approaches, LiPSG is the first to provide wide Q-learning-based confidentiality and integrity energy utilities with good precision and minimal performance loss. The presented model of power grids provides the secure machine learning algorithm, computer efficiency, privacy preserving. The only disadvantage of the work is that the handling capacity of accuracy does not allow the accuracy reduction.

Abir et al. [26] reviewed the present hazard and threat models for the Internet of Things power sources, as well as mitigating strategies for such security flaws also explained how emerging innovations (such as deep learning and machine intelligence) may help the Internet of Things power grid systems and related technologies become more reliable and protected, as well as solve current problems, resulting in improved, strong, and dependable functioning. This article will specifically assist in comprehending the structure for Internet of Things smart grid energy systems, as well as connected potential threats and the opportunities for new technologies to increase the efficacy of smart grids. Supervisory Control and Data Acquisition (SCAD) are used and this research chapter introduces a smart meter for billing and enhanced security. The only disadvantage is that the present work focuses only on the security domain and control domain of the smart grids.

Han et al. [27] focused on alternative energy like renewable sources and its management with the smart grids in a cost-effective way to improve environmental sustainability, but the research so far hasn't focused on the possibilities of edge computing in the controlled Internet of Things (IoT). Researchers work for the betterment of today's smart grids on households, and businesses to offer a machine learning framework for smarter power management. The research provides an economical and reliable means of communication between electricity distributors and households, and users by predicting future power energy use for short periods. Edge device-based real-time energy management via a common Cloud-based data supervisory server and an optimum normalization approach are among the main contributions. This research work gives multiple data pre-processing approaches to cope with the various kinds of power data, accompanied by such an optimal decision-making system for relatively brief forecasts and implementation on resource-constrained electronics devices. To applying diffrent comprehensive tests of mean-square error (MSE) and root MSE (RMSE) reductions of 0.15 and 3.77 units for residential and business databases, respectively. Also, it is suggested that in the future, resource-constrained devices can be joined in an IoT network for reciprocal energy sharing to meet each other's demand and conserve energy resources, in addition to edge intelligence utilizing reliable IoT. Similarly, for successful real-time energy forecasting approaches, researchers can also combine sequential learning with fuzzy logic, to investigate efficient set theory principles combined with effective CNN's employing weighted fusion methods, as well as Cloud and Fog computing for extremely accurate and fast output forecasts from time to time.

Siryani et al. [28] provided a data-driven decision-support system for improving ESM operations on the Internet of Things ecosystem. The suggested technique is innovative and reliable since it uses and compares four distinct ML algorithms: complete Bayesian network, naive Bayes, decision tree, and random forest to forecast either to send a technician to a delivery site or handle issues remotely. A random forest is a notable approach; the study of those IoT-based meter data for big datasets, with the greatest accuracy of 96.69 percent, provides the best alternating cost reduction techniques.

Hossain et al. [29] defined the structure of an IoT-based smart grid that processed the data on the processing layers, Application layer, Network layer, Aggregation layer, and Sensing layer from which the different infrastructure of smart grid. The application layer provides the Service domain, NL provides the Access points, AG provides the Data collection, and the SL provides the Smart meters. The heart of this new grid architecture is IoTs. The Smart Grid system with IoT integration may give optimized energy predictions and data gathering techniques while also being cost-effective. To gain these effects, predictive analytics and machine learning approaches are required. Cybersecurity becomes a key concern. In a smart grid complex linked system, IoT devices and their data are becoming important targets of assaults. This study provided a chronology of the grid's evolution into a smart grid, as well as how the Internet of Things (IoT) has become an integral element of the energy system. Other security problems in the smart grid, such as those connected with IoT-generated large data, such as their analysis and protection, were also highlighted. The big data analysis techniques discussed here have various disadvantages like Cloud sourcing and clustering, also the constraints of switching to a smart grid centered on renewable energy, as well as possible solutions, which must be studied.

The Dynamic Membership Data Aggression (DMDA) using ML for the power grid is presented by Song et al. [30] to ensure the collective usefulness of large data while maintaining the security of independent sources. The findings and model are provided to demonstrate that the security and performance standards are met. Particularly when users join or depart often, the Dynamic Membership Data Aggression is more lightweight, ensuring that the standard is more suited for the virtual aggregation area of Internet of Things settings. Results show that the Dynamic Membership Data Aggression (DMDA) is more appropriate for advanced future-based smart grid and other Internet of Things scenarios than standard privacy-preserving data aggregation schemes. Implementation time, Communication cost, Execution time with different numbers of users 100,200,300, and so on are discussed.

Mortaji et al. [31] discussed the use of a unique algorithm for smart direct load control and load shedding to lower the Peak-to-Average Ratio and minimize power outages in unexpected grid load fluctuations by changing data into intelligent predicted actions using IoTs. It also provides real-time power transfer and produces a daily plan for clients with Integrated Electronic Devices, using Internet of Things and ML. The findings showed that load shedding utilizing the ARIMA time series prediction model, smart direct load control (S-DLC), and Internet of Things may considerably minimize power outages for customers. Load shedding varies from 380 to 400 during 24 h of span which means an almost 30% reduction in the peak loads. Big data collection is the drawback because many database and control base methods are implemented.

Chin et al. [32] focused on the management domain of smart grids. The big data collected for various domains should be intelligently stored and handled to obtain useful information to cope with security risks, and vulnerability and blackout alerts should be issued at an initial point. The authors provide detailed research and questionnaire to emphasize problem statements on Internet of Things-based smart grid concerns. To deal with network-based threats, the research relies on automated detection techniques. Grid vulnerabilities should be identified as soon as possible. More study on quick and auto-recovery methods is required.

Li et al. [33] discussed the use of LPWAN with the IoTs which is emerging day by day. In this work, NB-IoT is integrated into the smart grid and compared to existing representative communication technologies in terms of data rate, latency, and range in the context of smart grid communications. Monte Carlo simulations are used to assess the effectiveness of NB-IoT in typical smart grid communication settings, such as urban and rural locations. The result shows that the NB-IoT-based smart grids have several advantages like low cost, covering a range of more than 35 km, etc.; also, it has a drawback that it is latency-insensitive which is less than 10 s and it does not provide distribution automation. It has been demonstrated that NB-IoT is capable of providing communication services with an extended range, suitable data rate, and high reliability.

Yao et al. [34] presented a smart grid energy theft detection system that preserves energy privacy. The research work employed integrated convolutional neural networks (CNNs) in particular to detect aberrant metered data behavior from a long-period sequence. Furthermore, it uses the Paillier algorithm to preserve energy privacy. In other words, the transfer of users' energy data is safe, and data leakage is kept to a minimum. Security and privacy are both achieved in this approach, according to a security study updated, the CNN model can detect aberrant behaviors with an accuracy of up to 92.67%, according to experimental data.

Tet al. [35] studied the comprehensive description of the dangerous environment that develops when CC and IoT are combined in a Smart Grid. The confluence of the Smart Grids, CC, and IoT concepts is centered on meeting client demands, increasing efficiency, and retaining total control. However, integrating various technologies under a single architecture creates a slew of new interdependencies, posing new difficulties ranging from overall power system stability to unique cybersecurity threats.

Proposed field of smart grid safety with sensor and communication techniques integrated into power systems were highlighted, along with a variety of security and vulnerability issues that the IoT-based grid is vulnerable. Only a few articles focus on neutralizing computer security, whereas the majority of studies focus on detecting and preventing cyber-threats. As a result, future advances in this field of research are expected to focus on cyber-threat mitigation with various robust machine learning techniques for effective cyber-threat identification. The security domain of the smart grid is discussed in this paper.

Qadir [37] categorized a machine learning model that might be effective and beneficial in predicting energy and electricity. Data from the past is handled both with and without data modification. Data modifications are done via cross-validation and recursive feature elimination using cross-validation (RFECV). Artificial neural network regressors are used to train the data, and correlations between different characteristics within the database are discovered. The proposed computational approach offers a lot of promise for improving the efficiency of smart grids. The model has a mean square error of 0.0000001041, an R-squared of 99.60%, and a calculation time of 0.02 s. This research work focuses on the management and service domain of the smart grid. It does not provide any accuracy on the security threats by the use of big data.

Babar et al. [38] presented safe demand-side management (DSM) engine for the Internet of Things-enabled grid utilizing machine learning. The suggested DSM engine is in charge of maintaining efficient energy consumption depending on priorities. To administer IoT-enabled HAN, an Interface Control Agent is suggested. An AEME is also proposed for effective energy use in smart grids. The results of the research show that the proposed DSM engine is less sensitive to attack and good enough even to minimize the smart grid's power consumption. The result shows that with the implementation, the power consumption decreases to 6000 W from 8000 W in a given simulation time. This research work focuses on the management and service domain of the smart grid. It does not provide any accuracy in the security domain.

Razavi [39] proposed the threat detection technique using five different algorithms using the data of 4000 households and six different cybersecurity attacked cases were created and the model is checked. The clustering method found five household groups using half-hourly power usage data from over 4000 households over 18 months. Out of the five algorithms used, the Gradient Boosting Machine algorithm outperformed all the others. This research work focuses on the security domain of the smart grid.

Gumaei et al. [40] presented an accurate prediction technique for smart grids, which increases accuracy and lowers computational burden, combining the CFS technique with the KNN algorithm to identify assaults on a SCADA power system The CFS technique reduces the number of characteristics required in classification, improving detection accuracy while reducing detection time. The KNN method helps increase prediction performance by tackling the issue of overlapping between SCADA electric grid features. The efficacy and efficiency of the suggested technique were assessed using 15 public datasets from a SCADA power system. 17 of the 128 smart-grid network characteristics are used in the proposed study to obtain the greatest detection rate. Other controlled techniques, such as deep learning algorithms, will be used in the future to manage vast volumes of smart grid data of various sizes.

Liu [41] presents the CNN model for the smart grids for forecasting to predict the various energy domain characteristics. Edge sensing data in the electrical system grids provide a lot of information that encourages the development of new power management applications in IoT-driven smart cities and societies. In smart cities and society, DIC is being proposed to enhance forecasting accuracy. The suggested DIC method improves training speed by 61.7 percent, decreases RMS error by at least 32.9%, and increases prediction accuracy by 1.4% when compared to support vector machines (SVM), and CNN, LST memory, according to observed measurements (Table 1).

7 Discussions and Challenges

The energy requirement is a key research area while implementing smart cities during the last decades. Information and Communications Technology (ICT) is considered

Table 1 Different approaches for MI/IoTs in smart grids

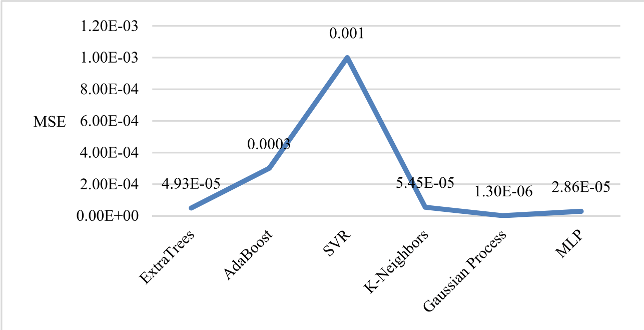
References	Year	Approach	Security domain	Bulk domain	Energy management	Description
Barbierato et al. [25]	2019	LiPSG machine learning algorithm	Yes	Yes	No	Provide cyber-threat, does not provide accuracy correction
Wang et al. [26]	2021	SACD algorithm, smart meter	Yes	No	Yes	Billing and enhanced security
Abu Adnan Abir et al. [27]	2021	Edge device-based real-time algorithm, CNN	Yes	Yes	Yes	Observed reduced MSE of 0.15 and RMSE of 3.77
Han et al. [28]	2017	Smart meter, different algorithm used	No	Yes	Yes	Random forest outperformed with greatest accuracy of 96.69%
Siryani et al. [29]	2019	Big data analysis, smart meters with IoTs (different layers)	Yes	Yes	Yes	Big data analysis is studied, Disadvantages are clustering and Cloud sourcing
Hossain et al. [30]	2020	DMDA machine learning algorithm	Yes	Yes	Yes	More focused on energy and customer domain not on security domain
Song et al. [31]	2017	ARIMA algorithm of IoTs	No	Yes	Yes	Handling big/large data is the only disadvantage, many data and control base method are used
Mortaji et al. [32]	2017	Internet of Things	Yes	Yes	Yes	More quick and auto-recovery methods required
Chin et al. [33]	2018	LPWAN+IoT	No	No	Yes	Extended range, highly reliable and suitable data rate, disadvantage is this is Latency-insensitive
Liet al. [34]	2019	Smart metres, CNN	Yes	Yes	Yes	Accuracy of 96.67% attained with CNN

to be the most promising technique for SEM in smart cities. In this section, some of the major contributions of AI/IoT and their performance are analyzed to prove their effectiveness. In [37], the energy and power output was predicted based on changing weather conditions using renewable resources in smart grid applications. For prediction, an Artificial Neural Network (ANN) was used for the prediction of energy output. The prediction was done based on weather data. Figure 8a represents the efficiency of different ML techniques for the accurate prediction of power output. In [42], the author worked on the topology of the smart grid using renewable energy (RE) sources for efficient energy savings and the use of cleaner energy. The topology was based on cellular networks to increase or decrease their grid consumption. Energy management policies are designed using the Markov chain. The weather pattern was also focused on smart control design to evaluate the performance of the system and to minimize the energy operational cost. Figure 8b represents the performance evaluation concerning renewable energy utilization. The figure shows with the integration of AI, the energy cost is reduced. In [43], the author presented a survey on AI applications for smart energy management by load forecasting. The smart grid scenario was implemented and deployed using a deep learning application. In [44], the author presented an ANN-based control and management of smart grid for improvement in power efficiency. Figure 8c represents the efficiency analysis of different ML techniques and shows that ANN is more efficient as compared to other algorithms.

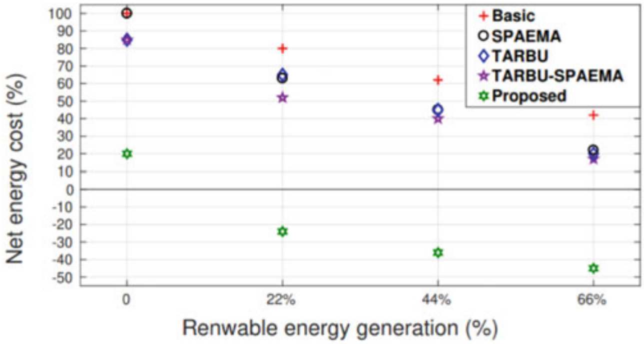
The chapter concludes that the existing works combine technical, control, and management approaches to achieve the sustainable green and sustainable energy management system. But still, there are many research scopes that need to be focused on in the future. From the study, some future research scopes are identified that are shown in Fig. 9. Real-time deployment in smart cities and its monitoring are performed using smart electrical equipment, AI-integrated sensors, and ML controls. Therefore, there is scope for optimization of the overall objectives at an affordable cost and need to be sustainable.

8 Conclusion

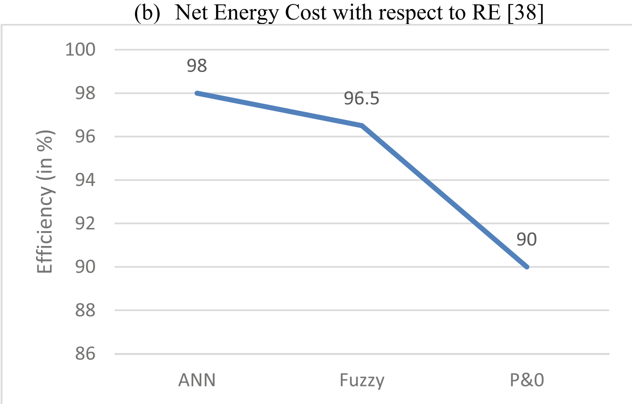
Renewable energy services powered by AI/IoT have a big environmental impact and are cost-efficient. A qualitative method for employing artificial intelligence (AI) as a disruptive technology to support and encourage the establishment of a new region of smart energy infrastructure as a service in the renewable energy industry is successful. In a changing climate and market context, AI will improve in the management of energy production and consumption. Among the most significant issues in this industry is the unpredictability of renewable energy sources, which is becoming increasingly important as the proportion of renewable energy in overall energy output rises. For minimizing the risk of the unpredictability of RE sources, AI will become the approach that really should be implemented at the economical level.



(a) MSE Analysisusing ML Techniques [33]



(b) Net Energy Cost with respect to RE [38]



(c) Efficiency Analysis using ML Techniques[40]

Fig. 8 Result analysis of ML techniques

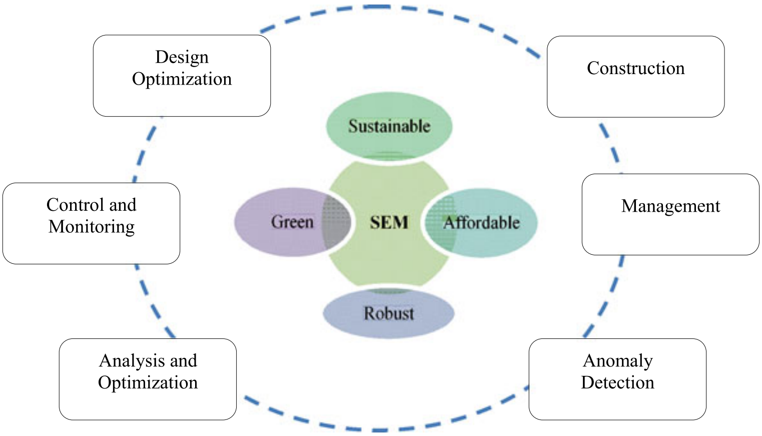


Fig. 9 Future research direction in SEM

References

1. Masera M, Bompard EF, Profumo F, Hadjsaid N (2018) Smart (electricity) grids for smart cities: assessing roles and societal impacts. Proc IEEE 106(4):613–625. https://doi.org/10.1109/JPROC.2018.2812212
2. Morello R, Mukhopadhyay SC, Liu Z, Slomovitz D, Samantaray SR (2017) Advances on sensing technologies for smart cities and power grids: a review. IEEE Sensors J 17(23):7596–7610. https://doi.org/10.1109/JSEN.2017.2735539
3. Chen X (2019) The development trend and practical innovation of smart cities under the integration of new technologies. Front Eng Manage 6:485–502. https://doi.org/10.1007/s42524-019-0057-9
4. Javadzadeh G, Rahmani AM (2020) Fog computing applications in smart cities: a systematic survey. Wirel Netw 26:1433–1457. https://doi.org/10.1007/s11276-019-02208-y
5. Cimmino A, Pecorella T, Fantacci R, Granelli F, Rahman T, Sacchi C et al (2013) The role of small cell technology in future smart city. Trans Emerg Telecommun Technol 25:11–20
6. Rajawat AS et al (2021) Fusion protocol for improving coverage and connectivity WSNs. IET Wirel Sensor Syst 11(4):161–168. https://doi.org/10.1049/wss2.12018. Accessed 21 Aug 2021
7. Rajawat AS, Upadhyay AR (2020) Web personalization model using modified S3VM algorithm for developing recommendation process. In: 2nd International conference on data, engineering and applications (IDEA), Bhopal, India, 2020, pp 1–6. https://doi.org/10.1109/IDEA49133.2020.9170701
8. Rajawat AS, Rawat R, Barhanpurkar K, Shaw RN, Ghosh A (2021) Vulnerability analysis at industrial internet of things platform on dark web network using computational intelligence. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_4
9. Rajawat AS, Rawat R, Barhanpurkar K, Shaw RN, Ghosh A (2021) Blockchain-based model for expanding IoT device data security. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_5
10. Rajawat AS, Rawat R, Shaw RN, Ghosh A (2021) Cyber physical system fraud analysis by mobile robot. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics

applications. studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_4
11. Hao L, Lei X, Yan Z, Chun Li Y (2012) The application and implementation research of smart city in China. System Science and Engineering (ICSSE), Dalian, Liaoning, China
12. Jawhar I, Mohamed N, Al-Jaroodi J (2018) Networking architectures and protocols for smart city systems. J Internet Serv Appl 9:26. https://doi.org/10.1186/s13174-018-0097-0
13. Poulkov V (2021) The wireless access for future smart cities as a large scale complex cyber physical system. Wirel Pers Commun 118:1971–1985. https://doi.org/10.1007/s11277-019-06343-9
14. Klaina H et al (2020) Aggregator to electric vehicle LoRaWAN based communication analysis in vehicle-to-grid systems in smart cities. IEEE Access 8:124688–124701. https://doi.org/10.1109/ACCESS.2020.3007597
15. Li G, Jin Y, Akram MW, Chen X, Ji J (2018) Application of bio-inspired algorithms in maximum power point tracking for PV systems under partial shading conditions—a review. Renew Sustain Energy Rev 81:840–873
16. Sobri S, Koohi-Kamali S, Abd Rahim N (2018) Solar photovoltaic generation forecasting methods: a review. Energy Convers Manage 156:459–497
17. McGovern A, Elmore K, Gagne DJ, Haupt SE, Karstens CD, Lagerquist R, Smith T, Williams J (2017) Using artificial intelligence to improve real-time decision-making for high-impact weather. Bull Am Meteor Soc 98(10):2073–2090
18. Jha SK, Bilalovic J, Jha A, Patel N, Zhang H (2017) Renewable energy: Present research and future scope of Artificial Intelligence. Renew Sustain Energy Rev 77:297–317
19. Voyant C, Notton G, Kalogirou S, Nivet ML, Paoli C, Motte F, Fouilloy A (2017) Machine learning methods for solar radiation forecasting: A review. Renew Energy 105:569–582
20. Das UK, Tey KS, Seyedmahmoudian M, Mekhilef S, Idris MY, Van Deventer W, Horan B, Stojcevski A (2018) Forecasting of photovoltaic power generation and model optimization: a review. Renew Sustain Energy Rev 81:912–928, Part 1
21. Ssekulima EB, Anwar MB, Al Hinai A, El Moursi MS (2016) Wind speed and solar irradiance forecasting techniques for enhanced renewable energy integration with the grid: a review. IET Renew Power Gener 10(7):885–898
22. Chaouachi A, Kamel RM, Andoulsi R, Nagasaka K (2016) Multiobjective intelligent energy management for a microgrid. IEEE Trans Industr Electron 60(4):1688–1699
23. Dawoud SM, Lin X, Okba M (2018) Hybrid renewable microgrid optimization techniques: a review. Renew Sustain Energy Rev 82:2039–2052
24. Barbierato L, Estebsari A, Bottaccioli L, Macii E, Patti E (2020) A distributed multimodel cosimulation platform to assess general purpose services in smart grids. IEEE Trans Ind Appl 56(5):5613–5624. https://doi.org/10.1109/TIA.2020.3010481
25. Wang Z et al (2019) LiPSG: lightweight privacy-preserving Q-learning based energy management for the IoT-enable smart grid. IEEE IoT J 2327–4662. https://doi.org/10.1109/JIOT.2020.2968631
26. Abu Adnan Abir SM et al (2021) IoT-enabled smart energy grid: applications and challenges. Digital Object Identifier. https://doi.org/10.1109/ACCESS.2021.3067331
27. Han T et al (2021) An efficient deep learning framework for intelligent energy management in IoT networks. IEEE IoT J 8(5):3170
28. Tanju SB, Eveleigh TJ (2017) A machine learning decision-support system improves the internet of things' smart meter operations. IEEE IoT J 4(4):1056–1066. https://doi.org/10.1109/JIOT.2017.2722358
29. E. Hossain et al.: "Application of Big Data and Machine Learning in SG, and Associated Security Concerns", https://doi.org/10.1109/ACCESS.2019.2894819, 13962 VOLUME 7, 2019
30. Song J et al (2020) A dynamic membership data aggregation (DMDA) protocol for smart grid. IEEE Syst J 14(1)
31. Mortaji H, Ow SH et al (2017) Load shedding and smart-direct load control using internet of things in smart grid demand response management. IEEE 0093–9994 (c). https://doi.org/10.1109/TIA.2017.2740832

32. Chin W, Li W, Chen H (Oct. 2017) Energy big data security threats in IoT-based smart grid communications. IEEE Commun Mag 55(10):70–75. https://doi.org/10.1109/MCOM.2017.1700154
33. Li Y, Cheng X, Cao Y, Wang D, Yang L (2018) Smart choice for the smart grid: narrowband internet of things (NB-IoT). IEEE IoT J 5(3):1505–1515. https://doi.org/10.1109/JIOT.2017.2781251
34. Yao D et al (2019) Energy theft detection with energy privacy preservation in the smart grid. IEEE IoT J 6(5)
35. Mavroeidakos T, Chaldeakis V (2020) Threat landscape of next generation IoT-enabled smart grids. In: Maglogiannis I, Iliadis L, Pimenidis E (eds) Artificial intelligence applications and innovations. In: AIAI 2020 IFIP WG 12.5 international workshops. AIAI 2020. IFIP Advances in information and communication technology, vol 585. Springer, Cham. https://doi.org/10.1007/978-3-030-49190-1_11
36. Sakhnini J, Karimipour H, Dehghantanha A, Parizi RM, Srivastava G (2019) Security aspects of internet of things aided smart grids: a bibliometric survey. Internet of Things. https://doi.org/10.1016/j.iot.2019.100111
37. Qadir Z, Khan SI, Khalaji E, Munawar HS, Al-Turjman F, Parvez Mahmud MA, Kouzani AZ, Le K (2021) Predicting the energy output of hybrid PV–wind renewable energy system using feature selection technique for smart grids. Energy Reports. ISSN 2352-4847,https://doi.org/10.1016/j.egyr.2021.01.018
38. Babar M, Tariq MU, Jan MA (2020) Secure and resilient demand side management engine using machine learning for IoT-enabled smart grid. Sustain Cities Soc. https://doi.org/10.1016/j.scs.2020.102370
39. Razavi R, Gharipour A, Fleury M, Akpan IJ (2019) A practical feature-engineering framework for electricity theft detection in smart grids. Appl Energy 238:481–494. ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2019.01.076. https://www.sciencedirect.com/science/article/pii/S0306261919300753
40. Gumaei B, Hassan MM, Huda S, Md. Rafiul Hassan, Camacho D, Ser JD, Fortino G (2019) A robust cyberattack detection approach using optimal features of SCADA power systems in smart grids. Appl Soft Comput 96:106658. ISSN 1568-4946. https://doi.org/10.1016/j.asoc.2020.106658. https://www.sciencedirect.com/science/article/pii/S1568494620305962
41. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Smart luminaires for commercial building by application of daylight harvesting systems. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_24
42. Banerjee A et al (2022) Construction of effective wireless sensor network for smart communication using modified ant colony optimization technique. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_22
43. Akhtaruzzaman M, Hasan MK, Kabir SR, Abdullah SNHS, Sadeq MJ, Hossain E (2020) HSIC bottleneck based distributed deep learning model for load forecasting in smart grid with a comprehensive survey. IEEE Access 8:222977–223008. https://doi.org/10.1109/ACCESS.2020.3040083
44. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Multi-objective fuzzy-swarm optimizer for data partitioning. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_25

Eye-Gaze Based Hands Free Access Control System for Smart City Public Interfaces

Debosmit Neogi, Nataraj Das, and Suman Deb

Abstract The working of Blink-Con, a framework for intelligent vision directed mobilization of onscreen mouse-cursor, without engaging any auxiliary assistance, is illustrated in this chapter. Blink-Con is framed keeping in mind the adverse effect of Covid-19 in our society, especially the smart cities of India. During this global pandemic, it is not at all advised to touch electronic gadgets at public places as infections spread through touch. Here, Blink-Con is believed to play a significant role in minimizing peoples' physical contact with public computers present in cyber cafes, malls, banks, etc. which are an inevitable part of a smart city. In this work the system explored are technically dominated in color spaces, precise ROI detection, closed loop sequential interaction and eventually a system gets constructed and attained where the GUI onscreen pointer (mouse cursor) gets directed by interpreting significant eye gaze and blink. The algorithm for eye blink detection from 2-D image feed been classified in two major steps for accomplishing a heuristic based region of interest (ROI) identification and tracking the ROI for rapid detection of volunteered blinks. The sequence of volunteered blinks is taken as trigger of robust mouse mobilization function input that results in highly optimized smooth mouse-travel, divulging an adaptable mouse control performance with only eye blink. The experimental results are favorable to the system viability for multi facet use of the algorithms and can be deployed effectively in various public places in a smart city.

Keywords Blink ratio · EBR · Eye gaze · Mouse control · Nictate rate · Voluntary eye blink

1 Introduction

The entire context of Human Computer Interaction revolves around the idea of how human beings interact with computer using input devices like mouse and keyboard. The abstract level functioning of computer mouse can be illustrated by sequence of two major phenomenon happening: state movement and state action. An abled

D. Neogi · N. Das · S. Deb (✉)
Department of Computer Science and Engineering, NIT Agartala, Agartala, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_9

person can control mouse movement precisely with periodic clicking and dragging of mouse with their hands. But for a person with disability, this task becomes next to impossible, leading to the context and development of the research work. But the spread of pandemic has unveiled another huge use case for Blink-Con, i.e., contact less computer operation in malls, cyber cafes, and banks widely present in smart cities across India.

In a smart city setting in India, Automatic Trailers Machines (ATM) are a very common sight. They are immensely beneficial as people can withdraw cash from their bank account easily at any time of the day, bypassing the hassles of the banks. ATMs usually have a monitor operated by touch, where users have to input their bank details, password, etc. But during this pandemic, doctors and experts have advised to avoid physical contact with any public device or installments as much as possible. Here. BlinkCon can very useful. BlinkCon can be installed as a software in ATMs that can basically convert it into touchless device, thus significantly reducing the spread of infections. In fact, Fig. 1 very well describes the motive behind the entire methodology described in the chapter. It also portrays a very clear picture of how BlinkCon can be an effective tool for Covid control in smart cities and proves its immense potential as a way for the future.

This is just one-use case of BlinkCon. In a typical smart city, a number of different Government and private owned facilities can be found. Smart cities and usually all significant cities in India have railway stations and bus stands. A majority of Indians do not have access to the internet. This means they physically go to railway or bus stations for ticket reservations. This entire process can be made contact free or touch free by using BlinkCon. This can in fact play a very important role in keeping a check at Covid cases surge in India, especially in the smart cities where majority of infections were reported.

In today's world computer and technology, in no doubt, is the way forward. So, it becomes very important to develop technology that inspires and helps people with disabilities to effectively use computers for their development.

The aim is to make a system that allows people to use computer without touch. This is achieved using voluntary eye blinks. There are instances from the past where people have effectively used eye blinks for expressing themselves to the rest of the world. For instance, [1] Jean-Dominique Bauby, a French journalist and author, suffered from severe stroke in his brain stem leading to his disability. He, despite being disable, was able to write an account of his life by selecting alphabets and numbers using his voluntary eye blinks. There are many advancements in this eld. Several systems of eye tracking have been framed and built over time that can detect alcoholism [2]. Reference [3] presented a study that brings for-ward the idea that eye tracking reveals subtle problems in understanding speech in children with dyslexia.

But eye tracking systems often come with an additional requirement of costly sensors and hardware. This is where the proposed work stands out. The algorithm proposed in this work uses precise ROI detection of eyes and extracting the regions that contribute toward Eye Blink Ratio (EBR) detection, which ultimately acts as controlling mechanism for mouse movement. This eliminates the use of sensors, hardware, etc. and make this methodology pocket friendly and easy to use for users.

Fig. 1 Process of prevention from Covid-19

Also the other primary focus was to make the system robust with maximum precision, as the significance of accuracy in real life applications has always been prioritized.

2 Literature Review

Several research works have been conducted in the past [4, 5] to analyses the viability and robustness of a vision based computerized control system. In the research done by [4], the main idea was developing a switch like device whose total control is in the hands of the user. The user uses either a bite command with the help of a precisely designed nipple or a hand command using artificially designed hand gloves. But the main agenda of this work is to eliminate the use of any external devices that can be used to replicate a keyboard or mouse. This system solely uses the power of voluntary eye blink of a person. Several studies have been executed to evaluate the impact of vision-based control system on lives of patients with disabilities of different severity such as Spinal Muscular Atrophy (SMA) [6] or severe nervous system disease like lateral amyotrophic sclerosis [7] also known as Lou Gehrig's disease.

Eye blink has found some great uses in solving behavioral problems like attention level estimation [8] and in solving problems like deep fake video detection [9]. Several algorithms and methodologies have been used for eye gaze detection. In chapter [10] Electrooculography (EOG) technique has been used by the researchers for moving the mouse cursor through eye retina. The signal captured from the eyes is amplified using electrodes, which in turn is used for controlling mouse movement.

Computation of nictate rate involves blink detection [11]. This involves calculating the distance between the specified landmarks of eye and taking out ratio of the horizontal eye length to vertical eye length. The lengths are determined by the distance formula of coordinate geometry. But their methodologies require sophisticated equipment which is not true for Blink-con. Concepts of mathematics like Coordinate geometry [12, 13] have always helped in graphical analysis of the physical world. Methods like the distance computing equations, dividing the net distance between two points on the basis of some mentioned ratio, have all contributed toward its wide viable usage [14–17]. The slope of a line also helps to deter-mine the rate of increment or decrement. Such steepness allows one to evaluate the amount of any kind of error for such drastic large changes.

3 Proposed Algorithm

3.1 Synopsis of the Working Methodology

People who are especially abled, deprived of moving their body parts unlike nor-mal humans, it is nearly impossible for them to interact with machines like computers. People suffering from paralyzing diseases like motor neuron attack or any kind of brain strokes are left with muscle immobility. However, it has been observed that in maximum cases there is a high probability of not losing control over the optical muscles. This fact has been taken as the lead in order to give rise to the idea of the total framework. Figure 2 describes each step of how such deprived human beings can take control over computer using the proposed framework, Blink-con. All the steps are performed precisely with various modules of python. Thanks to the concepts of machine learning that made possible for detecting and separating the ROI with least possible errors. The classification model, Support vector machine (SVM) has been deployed in order to classify the landmark points that is necessary to draw the outline of normal human face. The support vectors are chosen such that there is a maximum marginal distance across the central hyper plane. The regularization parameter and error handling parameters (gamma and C) are chosen such that the model has low bias and low variance. The kernel trick of SVM allowed to increase the dimensions

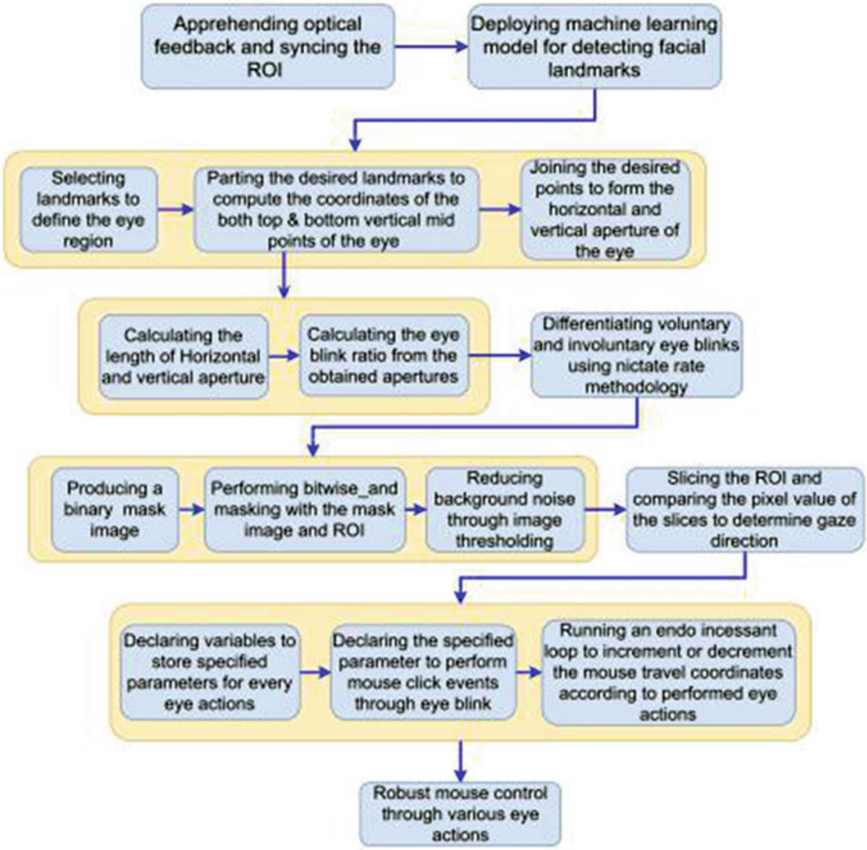


Fig. 2 Overview of the proposed algorithm

of the features so that a clear hyper plane can easily classify all the data points. In order to optimize the values of C, gamma and kernel, methods of hyper parameter tuning have been deployed.

3.2 Apprehending Camera Frame and Syncing Region of Interest (ROI)

The primary image source feed in this work is a consumer grade web camera. This challenging approach also deliberately adapted to eliminate the need for any special hardware or sensors [18] for high speed blink detection. The proposed application requires user to have a computer with a working webcam. Blink-con apprehends and processes real time video input of the user, taken from the webcam, using open

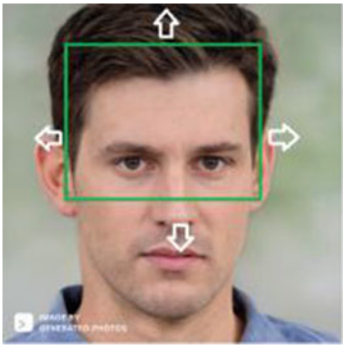


Fig. 3 Sliding window approach on AI generated image (Image retrieved from https://generated.photos/faces)

CV. Commonly used are "get-frontal-face-detector" function which is a pre-built Histogram of Oriented Gradients (HOG) [19] based function in dlib designed for optimized face detection. Object detection using HOG method is a fairly advanced process with high robustness. The HOG method encompasses an algorithm which basically creates a sample of positive and negative data points from the object. Positive sample refers to the data points that contains the object to be detected. Next step is to apply the Sliding window technique which slides the window across the image (as in Fig. 2) and collects the HOG descriptors. Next step is to then train a Support Vector Machine (SVM) classifier using the data points and do subsequent analysis and computations essential for face detection.

3.3 Facial Landmark Detection and Reference Points

The dlib library has a pre-trained facial landmark detector which returns 68 locations, in the form of X and Y coordinates, which represents the whole face combined.[1] From all the 68 landmarks those landmarks were separated which represents the eyes and store them in a python list (Fig. 3).

Left eye landmark points = (36, 37, 38, 39, 40, 41)

Right eye landmark points = (42, 43, 44, 45, 46, 47)

This step is crucial as it helps to get exact locations and coordinates of the eyes from the face and work on them separately (Fig. 4).

[1] Original work done by Davies King. https://github.com/davisking/dlib-models.

Fig. 4 Facial landmarks (Image retrieved from: https://github.com/es6rc/FaceMaskFilter)

3.4 Eye Blink Ratio

Calculating Eye Blink Ratio (EBR) is perhaps the most important step in the entire process of eye gaze detection. For the sake of simplicity, one eye at a time is considered and all the algorithms applied to one eye is valid for the other eye too [20]. It is known that each eye can be expressed in the form of a collection of 6 landmarks that have been stored in a python list. These locations as a whole describe the spatial orientation of human eye. These locations can be used to calculate Eye blink ratio [21].

The distances are calculated using Euclidean distance method using the co-ordinates of the desired eye landmarks. In order to end the vertical aperture what is needed is the mid eye coordinates as depicted in Fig. 5 that has been obtained using the following mathematical equations.

$$X_{i,k} = \frac{1}{2} * \left[[x_i, x_k] * \begin{bmatrix} 37 & 40 \\ 38 & 41 \end{bmatrix} \right] \quad (1)$$

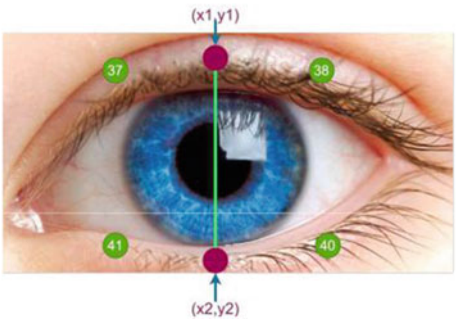


Fig. 5 Evaluating coordinates for calculating EBR (https://www.diabetes.co.uk)

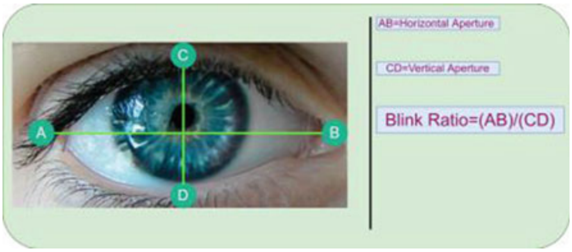


Fig. 6 Nictate ratio (https://www.visioneyeinstitute.com.au)

$$Y_{i,k} = \frac{1}{2} * \left[[y_i, y_k] * \begin{bmatrix} 37 & 40 \\ 38 & 41 \end{bmatrix} \right] \tag{2}$$

Thus after computing the values of desired landmarks, nal computation of Eye blink ratio gets executed (Fig. 6).

$$\text{EBR} = \text{Horizontal aperture/Vertical aperture} \tag{3}$$

The reason behind why the eye blink ratio (EBR) is chosen as the ratio of the horizontal aperture to vertical aperture because this will create a parameter whose value will be always greater than 1 and this will provide a parameter for easy comparison.

$$\text{EBR} >= 1 \tag{4}$$

However, if EBR is considered as the ratio of the vertical aperture to horizontal aperture, then EBR 1 and this would give an insignificant value for comparison.

For the purpose of generalization, the average values of horizontal and vertical distances were put in use for calculating eye blink ratio.

3.5 Nictate Rate Methodology: Differentiating Voluntary and Involuntary Eye Blink

Traditional eye blinks of a natural person are involuntary ones i.e. these blinzelns are unintentional [22]. In order to distinguish intentional blinzelns from the unintentional ones, the graphical structure of a normal human nictate rate is used [23] (Fig. 7).

From the graph it can be inferred that the nictate rates are quite non-uniform, i.e. the involuntary blinks did not follow a de nite pattern. Unlike involuntary ones, intentional blinzeln will have a de nite pattern and will be constant ac-cording to the will of the blinzeln owner. Throughout this work the blink rate has been kept at a threshold value of 2 blinks per 3 s i.e. nictate rate = 2/3 per second, which is achieved through hyper parameter tuning.

$$\text{Nictate rate} = (\text{No. of blinzeln}) = \text{Time interval} \tag{5}$$

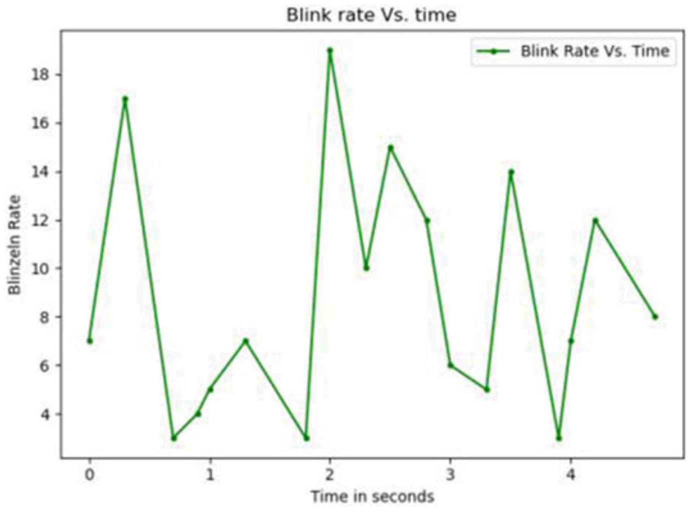


Fig. 7 Average nictate rate of a normal human eye

This blinzeln ratio served the purpose of mouse-click events. From the above graph (Fig. 8) it can be seen that in this case the nictate rate was 0.66 (intentional one) and this rate was used to trigger the mouse-click events. The constant linear graph of the blinzeln rate suggests that one has to maintain this linearity in order to perform the click operation. Thus, this linearity differentiates between the voluntary and involuntary eye blink.

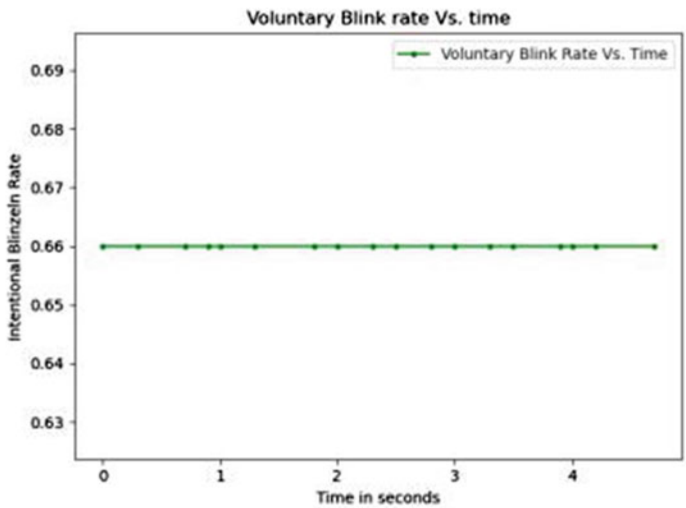


Fig. 8 Voluntary eye blinzeln rate

3.6 Faithful Gaze Detection Algorithm

Through landmark parting, it was identified the around-eye co-ordinates and a mask image for bitwise masking has been prepared as in Fig. 9. To perform bitwise masking, a 2-D image with BGR value (0, 0, 0) has been prepared so that a full dark image can be obtained. According to the eye landmarks, the co-ordinates were labeled and joined in the mask image created. Once the mask image gets constructed it is time for bitwise-AND operation. The bitwise-AND operation with the desired image from webcam and the created mask image was executed.

The result obtained is discussed as an eye with solid binary effect without extra noise. After execution of bitwise-and operation, only the eye region from the resulting image is extracted. In order to re new more and to reduce any sort of binary noise, image-thresholding comes into picture.

$$\text{th} = 170; \tag{6}$$

where th is the threshold value as set to serve the experimental requirement (average case) that was found out by hyper parameter tuning [20]. However, threshold value tends to fluctuate according to varying places and varying cornea color. Thus, we have the following operations:

$$A_{mask} = Argfill_i\left[\sum_{i=1}^{n}(x_i, y_i - x_{i+1}, y_{i+1})\right] \tag{7}$$

$$A_{initial} = Bitmask_{and}\left[A_{mask} \wedge A_{eye}\right] \tag{8}$$

$$A_{final} = Argthresh_{th}[A_{initial}] \tag{9}$$

Figure 9 depicts the visual of the entire process that has been carried out by the above equations in order to track the real time configuration of the user's eye. The final area has also been cropped out from the rest of the image for better understanding of the eye movements.

After reducing all sort of image noise along with binary noise through thresholding, each eye image was dissected into two parts: right half and left half. This is done so for the identification and calculation of zero (black) and non-zero (white) pixels.

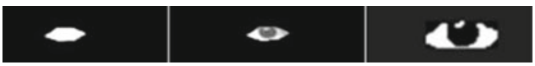


Fig. 9 **a** Mask image. **b** Bit-wise-masking image. **c** Threshold image

$$\text{nonzeropixel} = \text{cv2} : \text{countNonZero}() \tag{9}$$

Comparison of nonzero pixels as obtained in the left and right part gives the gaze detection ratio.

$$\text{C} : \text{R} := \text{left}_{\text{pixel}}\text{Value}/\text{right}_{\text{pixel}}\text{Value} \tag{10}$$

where CR is the comparison ratio whose value after comparing with a particular threshold value that has been set through hyper parameter tuning, arrests the gaze direction. However, the threshold value will differ from person to person, as the ratio of sclera region to corneal region will differ from person to person. So, the threshold value has to be provided every time for different volunteers in order to obtain accurate and precise results.

3.7 Deploying Gaze Detection Framework Toward Mouse-Cursor Automation

The next leap deploys the above gaze-detection framework toward complete automation and mobilization of mouse cursor [24, 25]. Under this case, first of all some foreign commodity python units were involved: keyboard, sys, pyautogui, readchar. Declaration of co-ordinates of the midpoint of the total available pixels has been made. In this case, the screen resolution was 1920 × 1080, so the mid-point came out to be x = 960 and y = 540. The next step was to move the mouse cursor to the desired midpoints and for that purpose pyautogui.moveTo(x, y, duration =) served the desired purpose. The duration is selected as per individual requirement. In this case a duration of 3 s (pyautogui.moveTo(x = 960, y = 540, duration = 3)) served the purpose. Here the duration is measured in seconds. Now a variable was proclaimed that will store the feedback from the gaze-blink detection framework. Subsequently three infinite nested while loop architectures have also been deployed.

Peri incessant architecture: The first infinite loop has been declared to enter the mouse mobilization process. Here readchar module was deployed so that one can set foot in the system just by pressing any key rather than storing the key value in the buffer memory. Since there is no storing of anything in the keyboard buffer memory, it was mandatory to keep it clear and to serve that purpose, the ush stdin from python-sys module was used. Finally the second infinite while loop is nested inside the infinite loop. The loop never ends so that an individual can use the framework as long as he or she wants.

Central incessant architecture: This loop section is where mouse click events are performed, according to the feedback received from the gaze-detection framework, after one breaks out from the third loop. Here also the ush stdin gets deployed so that the buffer remains clear.The feedback used here is the blink rate, for mouse double click operation.

Endo incessant architecture: The third loop is where x and y are incremented and decremented, according to the feedback received from the gaze and blink detection methodology.

The knowledge of working and functioning of mouse is an imperative pre-requisite for establishing a robust and precise framework. The most important technicality concerning the working of mouse is its movement across the computer screen through time. When a person performs an operation with mouse, the cursor moves in a continual path with a sequential differential increment. The speed of cursor travel is a subordinate of the resolution of the monitor The main function of the loop is to make mouse traveling smooth and robust by continuous increments and decrements in the values of x and y co-ordinates respectively. It has been known that a mouse travels pixel by pixel in order to reach the desired ROI. Thus the following trajectory gets deployed.

$$X' = X + - dx \tag{11}$$

$$Y = Y + -dx \tag{12}$$

Below table displays the increments and decrements process:

Direction	Increment/decrement
Down	$y = y - 10$
Up	$y = y + 10$
Right	$x = x - 10$
Left	$x = x + 10$
Double blink	Loop break

In this case (dx/dy) = 10 units served the purpose best that has been achieved through hyper parameter tuning. After the loop breaks, control shifts to the central incessant loop that witnesses the event of click operation (Fig. 10).

4 Viable Result Analysis

Blink-Con has been put through a different stage of testing and evaluation. Blink-con works extremely well when compared to other recent works. In [26], authors used an infrared vision system to track eye blinks and make a HCI device controlled by eye movements. Further, they have used 8-bit micro-controllers and created a full edged hardware dependent system. Blink-con works perfectly well, when tested with users from different age groups and sex, and the methodology has been successfully implemented without needing any external sophisticated hardware. A critical analysis of the entire framework has been executed through various performance metrics in

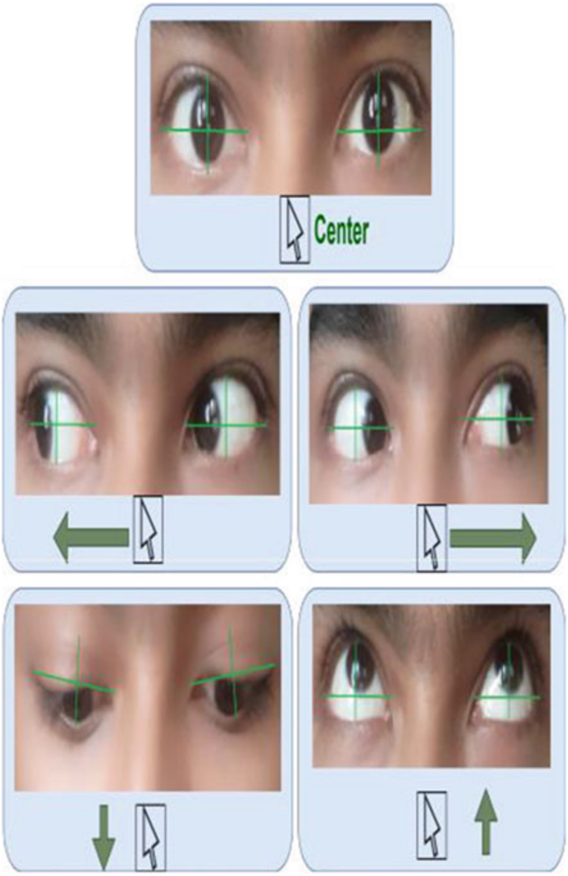


Fig. 10 Mouse automation through eye movements

order to determine the robustness, precision, and accuracy, thus contributing toward the optimization of the stated architecture to the next level.

4.1 Experimental Results with and Without Eye Glasses

In the experiment, it has been taken into consideration, various scenarios where the entire framework can potentially fail. One such scenario is where the user wears eye glasses. This has proven to be a bottle neck in many models involving Human Computer Interaction.

In this research it has been experimented with a user with eyeglasses on bearing lenses with power −3.5 dioptres. As shown in Fig. 11 this framework performs equally well with glasses and no glasses. The framework successfully determines

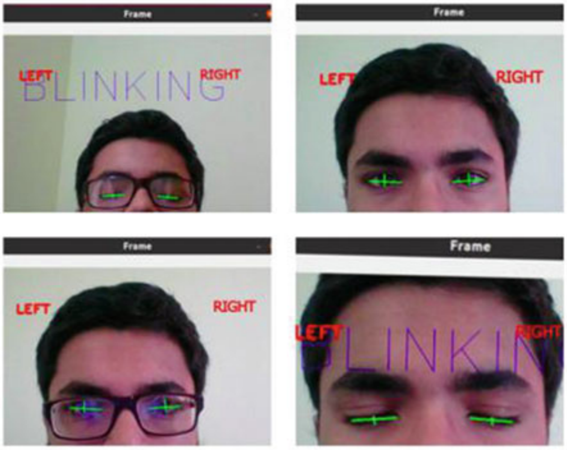


Fig. 11 Eye blink detection with glasses and no glasses

the vertical and horizontal apertures of the eye and draws line along it, which further calculates EBR and further processing is carried on.

4.2 Establishment of Gender and Age Invariance

Throughout the chapter it was extensively attempted to establish a gender in-variant framework. As discussed in 3.4 the structure of eyes changes with age and gender. It was experimented with both genders and tabulated all the findings:

Age	Gender	EBR at state 1	EBR at state 0
51	Male	0.37	0.26
50	Female	0.34	0.24
20	Male	0.36	0.26
17	Male	0.33	0.24
40	Female	0.33	0.26

Here, two states, State 0 and 1 have been declared. State 0 refers to the mo-ment before the framework detects an eye blink. Ideally the EBR value should approach 0 but still, a dip in the value can be seen. State 1 refers to the state when a person's eyes are open to the maximum. Here, the EBR value was expected to be maximum and similar trends were observed. These prove that the stated framework works perfectly and detects blink correctly irrespective of age and gender. More precise values can be obtained by using more high-resolution camera.

4.3 Operation Execution Period

A close observation on the time required by Blink-Con to execute each process has been recorded. Bar charts and line graph are chosen as the metrics in order to produce a clear visual of the performance of the stated framework. Figure 12 depicts a clear visual of the nitty-gritty of the frameworks precision and performance.

While doing hands on the framework's accuracy, the average response time for each mouse operation came to be equal to 571.42 ms (excluding blink operations). In Fig. 12 it can be noticed that there is a significant increase during mouse click events that has been achieved through blinking. The red line curve depicts at what increment rate the blink operation periods go up unlike other operations. Besides the click event, other mouse operations required more or less the same amount of time to get executed. The black line curve represents the average of all the mouse events except click events. Thus, it can be concluded that the robustness, precision,

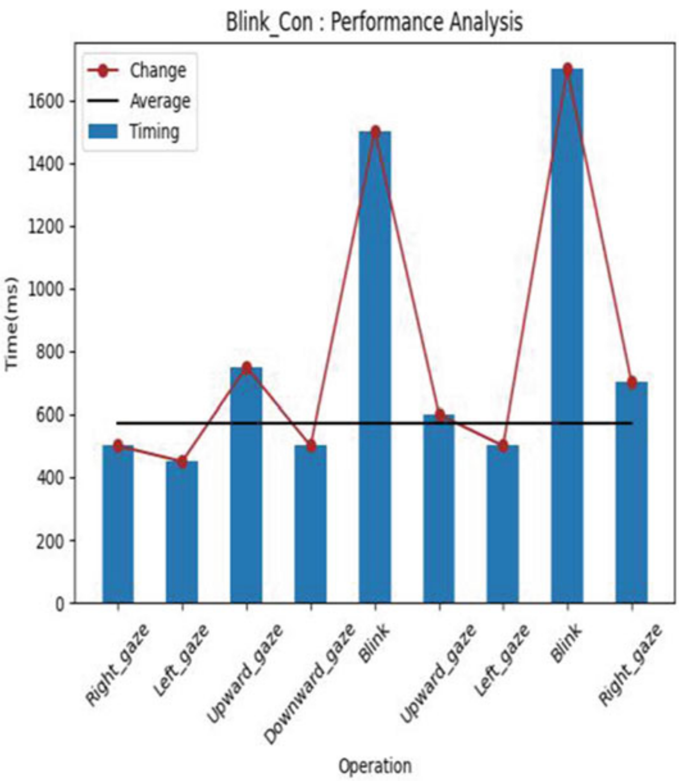


Fig. 12 Operation execution period

and overall performance of the stated architecture gets a bit deprived during blink-mouse click events, otherwise all other operations get executed with high precision and robustness, contributing toward better performance of the stated architecture.

5 Conclusion, Further Experimentation, and Carving Future Path

In line with the objective of the presented work, the solution for robust eye blink detection has successfully been achieved. The framework can be deployed in large scale distributed systems present in the smart cities, with little to no mod-i cations. One of the pre-requisites, the nictate rate as mentioned in Sect. 3.5 served a significant purpose to the eye gaze detection algorithm. This eye gaze system works on visual landmarks and cross referencing the identified landmarks with ROI the algorithms minimize the area for computation making the system responsive within 400 ms.

The following work is believed to open a gateway for multi directional mobilization of mouse that will include the diagonal pathway. This can be procured by altering each of two, X and Y co-ordinates at a time, such that the mouse cursor can budge along the diagonal of the display. Discrete direction of the mouse cursor that will also play a paramount factor in the co-ordinate altering operation. Overall, the entire framework can be effectively deployed in a real-life scenario especially in smart cities of India. The framework is believed to be able to promote contactless services in various public sectors, especially in smart cities of India.

Another point to flick through is the kernel level processing and program processing priority. The complication that was faced was that, in kernel level processing when the priority of the pop-up-mobilization-window changes, further execution of the program gets terminated. This phenomenon abruptly restricts the mobilization factor. So, kernel level processing and window priority tend to turn out to be a paramount factor, which paves the gateway for further research and innovation. Also, the drastic increase of response time while performing click events through blinking, can be solved using higher end benchmarks for the system into which the framework gets executed. Overall, it can be stated that BlinkCon well and truly has the potential to change the perspective of how various sectors provide their services and should be incorporated in future urban planning for holistic development of the present and future smart cities of India.

References

1. Bauby J-D (1997) The diving bell and the butter y. Knopf, New York
2. Masson N, Bollen Z, Hondt F, Maurage P (2020) Eye tracking correlates of acute alcohol consumption: a systematic and critical review. Neurosci Biobehav Rev 108:400–422

3. Gallant J, Robertson E (2019) Eye tracking reveals subtle spoken sentence comprehension problems in children with dyslexia. Appl Psycholinguist 228:102–105
4. Deb S, Deb S (2007) Single key omni directional pointing and command system (skops)—a smart on screen navigational tool for physically disabled persons. In: 2007 9th International conference on e-health networking, application and services, pp 197–201
5. Deb S, Deb S (2012) Designing an intelligent blink analyzer tool for effective human computer interaction through eye. In: 2012 4th International Conference on Intelligent Human Computer Interaction (IHCI), pp 1–5
6. Nance J (2020) Spinal muscular atrophy. Continuum (Minneapolis, Minn.), 26:1348–1368
7. Myers GA, Sherman KR, Stark L (1991) Eye monitor. IEEE Comput Mag 14–21
8. Tolosana JFR, Daza R, Morales A (2020) Mebal: a multimodal database for eye blink detection and attention level estimation
9. Li Y, Chang M-C, LyuInIctu S (2018) Oculi: exposing AI generated fake face videos by detecting eye blinking. abs/1806.02877
10. Jaramillo-Gonzalez A, Wu, Shizhe, Tonin A, Rana A, Khalili-Ardali M, Birbaumer N, Chaudhary U (2021) A dataset of eeg and eog from an auditory eog-based communication system for patients in locked-in state. Sci Data 8:01
11. Attiah A, Khairullah E (2021) Eye-blink detection system for virtual key-board, pp 1–6
12. Miolane N, Guigui N, Le Brigant A, Mathe J, Hou B, Thanwerdas Y, Heyder S, Peltre O, Koep N, Zaatiti H, Hajri H, Cabanes Y, Gerald T, Chauchat P, Shewmake C, Brooks D, Kainz B, Donnat C, Holmes S, Pennec X (2020) Geomstats: a python package for riemannian geometry in machine learning
13. Asher J, Dang K, Masters M (2020) A di erential geometry-based machine learning algorithm for the brain age problem. J Purdue Undergrad Res 10:08
14. Palimkar P, Bajaj V, Mal AK, Shaw RN, Ghosh A (2022) Unique action identifier by using magnetometer, accelerometer and gyroscope: KNN approach. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_48
15. Das S, Das I, Shaw RN, Ghosh A (2021) Advance machine learning and artificial intelligence applications in service robot. Artif Intell Fut Gener Robot 83–91. https://doi.org/10.1016/B978-0-323-85498-6.00002-2
16. Mandal S, Biswas S, Balas VE, Shaw RN, Ghosh A (2021) Lyft 3D object detection for autonomous vehicles. Artif Intell Fut Gener Robot 119–136. https://doi.org/10.1016/B978-0-323-85498-6.00003-4
17. Mandal S, Md Basharat Mones SK, Das A, Balas VE, Shaw RN, Ghosh A (2021) Single shot detection for detecting real-time flying objects for unmanned aerial vehicle. Artif Intell Fut Gener Robot 37–53. https://doi.org/10.1016/B978-0-323-85498-6.00005-8
18. Wu Z, Pan G, Sun L, Lao S (2007) Eyeblink-based anti-spoofing in face recognition from a generic webcamera. In: 2007 IEEE 11th International conference on computer vision, Rio de Janeiro, Brazil, 2007, pp 1–8, 2007
19. Deorankar, Tadam N (2020) Proposing SVM and hog techniques for effective face recognition in video surveillance. Int J Sci Res Comput Sci Eng Inf Technol 805–810
20. Han S, Choi I, Kim D (2011) Eye detection and eye blink detection using adaboost learning and grouping. In: 2011 Proceedings of 20th international conference on computer communications and networks (ICCCN), Lahaina, HI, USA, 2011, pp 1–4
21. Krolak, Strumillo P (2008) Vision-based eye blink monitoring system for human-computer interfacing. In: 2008 Conference on human system interactions
22. Matsuno S, Ohyama M, Sato H, Abe K (2020) Classification of intentional eye-blinks using integration values of eye-blink waveform, pp 1255–1261
23. Jeon Y, Song et al (2021) Relationship between the partial blink rate and ocular surface parameters. Int Ophthalmol 41
24. Gagnon L, Teasdale N, Lalonde M, Byrns D, Laurendeau D (2007) Real-time eye blink detection with gpu-based sift tracking. In: Fourth Canadian conference on computer and robot vision (CRV ’07), Montreal, QC, Canada, 2007, pp 481–487

25. Gupta A, Rathi A, Radhika (2021) Hands-free pc control controlling of mouse cursor using eye movement
26. Ruiz C et al (2019) Optical mouse sensor for eye blink detection and pupil tracking: application in a low-cost eye-controlled pointing device. J Sens Hindawi

Reliability Analysis in Cyber-Physical System Using Deep Learning for Smart Cities Industrial IoT Network Node

Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Rabindra Nath Shaw, and Ankush Ghosh

Abstract The reliability, availability, security, and survivability analysis of any IoT (Internet-of-things) device is important because it provides all necessary information about the IoT device applications for smart city development to improve its performance of smart cities' Industrial IoT Network Node. The in-depth knowledge about the IoT Device Applications to be analyzed from a parameters point of view is needed, which inspires the researcher to understand the IoT Device network system very profoundly in terms of Cyber-Physical System (CPS). Until now, less attention is being given to the reliability analysis of smart city-based Industrial IoT devices and Cyber-Physical Systems (CPS). The root failure causes a cyber-attack. The analysis provides the base failure causes, the information about the type of failures and estimates the various reliability parameters. Through this analysis, a better design, a better manufacturing process in Smart Cities, Industrial IoT devices, preventive and corrective maintenance, redundancy, etc., we can easily be recommended for better performance of the device or CPS Using Deep Learning for Smart Cities based Industrial IoT Device (IIOT) Applications. The proposed technique is useful for addressing the system's dependability, design, and development since it can correctly and efficiently analyze the IoT network's reliability.

A. S. Rajawat
Department of Computer Science Engineering, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, India

P. Bedi
Computer Science and Engineering, KCC Institute of Technology and Management, Greater Noida, Uttar Pradesh, India

S. B. Goyal
City University, Petaling Jaya, Malaysia

R. N. Shaw
Department of Electrical, Electronics and Communication Engineering, Galgotias University, Greater Noida, India
e-mail: r.n.s@ieee.org

A. Ghosh (✉)
School of Engineering and Applied Sciences, The Neotia University, Sarisha, West Bengal, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_10

Keywords Smart cities · Reliability analysis · Internet-of-things · Industrial IoT device

1 Introduction

Reliability, Security assessment, and enhancement of Cyber-Physical systems (CPS) [1] for Smart Cities based Industrial IoT Device (IIOT) network is the major concern of today's competitive era. The reliability, security-related problems should be addressed from the initial design stages to obtain high product reliability in Smart Cities, which can be achieved through reliability predictions. The reliability prediction approach to be adopted depends on the product development stages and its related reliability metric. To assess and enhance the Reliability of Smart Cities for Industrial IoT devices (IIOT) and systems, the following steps are to follow.

- Determine the Root failure causes by IoT device Network.
- Need Reliability assessment methods for IoT device Networks.
- Need Reliability Enhancement methods for IoT device Network
- Need a Reliability Prediction methods for Industrial IoT Device (IIOT) Network.

The following Cyber-Physical System (CPS) and the IIOT [2] are considered for reliability, Security assessment, and enhancement purposes. Analysis, simulation, and design of some Industrial IoT Device Networks support the objectives set to achieve.

- Reliability and security analysis of Cyber-Physical System (CPS).
- Energy irregularity analysis of Industrial IoT Device Network using Restricted Boltzmann Machine (RBM) to improve the reliability of the IIOT Device.
- Reliability analysis of Analog filter circuits to improve the reliability and efficiency of communication system by using best combination filters circuits.
- Design of deep learning model (DLM) based RBM to improve the secure data Transmission and Response quality of Industrial IoT Device Network Applications communication system.

The Industrial IoT (IIoT) [3] Device Network system failures are mainly due to Hardware failures, software failures, and Human errors. Hardware failures are the major cause of communication failures. Hence those failures are being taken in this research work. As a result, the overall reliability, security, quality, efficiency, and performance of the Industrial IoT Device Network communication [4] can be improved by improving devices like an active filter, antenna, and wireless sensor networks. The Intelligent electronic devices (IEDs) fails due to various stresses like cyber-attack, cascading failures, often catastrophic, atmospheric conditions, temperature, humidity, corrosion, voltage fluctuations, spikes, surges, bond wire lift off, thermal cracking, design, manufacturing process, mechanical stresses, preventive and corrective maintenance, and poor human handling. The contributions of this work are the following:

- To proposed a technique reliability analysis in IoT Node is the first method to assess the secure route through information exchange on gathered network parameters and new node top procedure.
- We have implemented a deep learning approach to select a suitable route for forwarding information transmissions to enhance effectiveness and reliability.
- The suggested intelligent strategy Smart Cities approach will assess the IIoT parameters and perform information integration on them in order to make an efficient cluster top choice; a new RBM head choice method has been suggested.

We analyze and assess the efficiency of the suggested RBM approach with the different hierarchical, place, and plain tracking procedures

2 Related Work

Intelligent industrial systems are designed to process a larger volume of data. An online assessment method has been developed to check the Cyber-Physical System (CPS) reliability [3]. Many domains combined with deep learning for the assessment of Cyber-Physical Systems. Sicato et al. [4] used blockchain technologies to analyze the industrial system consist of Cyber-physical systems. The Cyber-physical systems are very advantageous in the development of Industry on the basis of the development of Industry 5.0 and sustainable smart manufacturing [5]. The health systems and healthcare industry also developed Cyber-Physical systems (CPS) due to their accuracy and constancy [6]. Sztipanovits et al. [7] Cyber-physical systems also used in developing modern and sophisticated unmanned air vehicles (UAV). However, Cyber-Physical Systems designs contain some security issues that are needed to be addressed to protect the integrity and data of the entire system [8, 9]. Describe the Tables 1 and 2 Comparative analysis of different deep learning techniques used in developing cyber-physical systems and a comparative analysis of several factors for in CPS for Industrial IoT Device Applications.

3 Reliability Analysis of IoT Network Node in Smart City Industrial IoT (IIOT) Device

An IoT network node Application communication system is mainly divided into four main sections e.g., Network subsystem (NSS), (BSS), (MS), and PSTN/ISDN, etc. In this research work, the performance of various Industrial operators through Smart Cities (CPS) in different geographical regions during four quarters of a year is analyzed. Quality of service of a wireless communication system is also considered and the factor which affects the quality is also analyzed. Giving QoS the skill is especially significant due to resource hindrances and the complex design of remote systems. QoS support covers application layer, layer transition, layer configuration,

Table 1 Comparative analysis of different deep learning techniques used in developing cyber-physical systems

S. no.	Study	Deep learning technique	Type of technique	Highlights
1	O'donovan et al. [10]	PMM-encoded machine learning models	Supervised learning	We have designed a system to implement machine learning techniques for low latency
2	Singh [11]	Artificial neural networks (ANN)	Unsupervised learning	Development of cyber-physical system for smart cities
3	Hussain et al. [12]	Convolutional neural network (CNN)	Unsupervised learning	Deep learning for detection of DDoS attacks over 5G networks
4	Wickramasinghe et al. [13]	Deep neural networks	Unsupervised learning	Explained the importance and role of deep learning in the cyber-physical systems
5	Li et al. [14]	Convolutional neural network (CNN)	Unsupervised learning	Proposed DeepFed, a deep learning model which can be used in intrusion-detection systems

and physical layer in distant arrangement [8]. There are several appealing problems and challenges in remote systems that have no important influence on the traditionally wired web base. The main problems are described below.

Reliability analysis of Industrial IoT (IIOT) network node.

A. **Generated Faults**

Exceptionally impulsive digital media and package results are inevitable for smart cities-based Industrial IoT (IIOT) Device. For example, blurring, interference, and multipath revocation are challenges for the proliferation of flags. Such remote device properties calculate the flexibility of the data transfer and delay the relation whimsically.

B. **Hub Versatility**

The kinetics of jacks in the distant arrangement contributes to the complex topology of the system. Connections will be formed slowly as two hubs are brought into the transmission and removed by moving from the transmission.

C. **Restricted Battery Life**

The limited battery life restricts the frequency of innovations setting up the hubs in the Industrial IoT (IIOT) network node. The process for the provision of QoS Shrouded and uncovered terminal issue.

Table 2 A comparative analysis of several factors for reliability analysis in CPS for industrial IoT device applications

S. no.	References	Reliability analysis in CPS for industrial IoT device network node	Research gaps
1	Lv et al. [15]	IIoT systems based on AI	As P_{ref} increases, the system vulnerability increases
2	Castaño et al. [16]	A review and case study of sensor reliability in CPS using Internet-of-Things data	The models had a limited degree of generality
3	Castaño et al. [16]	Using machine learning techniques, a dataset reduction framework for intelligent fault detection in IoT-based CPS	There hasn't been any testing on intrusion detection datasets
4	Tertytchny and Michael [17]	Safeguarding industry 4.0 systems with a new threat intelligence scheme	Datasets designed expressly for Industry 4.0 systems aren't being used
5	Moustafa et al. [18]	Progress and challenges in deep learning continuing to learn anomaly detection in CPS	High maintenance costs and a lack of high-quality data For a long time, there has been a failure to discover irregularities

D. **Management of Smart Cities Operations**

It is particularly difficult to preserve system data precisely in complex topologies for data sharing. Because hubs can enter and exit the Industrial IoT (IIOT) device state, a steering route can be broken. As a result, there is a noticeable lag time. Effective strategies for reserving resources can finally be used to achieve quality of service by adopting an extremely flexible topology model.

E. **Security**

Unapproved access and use will interfere with QoS transactions without adequate security. The concept of communicating in IoT (IIOT) network nodes will lead to more security. Due to the laborious properties of multi-faceted IoT (IIOT)network nodes, delicate QoS was suggested. The delicate QoS aims to allow temporary time frames where QoS assignments do not exist following the establishment of an organization.

Energy Irregularity Analysis (IIOT) Network Node Using Deep Learning

The IIOT is an infrastructure-free system. Many sensor nodes are placed in the given range for various applications, e.g., tracking, surveillance, weather, precision. IoT

(IIOT) activities are of major importance. IoT-based sensor networks node can sense and transfer the various inputs like temperature, pressure, humidity, air acoustics, etc. The sensor node in IIOT consists of detectors, microcontrollers, communication devices, and energy backups. Each sensor node tracks the surrounding area collects the physical input after processing data through the communication system to other sensor nodes. However, the main constraints associated with the nodes are computation, energy, memory, and bandwidth. There are also some typical problems such as cyber security, tolerance of defects, connection, range, sync, and location problems. Generally, the nodes are located in bad atmospheric conditions, and changing or recharging batteries is very tough or impossible. The cost of interaction exceeds sensing and computing costs by a thousand times. The usable node power should be used efficiently due to limitations. Considering the characteristics of IIOT, the biggest problem that affects the network operations is the battery problems of IIOT-Sensor. The most important design feature is the versatile, simpler, reliable, secure, and energy-efficient algorithm using RBM design for IIOT-Sensor [19].

In our proposed algorithm, the hard threshold thus (IIOT) network node to transmit the sensed value is within the required range. Transmission numbers can also be reduced by soft threshold by removing all transmissions that change little sensed quality from the hard threshold. As per condition and specification, the soft threshold can be varied. A smaller soft threshold value offers a more reliable network process at the cost of increased energy usage. The user is, therefore, able to control the balance between energy efficiency and precision. While in certain situations, the reactive protocol is working well, reactive protocols can not define the overall photo of the network [20]. This means implementing a hybrid protocol to provide adaptive data and periodic data for the IIoT network [21]. To make better use of available energy, regular data transfer with a longer period of time is introduced in addition to hybrid manners. Routing also plays an important role in energy production. Meissen was used from earlier days to find the shorter path. In addition to the shortest paths, unused paths are used to balance loads correctly and to utilize consistent energy consumption. With IIOT reliability, accessibility, and survival performance, we deal with the hot spot problem.

Restricted Boltzmann machine (RBM) solves the routing problem. For the inter-cluster routing from various CHs, the proposed solution uses a deep learning-based RBM. In contrast to regular data transmission for longer durations, Threshold-based Data Transmission is used to reduce the transmission numbers. We design a new routing strategy for the proper security in which the threshold data transfer takes the shortest possible route, and intermittent data transmission uses new routes. In addition, we have proposed a maintenance process for clusters that balances the problem of energy dissipation and hot spot. We perform a detailed simulation of the proposed method with the first-order radio energy model in various scenarios. There is also a measure of energy consumption, residual energy, BS packets, and network life.

Given the inputs for the evident layer and to discover the probability of hidden layer, to get the probability of visible layer given the inputs in a hidden layer, the distribution employed is a conditional probability distribution. Dimensionality reduction, feature learning, classification, collaborative filtering, and topic modeling are all areas where this XAI is used. RBM's intralayer connections are constrained compared to other neural network learning methods, resulting in efficient training and faster learning. RBM is made up of two parts: a visible unit and a concealed unit. The visible layer trains the input features, and the buried layer processes the inputs for further processing. RBM has binary-valued visible and hidden units and a weight matrix for the bias-weighted links between them. The weight matrix changes as the network's dynamic behaviour changes. The softmax classifier at the hidden layer classifies network traffic depending on the target class. RBM supports both discrete and continuous valued target classes. The neurons of RBM's visible layer receive traffic flow features and their threshold values of reliable network measurements as inputs. RBM's hidden layer self-learns the provided inputs in a dynamic network environment and analyses the incoming traffic flows. Due to the limited connections in the intra layers, learning and training to detect traffic flow with varying threshold values from defined is faster and more efficient. RBM is employed in this study to detect attack traffic flows.

As illustrated in RBM contains a pair of nodes, specifically "L" Evident units EU = (EU_1,…,EU_L) and hidden units HU = (HU_1,…,HU_M) that consist of a weight matrix WM = (WM_{LM}) between hidden unit (hu_n) and evident unit (EU_L), with bias weights (ai) for the evident units and (bj) for the hidden units.

Where ENERGY (EU, HU) is the RBM deployed network's energy configuration.

Weight matrix between two network nodes. = W_{LM}.

Bias unit of visible and hidden layers (am, bn). vm = The network's visible unit.

M = The network's hidden unit.

$$\text{ENERGY}(\text{EU}, \text{HU}) = \sum_{i=1}^{L}\sum_{j=1}^{M} W_{M,L} HU_M EU_L - \sum_{i=1}^{L} a_m EU_L - \sum_{j=1}^{M} b_m EU_m$$

The following is the joint probability distribution of the visible and hidden layers: where LPF is the layer's partition function. In comparison to previous energy-based models, the constrained connections between the intra layers allow for a quick learning technique. The predicate (Fig. 1)

$$P(V, H) = \frac{1}{z} e^{-(V,H)}$$

$$Predicate(EU, HU) = 1/\text{LPF} e^{-(EU,HU)}$$

$$Predicate^{HU}/_{EU} = \prod_{j=1}^{m} sinmoid\left(b_n + EU^T W_m\right)$$

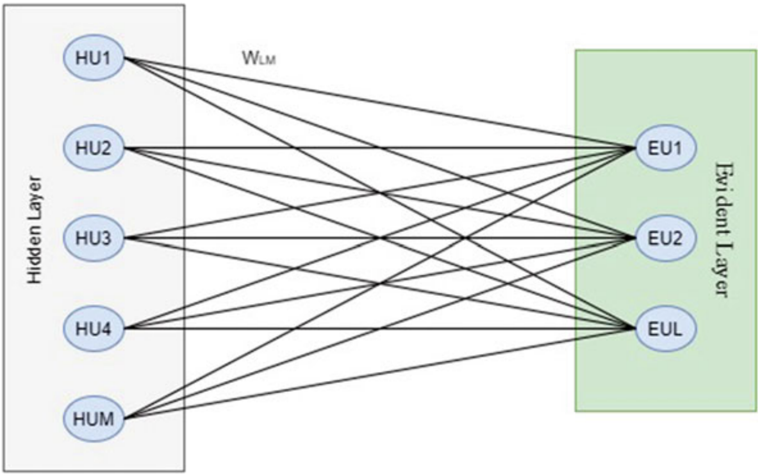


Fig. 1 RBM structure the following is the joint probability distribution of the visible and hidden layers

4 Result

To perform the simulation using OMNET++ simulator with 8 GB RAM and 250 GB SSD environment. To creates IIoT Network with 100 Node and divided the clustering () Cyber-Physical System (CPS) [22, 23] are capable of considerably more than we explain in an existing model on CPS cognition, according to the new conceptual framework. CPS is becoming a lot more automated as new information from IoT tools network nodes become available. CPS can also comprehend the connections between apparently inapplicable events and create brand-new products and services utilizing the details of high-dimensional information. These new information streams are very intricate, as well as just AI can evaluate them and also make low-latency forecasts. Therefore, AI's development in CPS is unavoidable, autonomous, as well as currently started.

We offered innovative ideas in several sectors of CPs in this research work. We discovered that present research efforts on CP-based IIOT devices network nodes [24] mostly focus on security, fault creation and detection, and management operations. Using a deep learning-based RBM, we proposed a solution for intercluster routing from various CHs. Indifference, Threshold-based Data Transmission is employed to limit the number of transmissions required for regular data transfer over long periods. Additionally, we designed a new routing strategy that uses the shortest available route for threshold data transmission, while intermittent data transmission utilizes unused channels.

Additionally, we've developed a cluster management strategy that strikes a compromise between energy dissipation and hot spot difficulties. First-order radio energy model was used to run a full simulation of the approach. A highly effective active service was obtained by using the empirical prediction method.

Ongoing attacks on (IIOT) networks, such as network node hijacking attacks that target the data delivery nodes, damaging or stealing their load, require advanced deep learning algorithms. For example, complicated malicious attack protection and data recovery can be improved by applying intelligent mechanisms to more manufacturing processes of genuine Industry 4.0 systems and verifying their performance in real-world cyber-physical settings and unique scenarios [25, 26]. A variety of training data must also be extracted to increase threat detection's relative accuracy. Finally, as more IIoT devices and platforms are deployed and connected under a range of abnormal conditions during the manufacturing process, both software and hardware security of IIoT devices and platforms should be considered in future works. [16] Reliability Verification for IoT in this chapter creates the RBM method through an experiment and compares it to researching the unreliable node network and the unreliable edge network. RBM variable order optimization method is used as a comparison method in the former approach to comparing experiments. As a result of the experiment, multiple benchmark networks were tested, and the results are summarised in Table 3. These networks are widely employed as benchmark test networks for checking and testing the correctness and efficiency of dependability algorithms [27, 28]. Calculating the reliability of smart cities-based IIoT networks Node took time, as shown in Table 3. As a result of the contrast experiment, the table is divided into two part. The right half of the table shows comparison experiment results for the faulty node calculation approach. Nodes in the experiment have identical probabilities of working. On the right side of the table, you can see the comparison results of the unreliable edge computation approach. Using a reliability analysis tool, you may check the dependability of different test networks. Listed below is the average computing time for each technique [29]. As a result of running each procedure 100 times, the average computation time is shown in the table as time overhead. This is because these networks are tiny and have simple topologies, so the average operation time of the RBM method and contrast approach are identical. However, networks have a pretty large scale. The RBM approach is faster than the method. RBM is faster than other methods as the size of the network increases, according to experiments.

Table 3 Evaluation of the computation time (seconds) existing algorithm, decision tree algorithm and computation time (seconds) RBM for approach IIoT network node

Existing approach			
IIoT network node	Reliability	Computation time (s) Decision tree algorithm	Computation time (s) RBM algorithm
10	0.81	0.22	0.051
15	0.83	0.32	0.025
20	0.82	0.42	0.063
25	0.88	0.53	0.32
30	0.89	0.60	0.50

Table 4 Evaluation of the computation time (seconds) proposed algorithm, decision tree algorithm and computation time (seconds) RBM for approach IIoT network node

Proposed approach			
IIoT network node	Reliability	Computation time (s) Decision tree algorithm	Computation time (s) RBM algorithm
10	0.98	0.20	0.049
15	0.98	0.26	0.023
20	0.97	0.39	0.034
25	0.95	0.49	0.39
30	0.94	0.60	0.50

According to the experimental data in Table 3, the average computing time of the RBM approach and the contrast method has minor differences in the computation time of the dependability of the unreliable edge network. Ten to twenty and thirty networks have smaller networks, and the correlation between nodes is lower [30, 31]. As a result, the decision tree method is more efficient than the RBM method in terms of its operating efficiency. Network 10 can be seen in networks 10–20–30 because of the massive extent and large fraction of connected edges. As a result of the Decision Tree's edge order optimization process, RBM's operation time is faster than Decision Tree's. In a large network with a complex edge topology, the RBM methodology appears to be faster than the Le method. RBM is not only effective for calculating dependability of an unstable network of nodes and edges, but it also has a high operational efficiency in a large-scale IoT network with a complex internal structure, according to the results of the two halves of this experiment. Considering that the number of nodes in a system is not monotonous, it is necessary to determine the number of nodes that corresponds to the dependability of first technique [32, 33]. When the IoT system has 100 nodes, the most resources are saved, and the reliability is 0.98, which fulfills the needed system reliability of 0.94, as demonstrated by the following example. Table 3 Evaluation of the Computation time (seconds) Existing Decision Tree Algorithm and Computation time (seconds) RBM for Approach IIoT Network Node. Table 4 describes the Evaluation of the Computation time (seconds) Proposed algorithm, Decision Tree Algorithm and Computation time (seconds) RBM for Approach IIoT Network Node.

5 Conclusion

To achieve the Smart Cities Industrial IoT Network Node aim, utilizing Industrial Internet of Things deployments and subsequent gathering and processing of heterogeneous data is vital. Enoutre, a comprehensive view of dependability detection and the prediction was presented by thoroughly examining closely connected factors such as cyber-security problems and the role of humans in the manufacturing loop. Cyber-physical systems' components are prone to various anomalies; therefore, ensuring their reliability is becoming increasingly important as many systems grow. Use Deep Learning to Analyze Reliability in Cyber-Physical Systems in Smart Cities. Industrial systems should prioritize safety and security to avoid injury and minimize threats to personnel, assets, and the environment. To a growing extent, industry professionals understand the interrelationship between safety and security. Existing IIoT technologies do not have standardized methods for assessing the combined safety and security threats. However, further work is needed to formalize its application and test it in industrial processes. Finally, a list of unresolved difficulties was offered to spur more research in this area, noting the shortcomings of current solutions and offering alternative future research areas.

References

1. Castaño F, Strzelczak S, Villalonga A, Haber RE, Kossakowska J (2019) Sensor reliability in cyber-physical systems using internet-of-things data: a review and case study. Remote Sens 11(19):2252. https://doi.org/10.3390/rs11192252
2. Wang J, Shi D (2018) Cyber-attacks related to intelligent electronic devices and their countermeasures: a review. In: 53rd International universities power engineering conference (UPEC), Glasgow, UK, 2018, pp 1–6. https://doi.org/10.1109/UPEC.2018.8542059
3. Lv Z, HAN Y (2020) Trustworthiness in industrial IoT systems based on artificial intelligence. IEEE Trans Industr Inf 1–1. https://doi.org/10.1109/tii.2020.2994747
4. Sicato JCS, Cha J, Pan Y, Park JH (2021) Deep learning adoption blockchain secure framework for cyber physical system. In: Advanced multimedia and ubiquitous engineering, pp 195–200. Springer, Singapore
5. Durana P, Perkins N, Valaskova K (2021) Artificial intelligence data-driven internet of things systems, real-time advanced analytics, and cyber-physical production networks in sustainable smart manufacturing. Econ Manage Fin Mark 16:1
6. Wang T, Shao F, Zhu K (2021) Structural health analysis on cyber physical system based on reliability. J Supercomput 77(1):445–470
7. Sztipanovits J, Koutsoukos X, Karsai G, Kottenstette N, Antsaklis P, Gupta V, Wang S (2011) Toward a science of cyber–physical system integration. Proc IEEE 100(1):29–44
8. Wang EK, Ye Y, Xu X, Yiu SM, Hui LCK, Chow KP (2010) Security issues and challenges for cyber physical system. In: 2010 IEEE/ACM International conference on green computing and communications & International Conference On Cyber, Physical And Social Computing, pp 733–738. IEEE
9. Kim NY, Rathore S, Ryu JH, Park JH, Park JH (2018) A survey on cyber physical system security for IoT: issues, challenges, threats, solutions. J Inf Process Syst 14(6):1361–1384
10. O'donovan P (2018) A fog computing industrial cyber-physical system for embedded low-latency machine learning Industry 4.0 applications. Manuf Lett 15:139–142
11. Singh SK, Jeong YS, Park JH (2020) A deep learning-based IoT-oriented infrastructure for secure smart city. Sustain Cities Soc 60:102252
12. Hussain B, Du Q, Sun B, Han Z (2020) Deep learning-based DDoS-Attack detection for cyber-physical system over 5G network. IEEE Trans Industr Inf 17(2):860–870
13. Wickramasinghe CS, Marino DL, Amarasinghe K, Manic M (2018) Generalization of deep learning for cyber-physical system security: a survey. In: IECON 2018—44th Annual conference of the IEEE industrial electronics society, pp 745–751. IEEE

14. Li B, Wu Y, Song J, Lu R, Li T, Zhao L (2020) DeepFed: dederated deep learning for intrusion detection in industrial cyber-physical systems. IEEE Trans Ind Informat
15. Lv Z et al (2020) Trustworthiness in industrial IoT systems based on artificial intelligence. IEEE Trans Ind Informati 17(2):1–1, https://doi.org/10.1109/tii.2020.2994747. Accessed 16 Aug 2020
16. Castaño F et al (2019) Sensor reliability in cyber-physical systems using internet-of-things data: a review and case study. Rem Sens 11(19):2252. www.mdpi.com/2072-4292/11/19/2252/htm. https://doi.org/10.3390/rs11192252. Accessed 25 Aug 2021
17. Tertytchny G, Michael MK (2020) dataset reduction framework for intelligent fault detection in IoT-based cyber-physical systems using machine learning techniques. International Conference on Omni-layer Intelligent Systems (COINS) 2020:1–6. https://doi.org/10.1109/COINS49042.2020.9191393
18. Moustafa N, Adi E, Turnbull B, Hu J (2018) A new threat intelligence scheme for safeguarding industry 4.0 systems. IEEE Access 6:32910–32924. https://doi.org/10.1109/ACCESS.2018.2844794
19. Luo Y et al (2021) Deep learning-based anomaly detection in cyber-physical systems. ACM Comput Surv 54(5):1–36, https://doi.org/10.1145/3453155. Accessed 25 Aug 2021
20. Radanliev P et al (2020) Artificial intelligence in cyber physical systems. AI & Society. https://doi.org/10.1007/s00146-020-01049-0
21. Angelopoulos A et al (2019) Tackling faults in the industry 4.0 era—a survey of machine-learning solutions and key aspects. Sensors 20(1):109. https://doi.org/10.3390/s20010109
22. Angelopoulos A et al (2019) Tackling faults in the industry 4.0 era—a survey of machine-learning solutions and key aspects. Sensors 20(1):109. https://doi.org/10.3390/s20010109. Accessed 25 June 2020
23. Yussupova N, Rizvanov D, Andrushko D (2020) Cyber-physical systems and reliability issues. https://doi.org/10.2991/aisr.k.201029.026
24. Boyes H et al (2018) The Industrial Internet of Things (IIoT): an analysis framework. Comput Ind 101:1–12. https://www.sciencedirect.com/science/article/pii/S0166361517307285. https://doi.org/10.1016/j.compind.2018.04.015
25. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Smart luminaires for commercial building by application of daylight harvesting systems. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_24
26. Rajawat AS, Barhanpurkar K, Goyal SB, Bedi P, Shaw RN, Ghosh A (2022) Efficient deep learning for reforming authentic content searching on big data. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_26
27. Palimkar P, Bajaj V, Mal AK, Shaw RN, Ghosh A (2022) Unique action identifier by using magnetometer, accelerometer and gyroscope: KNN approach. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_48
28. Das S, Das I, Shaw RN, Ghosh A (2021) Advance machine learning and artificial intelligence applications in service robot. Artif Intell Fut Gener Robot 83–91. https://doi.org/10.1016/B978-0-323-85498-6.00002-2
29. Huneria HK, Yadav P, Shaw RN, Saravanan D, Ghosh A (2021) AI and IOT-based model for photovoltaic power generation. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_55
30. Paul A, Sinha S, Shaw RN, Ghosh A (2021) A neuro-fuzzy based IDS for internet-integrated WSN. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_6
31. Bodapati S, Bandarupally H, Shaw RN, Ghosh A (2021) Comparison and analysis of RNN-LSTMs and CNNs for social reviews classification. In: Bansal JC, Fung LCC, Simic M, Ghosh

A (eds) Advances in applications of data-driven computing. Advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_4
32. Rawat R, Mahor V, Chirgaiya S, Shaw RN, Ghosh A (2021) Sentiment analysis at online social network for cyber-malicious post reviews using machine learning techniques. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_9
33. Banerjee A et al (2022) Construction of effective wireless sensor network for smart communication using modified ant colony optimization technique. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_22

Multi Robot Environment Exploration Using Swarm

Hardik Gossain, Bhavya Sharma, Rachit Jain, and Jai Garg

Abstract This chapter describes the exploration of unknown environment using multiple robots. We designed this system in order to overcome the various disadvantages of exploration and mapping robots. When it comes to the mapping of large unknown environment, single robot would be inefficient and inaccurate. It leads to more exploration time and inaccurate mapping of the environment. There are multiple algorithms which already exist and are used but seeing their inefficiency we have worked on RRT that is random-exploration random tree. Multiple robots will be deployed in an unknown environment and based on which the robots will explore environment, to make robot communicate with each other we have implemented swarm algorithm so that robot communicate with each other in coordinated way. The Swarm algorithm will help robots explore the environment in a coordinated way because of which the two robots will never explore the same area repeatedly and hence will same time and will lead to more accurate mapping of the environment. To implement this solution, we used ROS as the middle ware, with the help of the ROS we can encounter and handle many real time parameters which will make our system more accurate and efficient. GAZEBO simulator is used in order to test and implement the system. This multi robot system will be very useful in the future smart city ecosystems.

Keywords Multiple robots · Exploration · RRT · Random-exploration · Swarm · Middle-ware, · ROS · GAZEBO

H. Gossain · J. Garg
Department of Electronics and Communication Engineering, Dr. Akhilesh Das Gupta Institute of Technology and Management, New Delhi, India

B. Sharma (✉) · R. Jain
Department of Electrical and Electronics Engineering, Dr. Akhilesh Das Gupta Institute of Technology and Management, New Delhi, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_11

1 Introduction

Robotics is the field of attraction for many researcher and hobbyist, in recent decade the robotics saw development, advancement and technical growth. From mobile robot to UAV i.e. Unmanned aerial vehicle has wide field of research opportunity. All humans want their work load to decrease. We are in search of everything automatic and robotic that can help humans make their lives easier. Currently, autonomous robots are capturing the market and are the centre of attraction for many hobbyists and researchers. Many advancement is going on in the field of autonomous robots. Autonomous mobile robot is wide application in the field of exploration of unknown environment such as mining, disaster management and many more [1–5].

Autonomous robots are useful in many ways, they are helping hand for humans, in various way they make themselves useful in various activities such as mapping and navigation of unknown environment, there are various programmes and algorithm for the autonomous robots which are currently used but they are not efficient when it comes to mapping of the unknown environment which has large area, they take more time and the final map is not accurate hence to overcome this we have implemented an algorithm to make multiple robot work in coordinated manner and increase the efficiency. Using ROS as middle ware to implement RRT and swarm algorithm on our robots we have designed this solution [6–10].

The RRT i.e. random-exploration random tree is implemented in this chapter. Rapid-exploration Random Tree also known as RRT is an algorithm used for exploring unknown map. It is used in non-convex searches where it randomly builds space filling trees. This algorithm is the base of our research. As explained in [1] it generates random maps and find the path closest to it, that is obstacle free and has been explored. Since we are also using the IR sesnor the output of data is in the form of 0 and 1 and -1 in our algorithm, 0 signifies that the path is free from obstacles, 1 signifies the obstacle in the path, and -1 signifies that the path is unexplored. To make our robot more efficient and faster, we have made multiple robots communicate to each other rather than just treating each other as obstacle. Considering each other as obstacle grows possibilities that another robot can revisit positions on the map that other robot has already visited and made its map in the master node.

Simulation result obtained from the above proposed solution is compared with the other standard algorithms already available. Since the main aim of our research was to minimize the exploration time we have compared exploration time with the standard algorithm and also with exploration time of the multiple robot in comparison to single robot [11–15]. We wanted to give reference of some of the research work done in field of swarm [16–20]. We also took into consideration the exploration area of the robot as when exploration using a single robot was not accurate and sometimes do not some area, while testing our solution we tried to maximize the exploration area. Various algorithms were tried for merging of the map and the best algorithm is presented in this chapter.

This research chapter is organized as follow. Section 2 challenges and solution explain the challenges faced during designing of the algorithm and its solution.

Section 3 describes the methods adopted while designing this solution which includes explanation of “RRT’, “SLAM” and “SWARM”. Section 4 gives the brief about how the algorithm is implemented in simulation and how practically we can approach it further. Section 5 gives the overall result of the research chapter followed by Sect. 6 Conclusion.

2 Challenges

2.1 Task

The system involved in [1] is improved for improving efficiency and reducing time in map generation. Multiple robots working independently based on SLAM algorithm are used for mapping unknown locations.

2.2 Problem

The main problem caused by the algorithm given in [1, 2, 5] is that robots doesn’t communicate with each other and treat each other as a dynamic obstacle. Main element of the algorithm could be improved by reducing the runtime and letting a single robot cover a particular part of the unknown locations.

2.3 Solution

Our system focuses on the communication of robots along with navigation and mapping of an unknown environment. Along with SLAM algorithm and RRT exploration, our system involves SWARM algorithm. This allows robots to know which robot is near to them and in which direction. The information of direction gives a probability that region on that particular is already been mapped. Apart from this, a single ROS node runs on the main processing unit that subscribes to all other nodes (robots) and generates map by taking multiple inputs. Independent robots are based on hector slam.

3 Method

3.1 RRT Exploration

- Unknown Region is the space which is not explored by robot or it's sensors
- Known Region is the space which is explored by robot—Open-Space is a known region where there are no obstacles.
- Occupied-Space is a known region which contains an obstacle.
- Occupancy Grid is a grid representation of the whole space. Its cell holds a value that defines the probability of it being occupied.
- Frontier is the segment that separates known (explored) regions from unknown regions. Generally, a frontier is a set of unknown points with at least one point in neighbour with Open-space.

Algorithm 1: RRT Exploration

```
Qgoal
Counter=0
lim=n
G(V<E)
While counter<Lim
Xnew=RandomPosition()
If IsInObstacle(Xnew)=True:
Link=Chain(Xnew,Xnearest)
G_append(Link)
If Xnew in Qgoal:
Return G
Return G
```

3.2 Frontier Detection

There are two modules for successful detection of a frontier. The above Algorithm is an independent process that resets after detection of each new node in unknown region. It is a sub-loop that is a part of the main loop that stores the detected frontiers and form the whole tree. In the inner loop, the code starts with an initial vertex v and the edge is set $E \leftarrow \varphi$, at each iteration a random point x_{new} is sampled that is the part of unknown region. The first vertex nearest to the random point is found called the $x_{nearest}$. Then it is checked that whether the new point or any point on the line segment x_{new} and $x_{nearest}$ lies in the unknown region using the Grid Check function. If either condition is true, frontier point is assigned. One more condition for obstacle detection is checked. If the line segment is obstacle free, then the point x_{new} is set as the new frontier and everything is reset, setting the current point as V ($V \leftarrow x_{current}$)

for the new iteration. This method will run as the robot traverses through the map and finding new frontiers.

This loop stores the current path of the robot to the new point while the main loop stores the whole map that has already been traversed including the current. This approach increases the overall speed of the map exploring algorithm. With multiple robots, each running this individually, the map is recorded and sent to the main ROS node which by filtering methods stores the whole map in a grid form. This algorithm plus multiple robot's implementation makes the mapping process really fast, efficient and time saving. Here we have implemented this on ground robots but it can be even implemented on drones.

Algorithm 2: Frontier Detection

$V \leftarrow x_{init}$; $E \leftarrow \varphi$;
while True do
$x_{rand} \leftarrow$ Sample Free;
$x_{nearest} \leftarrow$ Nearest (G (V, E), x_{rand});
$x_{new} \leftarrow$ Steer ($x_{nearest}$, x_{rand}, η);
if GridCheck(map, $x_{nearest}$, x_{new})=−1 then
PublishPoint(x_{new});
$V \leftarrow x_{current}$; $E \leftarrow \varphi$; ◁ reset the tree
else if GridCheck(map, $x_{nearest}$, x_{new})=1 then
$V \leftarrow V \cup \{x_{new}\}$; $E \leftarrow E \cup (x_{nearest}, x_{new})\}$;
end if
end while

3.3 SLAM

The whole project revolves around Simultaneous Localization and Mapping and the improvement made in the traditional method to increase efficiency and speed of map generation using a greater number of robots. RRT based algorithm has been applied for finding unknown regions in the environment. The map generation is totally based on ROS hector slam. Hector SLAM is a very efficient tool to produce a graphic map for the user to further command and make the robot perform particular tasks. The generated map can have only three possibilities, Unknown, Occupied-space, free-space represented by −1, 1, 0, respectively [10, 11].

The exploration of unknown area uses RRT algorithm as explained in Sect. 2.1. After map generation, there were many path planning algorithms to move from one point of the known location to other. We had the option of using A* but we instead used Dijkstra algorithm for making our work simple as our main goal was to implement multiple robots. Dijkstra finds the smallest path between the robot's current position and the goal position. Even though our occupancy grip has the data of obstacles, still we implemented bug 2 algorithm that is a greedy algorithm that follows a path nearer to the goal location when there is an obstacle in between. This

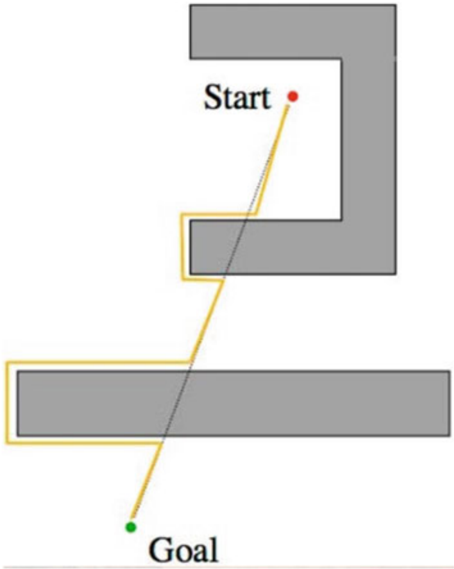


Fig. 1 Robot objective to reach goal while avoiding obstacle

was included mainly for avoiding dynamic obstacles or newly added obstacles which were not included while the generation of the map (Fig. 1).

3.4 Swarm

Swarm algorithm is responsible for establishing communication between multiple robots and make them work together to increase efficiency and decrease time to complete any task [3, 6]. In its usual implementation, generally one of the robots from the swarm is treated as the leader and other units become the slave and follow the master's command. In our implementation, we have made the main processing unit (computer) as the master node which gives command to other mobile robots to move around the arena. The master sends and receives data from other robots using Wi-Fi but other robots communicate to each other using infrared sensors. Four infrared transmitters and receivers are placed at each quarter of each unit. They constantly produce data containing a unique address assigned to each individual robot. By this method whenever there will be two robots' side to side or front back, they would be able to know that which robot is on which of their sides. This information will make the robot to avoid the path that is already been traversed by other robots. The algorithm also makes the robot able to distinguish between an obstacle and other moving robots [8].

3.5 Odometry Position

After the frontier detection, the main task revolves around detecting the current position of the robot. One cannot rely on image processing and detecting common points to find the position of the robot. Odometry data is very important for building an error-less map for the robot traversal. There are various ways to do so, we considered using Accelerometer and Encoders. One of them is enough by in cases where slipping of the robot can cause an error in encoder readings, we used accelerometer along with it. We avoided individual use of the Accelerometer as the probability of error in it is more as compared to digital encoders.

We cannot directly use the data from these sensors to be used as the input for ROS. We have to find the position of the robot using both the reading and then give it as an input for ROS. To do so we used a microcontroller (Namely STM32F103C8) for the collection of data and further calculation of the position of the robot.

As shown on [11], we used the motion model to calculate the position of the robot from the encoder's input. As told earlier, the probability of errors in the accelerometer is more so while applying the Kalman filter, the weightage of the accelerometer was 30% as compared to 70% of encoders approximately. Internally, the accelerometer is only considered when there is a large dissimilarity in the encoder's predicted reading along with the difference in accelerometers readings.

The overall process proceeds as followed, the microcontroller records the data, then calculates the position from both the sensors, and finally sends the position data to ROS (Fig. 2).

4 Implementation

Above stated solution was implemented on GAZEBO software with the help of which we were able to demonstrate the working of the RRT and were able to handle robot in unknown environment [9].

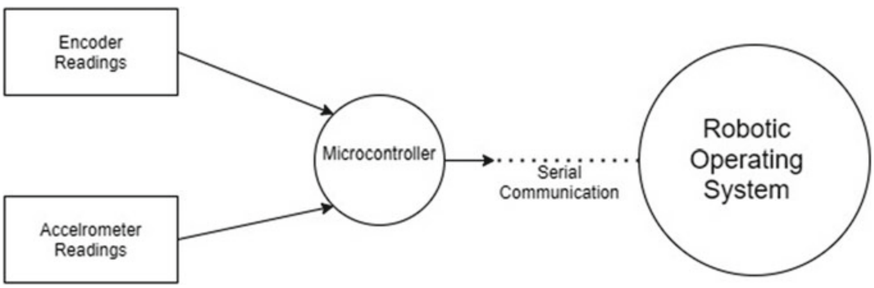


Fig. 2 Calculation of robot position

4.1 Simulation

Gazebo stimulator was used along with ROS as the middle ware. Software setup required for the stimulation is as follow:

1. Ubuntu 18.04 O.S
2. ROS melodic
3. GAZEBO
4. RVIZ.

Initially for the testing purpose Sample world was imported in GAZEBO and with the help of the ROS two robots were simultaneously spawned into the sample world (Fig. 3).

After the robots were spawned in the world, with the help of the LIDAR scanner installed on the robots started mapping and navigating through the environment autonomously (Fig. 4).

The final map of the environment which was mapped by the robots is shown below. With the help of the multiple robots we were able to map the unknown environment. The technique used while mapping the environment was hector slam.

With the help of the hector slam mapping we got more accurate result because hector slam mapping the mapping also consider robots localization which make it the accurate mapping technique.

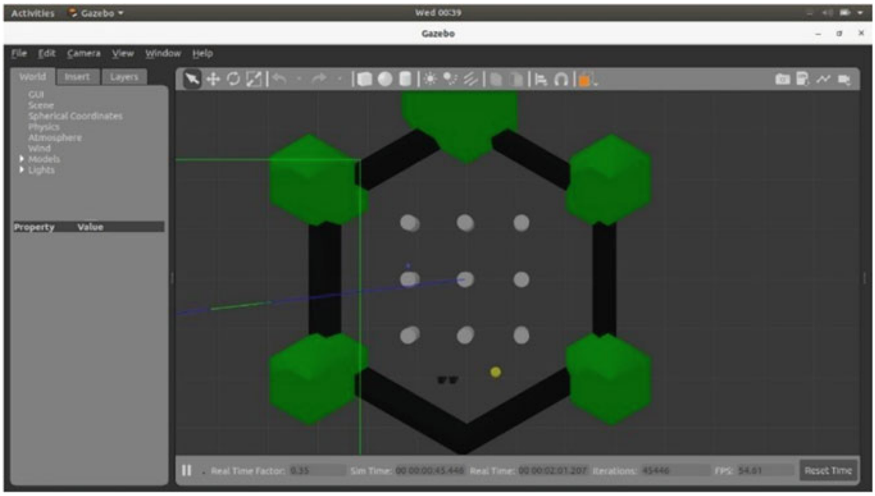


Fig. 3 Two robots spawned in simulation world

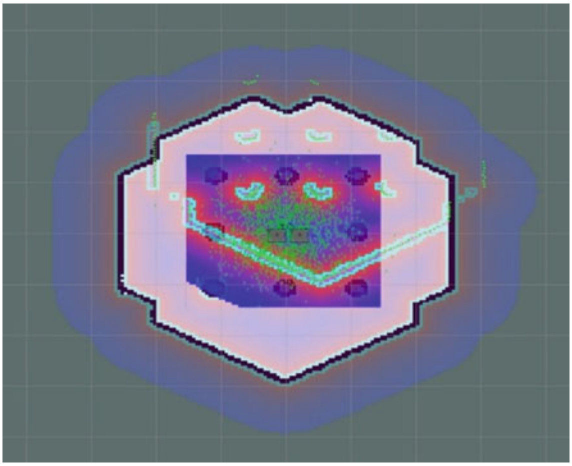


Fig. 4 Robot mapping unknown environment

4.2 Practical Approach

The RRT algorithm which was used in this chapter was helpful in designing the whole system [4]. With the help of the RRT and frontier detection we avoided the obstacle along with avoiding obstacle and reaching goal destination.

In Fig. 6, we can see robot initialized from co-ordinate (0, 0) and the goal destination is at (5, 10) with the help of the algorithm the robot was able to reach the goal by traversing shortest path and also avoiding obstacle along the path [7] (Fig. 6).

Fig. 5 Final map created by robots

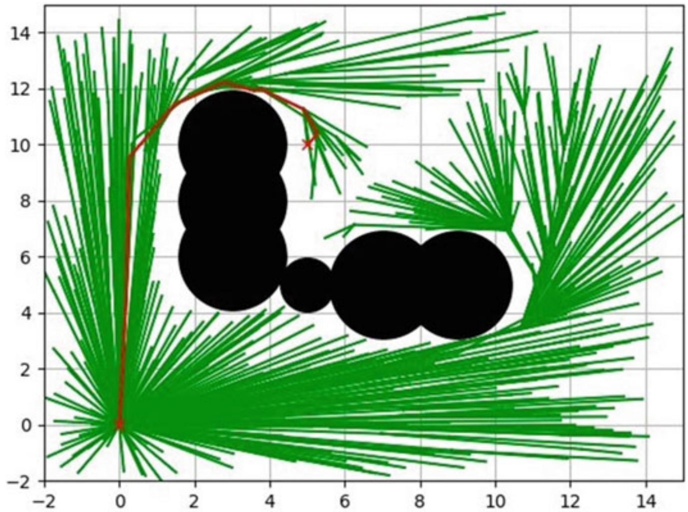


Fig. 6 Working representation of RRT algorithm

5 Result

From the simulation we can observe that we were able to reach the goal in less time, we compared our algorithm with the existing algorithm available and found that our algorithm is 98% accurate and take less time in mapping and navigating through the environment.

6 Application

SLAM is central to a range of indoor, outdoor, in-air and underwater applications for both manned and autonomous vehicles.

Examples:

- At home: vacuum cleaner, lawn mower
- Air: surveillance with unmanned air vehicles
- Underwater: reef monitoring
- Underground: exploration of mines
- Space: terrain mapping for localization.

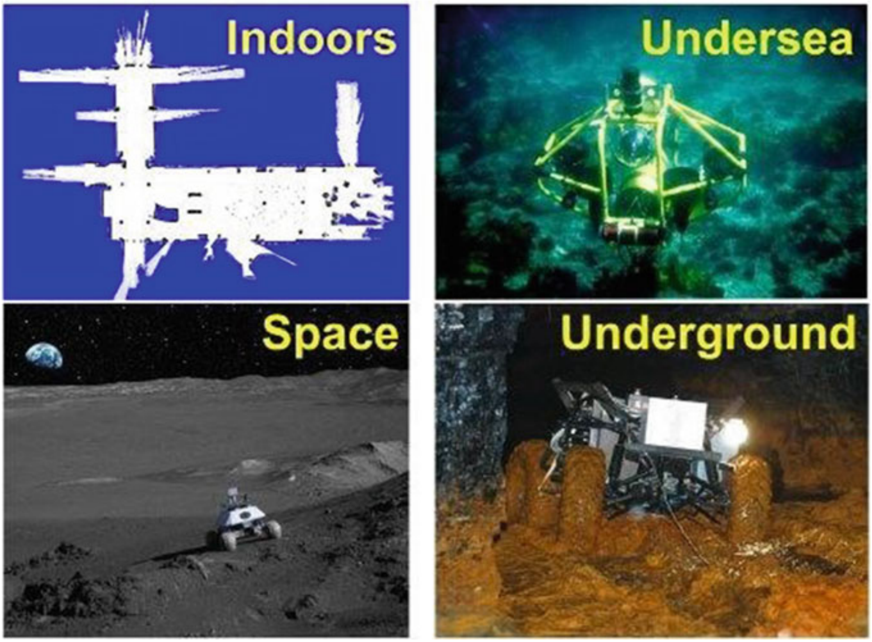


Fig. 7 Application of slam robot

7 Conclusion

In this chapter we have successfully developed and implemented an algorithm for multiple robot exploration and mapping. With the help of the developed algorithm, we were able to minimize the time consumed by robot to navigate and map the unknown environment. The mapped environment is observed in form of g-mapping which helps us in clear understanding of the environment. Further, swarm algorithm was successfully implemented with the help of which multiple robots were able to communicate with each other. This helped us with increased efficiency and reduced exploration time with 98% of efficiency in environment exploration. This multi robot system will be applicable in the smart city environment in near future (Fig. 7).

References

1. Umari H, Mukhopadhyay S (2017) Autonomous robotic exploration based on multiple rapidly-exploring randomized trees. In: 2017 IEEE/RSJ International conference on intelligent robots and systems (IROS), Vancouver, BC, 2017, pp 1396–1402. https://doi.org/10.1109/IROS.2017.8202319

2. Reid R, Cann A, Meiklejohn C, Poli L, Boeing A, Braunl T (2013) Cooperative multi-robot navigation, exploration, mapping and object detection with ROS. In: 2013 IEEE Intelligent vehicles symposium (IV), gold coast, QLD, 2013, pp 1083–1088. https://doi.org/10.1109/IVS.2013.6629610
3. Mahdoui N, Fr´emont V, Natalizio E (2018) Cooperative frontier-based exploration strategy for multirobot system. In: 2018 13th Annual conference on system of systems engineering (SoSE), Paris, 2018, pp 203–210. https://doi.org/10.1109/SYSOSE.2018.8428787
4. Sim´eon DT, Cort´es J (2014) A multi-tree extension of the transition-based RRT: application to ordering-and-pathfinding problems in continuous cost spaces. In: 2014 IEEE/RSJ International conference on intelligent robots and systems, Chicago, IL, 2014, pp 2991–2996. https://doi.org/10.1109/IROS.2014.6942975
5. Zhang B, Shang W, Cong S (2018) Optimal RRT* planning and synchronous control of cable-driven parallel robots. In: 2018 3rd International conference on advanced robotics and mechatronics (ICARM), Singapore, 2018, pp 95–100. https://doi.org/10.1109/ICARM.2018.8610680
6. Dos Reis WPN, Bastos GS (2015) Multi-robot task allocation approach using ROS. In: 2015 12th Latin American robotics symposium and 2015 3rd Brazilian symposium on robotics (LARSSBR), Uberlandia, 2015, pp 163–168. https://doi.org/10.1109/LARS-SBR.2015.20
7. Andre T, Neuhold D, Bettstetter C (2014) Coordinated multi-robot exploration: out of the box packages for ROS. In: 2014 IEEE Globecom workshops (GC Wkshps), Austin, TX, 2014, pp 1457–1462. https://doi.org/10.1109/GLOCOMW.2014.7063639
8. Werger BB (2000) Ayllu: Distributed port-arbitrated behavior-based control. In: Parker LE, Bekey G, Barhen J (eds) Distributed autonomous robotic systems 4, pp 25–34. Springer-Verlag, Knoxville, Tennessee, October 2000
9. Wu F, Rdiger C, Yuce MR (2017) Real-time performance of a self-powered environmental IoT sensor network system. Sensors 17(2):282
10. Lie S et al. SLAM and navigation of a mobile robot for indoor environments. Extended Kalman filter (EKF)—Data Association
11. Gossain H, Sharma B (2020) Mobile robot navigation and mapping using optical encoders. Int J Creat Res Thoughts (IJCRT) 8(7):254–258. ISSN: 2320-2882
12. .Thrun S, Leonard JJ (2008) Simultaneous localization and mapping. In: Siciliano B. Khatib O (eds) Springer handbook of robotics. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-30301-5_38
13. Thrun S, Liu Y (2005) Multi-robot SLAM with sparse extended information filers. In: Dario P, Chatila R (eds) Robotics research. The eleventh international symposium. Springer tracts in advanced robotics, vol 15. Springer, Berlin, Heidelberg. https://doi.org/10.1007/11008941_27
14. Eustice RM, Singh H, Leonard JJ (2005) Exactly sparse delayed-state filters. In: Proceedings of IEEE international conference on robotics and automation (ICRA), Barcelona, Spain, pp 2428–2435
15. .Wang Z, Huang S, Dissanayake G (2005) Implementation issues and experimental evaluation of D-SLAM. In: Proceedings of the 5th international conference on field and service robotics (FSR), Port Douglas, Australia, pp 153–164
16. Mandal S, Biswas S, Balas VE, Shaw RN, Ghosh A (2021) Lyft 3D object detection for autonomous vehicles. Artif Intell Fut Gener Robot 119–136. https://doi.org/10.1016/B978-0-323-85498-6.00003-4
17. Banerjee A et al (2022) Construction of effective wireless sensor network for smart communication using modified ant colony optimization technique. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_22
18. Biswas S, Bianchini M, Shaw RN, Ghosh A (2021) Prediction of traffic movement for autonomous vehicles. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_12

19. Soni A. Dharmacharya D, Pal A, Srivastava VK, Shaw RN, Ghosh A (2021) Design of a machine learning-based self-driving car. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_11
20. Mandal S, Sk Md Basharat Mones, Das A, Balas VE, Shaw RN, Ghosh A (2021) Single shot detection for detecting real-time flying objects for unmanned aerial vehicle. Artif Intell Fut Gener Robot 37–53. https://doi.org/10.1016/B978-0-323-85498-6.00005-8

AI and Blockchain for Healthcare Data Security in Smart Cities

Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Rabindra Nath Shaw, Ankush Ghosh, and Sambhav Aggarwal

Abstract The healthcare industry is interested in various AI and blockchain technology characteristics, such as the immutability of data stored in a blockchain. Numerous interesting IoT-based applications are being examined. IoT-based Clinical and biological research will be sped up, biomedical and healthcare data ledgers will be advanced using *Blockchain and AI*. These evaluations are based on essential Blockchain and AI technology features such as decentralized management, immutable audit trails, data authenticity, resilience, better security, and most importantly, the restoration of charterers' rights. Blockchain and AI are being used to create innovative and advanced solutions to improve the present standards of medical data handling, sharing, processing, analysis, and classification according to the outcomes. With enhanced efficiency, access control, technical development, privacy protection, and security of operational data processes, blockchain technology is transforming the IoT-based healthcare industry. In this chapter, we proposed AI and Blockchain based framework for improving the data security in the smart cities domain.

A. S. Rajawat
Department of Computer Science Engineering, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, India

P. Bedi
Computer Science and Engineering, Lingaya's Vidyapeeth, Faridabad, Haryana, India

S. B. Goyal
City University, Petaling Jaya, Malaysia

R. N. Shaw
Department of Electrical, Electronics and Communication Engineering, Galgotias University, Greater Noida, India
e-mail: r.n.s@ieee.org

A. Ghosh (✉)
School of Engineering and Applied Sciences, The Neotia University, Sarisha, West Bengal, India

S. Aggarwal
Department of Computer Science Engineering, Maharaja Agrasen Institute of Technology, New Delhi, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_12

Keyword Artificial intelligence · Blockchain · Healthcare data security · Smart city

1 Introduction

Blockchain was first developed to support Bitcoin, but it has now evolved into a technology used to operate a wide range of distributed systems. Overall, healthcare [1] can be thought of as a three-part system: (a) core service provider of medical care services including such physicians, nurses, healthcare administrations, and professionals; (b) important services associated with medical care services such as medical research and health insurance; and (c) consumers or members of the general public who require medical or health-related services. It is believed that the current healthcare system will incorporate contact-based and technology-based remote monitoring services provided by constituent service providers to encourage, maintain, or repair recipients' health [2]. The healthcare industry is becoming increasingly interested in several areas of artificial intelligence and Blockchain, such as the immutability of data stored on a blockchain. Many of the apps already available show promising results in this regard. Incorporating artificial intelligence, blockchain technology, and smart healthcare can address conventional smart healthcare's pain points in sharing information, data security, and privacy management, enhance user-centered smart healthcare systems, and establish a multiparty medical alliance chain encompassing government agencies, private companies, and persons to enhance smart healthcare's industrialization. In Fig. 1 show AI And Blockchain-based Data Security in Smart Cities.

We are starting with the top-level design, doctor management, medical records [3] record keeping, treatment optimization, social inclusion, cost savings, externally and internally regulation, medical insurance, and environmental governance, artificial intelligence and Blockchain are helping to improve the Internet of Things-based smart healthcare system. Designing at the highest level, managing medical records, and managing doctors are the primary reasons for system construction; second, in the field of smart healthcare, artificial intelligence and blockchain applications are focused primarily on intelligent contracts, which are dependent on medical records management and are confined by the system, and optimizing the application is the key to upgrading the system. The third point to make is that as the system grows and evolves, regulation, medical insurance, and environmental governance all serve as protective functions, effectively defending stakeholders' interests. The effectiveness of internal and external regulation is critical to the system's health, and health insurance and environmental governance must be encouraged at the first three levels of government. Therefore, the transaction, information, and stakeholder layers must all be present in the intelligent medical service system based on artificial intelligence and blockchain technology.

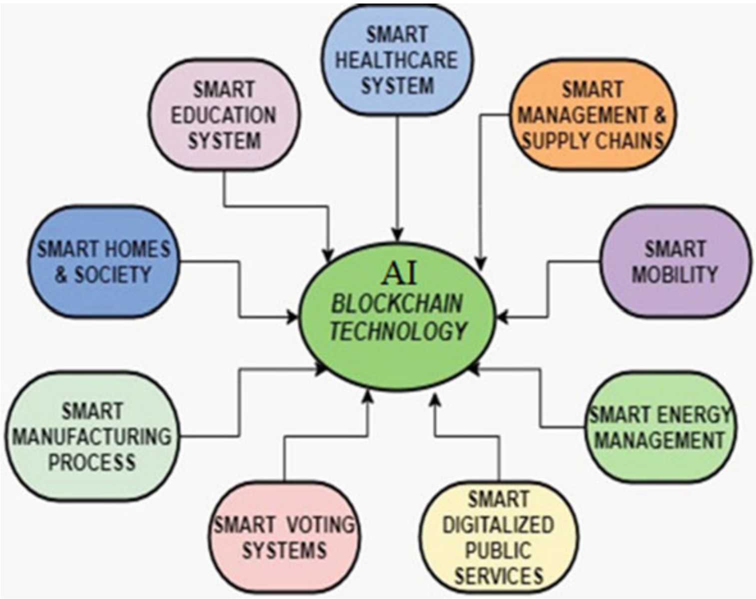


Fig. 1 AI and blockchain-based data security in smart cities

2 Related Work

Bitcoins are just one example of how blockchain technology might be used. It can be employed in a variety of areas, including healthcare. The proposed solution was based on the bitcoin technique, which satisfied the needs of information clients while also protecting patients' privacy. According to this concept, if a consumer wants to look at a patient's record, they must pay a fee in bitcoins. The disadvantage is that the patient's information could be exploited, and paying fees each time is costly. The research changed from public blockchain networks to private blockchain networks. Many people in the healthcare industry need access to the same information. Gem Health Network was founded as a blockchain-based healthcare platform [4]. This design allows information to be shared among multiple entities. The most up-to-date treatment information is readily available to avoid the usage of outdated material. It also shows all of the patent's prior interactions with doctors.

The Blockchain's Ownership The two most popular types of blockchains are permissioned and permissionless blockchains [5]. A permissioned blockchain has been created with a single or several authorities in mind. The verification procedure might be carried out by a central authority or a group of trusted pre-selected partners (consortium).

A group of individuals or several groups controls the Blockchain, and data access is limited to them [6]. A smaller number of players means more efficiency and scalability.

At the end of the day, these blockchains have a central authority [7]. Due to their large number of nodes, permissionless blockchains are completely decentralized and inefficient. Participants' prior consent is not required for the mining of transaction blocks in these blockchains. In exchange for a monetary payment, anyone can lend their computer power to network operations.

This Blockchain is public since it allows the whole public to read and publish transactions to it [8]. The system has decentralization, timestamps, communal maintenance, programmability, and tamper-proofing. Due to a shortage of blockchain applications in medical care, researchers are currently looking to combine Blockchain with other specialized information technology.

Similarly, health insurance might be simplified by removing the need to review medical records [9]. Assuring patients' rights and reducing hospital uncollected payments and management costs are all benefits of using blockchain technology in medical insurance. Table 1 represents the For smart cities, a comparative analysis of several factors for Blockchain Applications in Healthcare System and Table 2 Comparative analysis of different parameters for Blockchain Applications in Healthcare System for smart cities.

Comparative Analysis

Table 1 For smart cities, a comparative analysis of several factors for Blockchain Applications in Healthcare System

S. no.	Citation	Blockchain-based healthcare system for smart cities	Research gaps
1	Hölbl et al. [10]	DEMATEL, fuzzy set theory, and the ISM technique	All possible qualities are missing. China provided the majority of the data
2	Wang et al. [11]	Artificial systems for healthcare	The technology digitizes patients' vital signs and uses a wearable gadget
3	Wang et al. [12]	A decentralised Ethereum network connects manufacturers, distributors, GPOs, and healthcare providers	Contracts should remain secret. Changes to contract source code data fields would be necessary
4	Zheng et al. [13]	Simulation of a PBFT-based healthcare blockchain network using CTMC models	Nodes that fail to replicate are not counted. Component processing methods are not evaluated. In the future, a more detailed CTMC model will be constructed
5	Goel et al. [14]	A blockchain-based healthcare duo Healthcare authority and patient blockchains are combined to promote privacy	Health data is too big for Blockchain. A third party's access may compromise security

Table 2 Comparative analysis of different parameters for AI based appraoch Healthcare System for smart cities

S. no.	Citation	AI based approach healthcare system for smart cities	Research gaps
1	Yu et al. [15]	The usage of image-based diagnostics is increasing in fields like robotic surgery and pathology	In the absence of high-quality training data, deep networks' results are difficult to interpret by humans
2	Dorado-Díaz et al. [16]	Cardiography Using NN	The risk of inaccurate findings and the ML model's interpretability
3	Khan et al. [17]	Mobile health systems use ESMs, EMAs, CT and MRI images to measure patients' correlations between events and disease development	A lack of trained medical people to analyze AI-generated data
4	Reddy et al. [18]	Fuzzy logic-based healthcare delivery, management, and patient monitoring systems	Medical-legal considerations, as well as the risk of sampling bias
5	Noorbakhsh-Sabet et al. [19]	Epidemic forecasting, disease diagnosis, treatment efficacy, medication discovery, and clinical trials	Concerns about data security, clinical staff and patient acceptance of system outcomes

3 Artificial Intelligence (AI) and Blockchain in the Healthcare Industry

The quantity of patient data that healthcare providers and insurance companies have been sharing has increased rapidly in recent years, resulting in the establishment of data-driven healthcare models. The presence of high levels of security and access control in IoT-based healthcare services, which generate and manage tremendous amounts of personal data, is essential. There are numerous methods to enhance the efficiency and quality of smart healthcare with AI. Blockchain technology can help increase claim adjudication quality while also aiding with administrative issues related to healthcare, as medical records are accurate and interoperable with the use of Blockchain in healthcare systems. In this context, the combination of AI and Blockchain [20] can improve data security and data integrity. We could design a data management system that uses Blockchain to manage patient health data by building a shared and unchangeable data structure. Many healthcare records are scattered throughout different healthcare institutions and organizations, leaving patient data out of reach to healthcare providers when they need it most. Healthcare providers have a big problem on their hands. With the usage of AI and Blockchain for the transfer and securing of patient health records and medical data as well as its monetization for

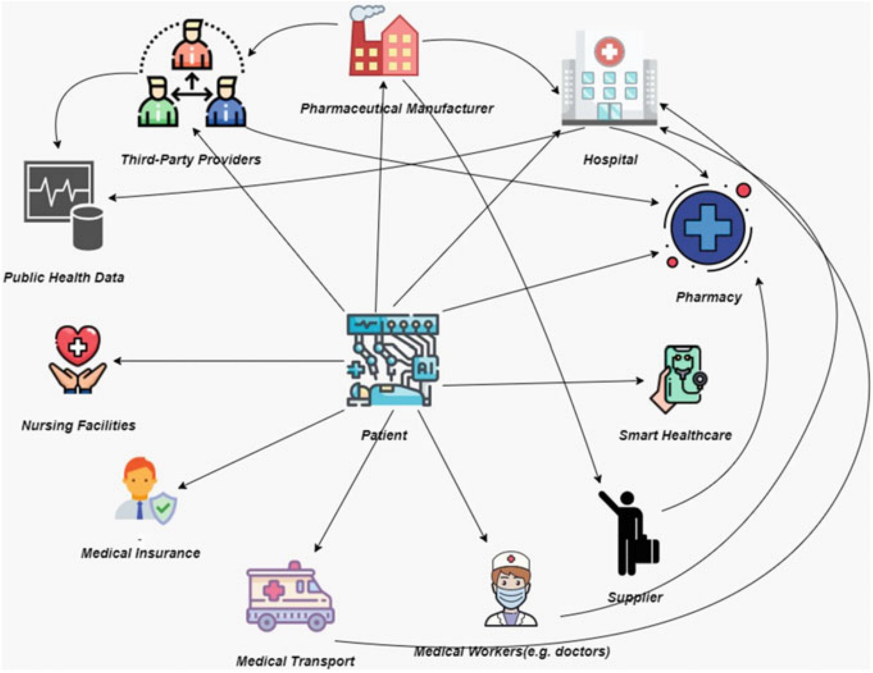


Fig. 2 Stakeholders of healthcare sector

research, smart healthcare is on the rise. In Fig. 2 show the Stakeholders of healthcare sector.

Working Principle of AI And Blockchain

This is how AI and Blockchain are implemented:

Step 1: A blockchain user requests a transaction.

Step 2: Other members are shown the request (i.e., nodes).

Step 3: The network of nodes then confirms the transaction.

Step 4: The nodes complete the transaction after approving the request.

Step 5: A new immutable block is introduced to the blockchain network.

Step 6: A new data block is formed by joining confirmed transactions. To submit data to the Blockchain, one must first log in with a public address and a private key.

AI and Blockchain [21] offer great reliability in e-health services, which may help deliver more tailored and effective treatment. Blockchain allows for secure decentralisation of patient data, using AI-based technique machine learning and deep learning, making medical records and paperwork more accessible to patients and professionals. Doctors may detect severe illnesses earlier with rapid access to health data, perhaps saving many lives. As the horrific events around COVID-19 demonstrated [22], this is critical in urban environments. COVID-19 makes a solid argument for further blockchain integration. These qualities can replace today's value networks, which lack connectedness and frictionless data interchange. To tackle the COVID-19 epidemic, several researchers used blockchain technology to help health professionals make better decisions about social distance and quarantine measures. Using technology, smart citizens' health data might be protected from theft and misuse during this outbreak. For patient ID validation, data security businesses [23] collaborated with smart cities users. Every citizen got a smartcard that linked their SHER (Standardized electronic health record) data to their blockchain identification. Changing the SEHR generates a hash that gets logged in the Blockchain. That way, the SEHR data has a permanent audit trail and cannot be purposely altered. Immutable, timestamped data logs can also be utilized to archive data in existing healthcare databases. Any change to the healthcare database is timestamped and cryptographically signed in a block. In the pharmaceutical industry, drug development and research are among the most costly activities due to escalating healthcare expenses and a drive to develop novel pharmacological cures faster. To allow the exchange of reliable information and knowledge among many people, blockchain technology may be used. Even in non-collaborative research and drug development scenarios, Blockchain can help track and manage data, consent, and adverse drug effects, to mention a few. Pharmaceutical companies rarely outsource clinical research jobs. In this scenario, Blockchain could help ensure data integrity and outcomes verification. With its distributed nature, blockchain technology is suitable for big medical data and IoT-based wearable devices. Blockchain technology can help big data technologies deliver on their promises and generate new applications based on healthcare data. When managing or keeping data, privacy and security are always concerns. To authenticate records, the Blockchain uses consensus rather than third-party permission because all participants can see data. This technology threatens information security and privacy by allowing anyone to view records. Patients can provide authorized staff members access to their data in an emergency, placing it in danger. Blockchain was developed to store and process transaction data. Its limited storage capacity has become a major healthcare data storage issue. Rapid data collection and analysis using Deep learning is used for Covid-19. Hospitalizations, covid-19 test results, X-rays, and death require a lot of storage. Fast-paced programs hate it when database growth slows record searching and information access. Using massive algorithms to secure blockchains can lead to data leakage. Algorithms can be used to bypass security and access a database. The security of patient data is critical.

This is a serious challenge in blockchain-based healthcare. As indicated previously, experts or other employees share patient data. Also, because blockchain and service providers interact, unsecured data exchange is Covid-19 raises possible Indirect and direct cybersecurity threats in healthcare networks. These include DDoS attacks [24], health data theft, and ransomware.

4 Proposed Methodology

Using private Blockchain in healthcare is a great way to preserve data while also preserving patient privacy. Private blockchains allow only a few people to access data, limiting information access [25]. Data access control on a private blockchain is stringent. Furthermore, only approved individuals or patients will access and maintain their data and medical records, held in a private centralized blockchain. It may be a feasible way to protect data. It also improved privacy and security.

Cloud data storage and analysis using AI: Insecure cloud architecture, this option is useful for data storage, sharing, and classification [26]. This gives patients access to and control over their own data. Because Blockchain only provides a limited amount of data storage, healthcare apps have issues keeping regularly generated data. Cloud storage allows the Blockchain to manage enormous amounts of data while also allowing these apps to store data.

Proof of interoperability is a consensus approach that efficiently allows healthcare apps to perform transactions based on network participants' compatibility. The Cloud Middleware will fetch information from the previous level utilizing REST services. The third level will manage the blockchain [27] network's nodes. The blockchain function is separated into various layers, improving interoperability. Figure 3 show the Proposed AI and Blockchain framework.

Multi-factor authentication [28]: Identification can be verified via MFA. To modify the information or store it in blocks or add new blocks of information, 51 percent of all participants must agree. Fraudsters can assume a verified participant's identity and manipulate data. To avoid this risk, multifactor authentication can be utilized to authenticate users. Researchers are leveraging these tools to build AI-based predictive frameworks to improve medical informatics and diagnostics. A few of the practical responsibilities addressed in the healthcare area include prescription fraud prevention, verifiable data collecting, and automatic claim settlement.

Studies have built frameworks to lower the cost of execution, storage, and preservation of data of any scale. These new frameworks are said to improve runtime, delivery, and reaction times. System interoperability, inter-institutional credential management, and data control have all been examined. Prior work on AI and blockchain [29] data management features in healthcare focused on safeguarding data privacy by limiting access to medical records. The study states that access control management [30] has received specific attention. This research focuses on critical healthcare because it protects patient privacy by improving accountability, immutability, and access control. A priori research has established AI-blockchain-based [31] frameworks for efficient, user-centric, secure/encrypted access to patient PHRs and other medical data. Interoperability, authentication, and safe data sharing are all addressed by blockchain applications.

Results

To perform the simulation using the python language and anaconda tools. This study's purpose was to assess the existing state and future possibilities of blockchain

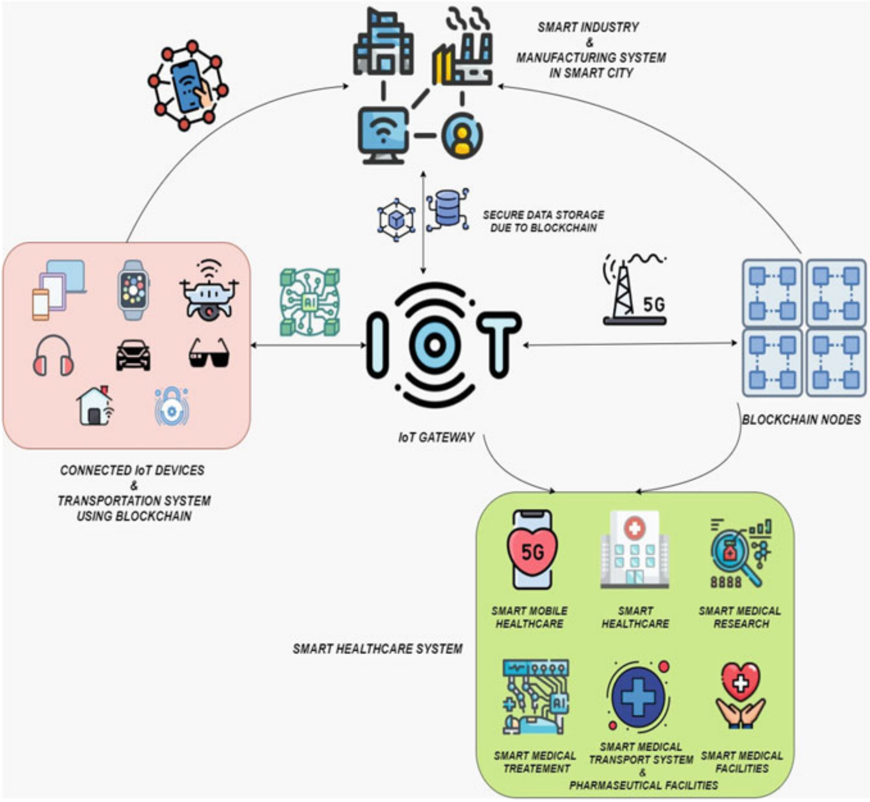


Fig. 3 Proposed AI and blockchain framework

applications in healthcare. Several factors influence the adoption of Blockchain in smart healthcare development [32]. The manner, mechanism, and degree of activity vary depending on the conditions. Blockchain is being investigated and used more in healthcare. According to current trends, Blockchain is used in healthcare for data exchange, health records, and access control, but not for supply chain management or pharmaceutical prescription management. That means a lot of Blockchain's power is unused. Blockchain is largely utilized in healthcare [33] to share EHRs. The traditional security approaches to protecting healthcare apps were inadequate in the past. Blockchain has recently offered new security approaches and procedures for healthcare applications, enabling data security and privacy for clinical, biological, and HER medical applications. Secure blockchain-based [34–36] service computing is vital for trust-free sharing services. Because the Blockchain is decentralized, data availability is not dependent on other parties [26, 37, 38].

We considered the following aspects before making our decision:

- Batch-Time-out: This is when the ordering requires a batch to be generated before it is canceled.

- Batch Size: The number of total messages and bytes in a batch. Amount OF BYTES PER BATCH—The most desired option is the total bytes per batch of serialized messages. Messages that are over the length of the maximum byte will result in batches that are too long. Components running Python and Anaconda with a Laptop with 4 GB RAM and 2.3 GHz Intel Core i3 7th Gen. the process of putting additional pieces in.

Clustered blockchain-IoT architecture: To simulate the prototype, ten IoT sensors were used. Each device generated a random number of network transactions (Figs. 4 and 5).

The blockchain implementation will raise network traffic overhead. In our experiments, we compared the network traffic overhead of conventional and clustered blockchain implementations [39–41]. Block Time: We simulated for 3 h. We found that as the number of blocks increased, so did the processing time. Most systems use a permissionless blockchain network, allowing anybody to join while remaining

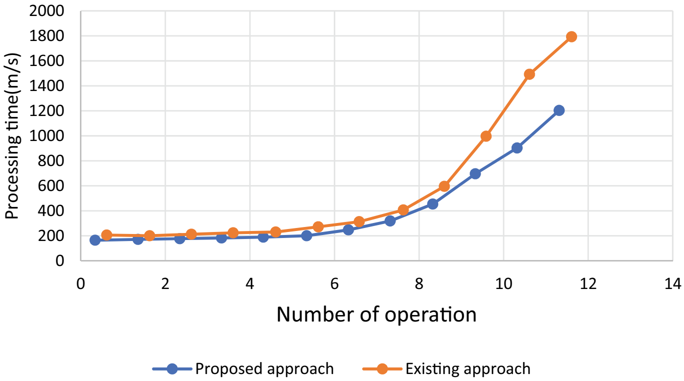


Fig. 4 Comparing processing time between the existing system and the planned blockchain system

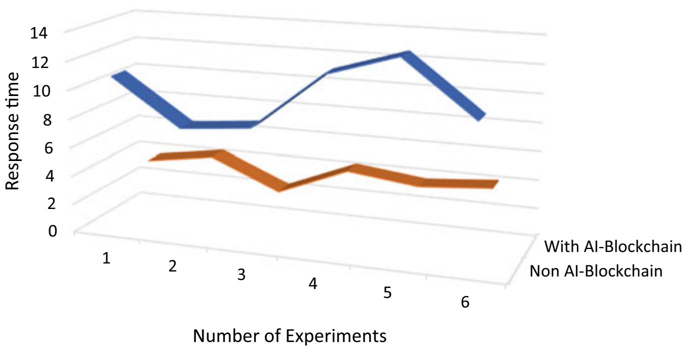


Fig. 5 Write time comparison: existing system versus planned blockchain system

anonymous. So neither the contracts nor the transaction details are secret [42–44]. To maintain privacy, the systems incentivize high-cost or high-performance mining of intelligent contracts. A transaction's cost and speed can be altered.

5 Conclusion

Data breaches, data theft or leakage, manipulation, and other security threats make healthcare data management and storage problematic. Traditional security approaches to protect healthcare apps have proven ineffective. AI and Blockchain have recently offered new security approaches and processes for healthcare applications, giving data confidentiality and privacy. When implemented appropriately, blockchain technology opens up a world of possibilities beyond bitcoin. Blockchain may eliminate central authority and thus the commission. Data can be supplied directly to machine learning algorithms. Due to its rapid expansion, Blockchain has been employed in various ways to improve medical care automation. Most AI and blockchain-related healthcare research focus on e-health record sharing. Blockchain researchers are also interested in biotechnology, pharmaceutical supply chains, and insurance. Articles on implementation are also infrequent. While blockchain technology holds great promise, more research is required to comprehend, develop, and assess it completely. To increase stakeholder trust in adopting this technology and its acceptance in healthcare, ongoing efforts are being made to address scalability, security, and privacy issues.

We will study and analyze advances in electronic devices that have expanded wireless communication system technology globally in future work. As a result, 5G and Blockchain have accelerated communication. We will study the global issue of COVID-19 that has created worry about Blockchain-based smart healthcare application issues in the edge computing environment.

References

1. Yoon H-J (2019) Blockchain technology and healthcare. Healthcare Informat Res 25(2):59. https://doi.org/10.4258/hir.2019.25.2.59
2. Tandon A et al (2020) Blockchain in healthcare: a systematic literature review, synthesizing framework and future research agenda. Comput Ind 122(103290):103290. https://doi.org/10.1016/j.compind.2020.103290
3. Ahmad K (2020) Blockchain technology and its implementations in medical and healthcare field. Int J Eng Res Technol 9(9). https://www.ijert.org/blockchain-technology-and-its-implementations-in-medical-and-healthcare-field. Accessed 20 Aug 2021
4. Du X et al (2021) Research on the application of blockchain in smart healthcare: constructing a hierarchical framework. J Healthcare Eng. https://www.hindawi.com/journals/jhe/2021/6698122/. Accessed 10 June 2021

5. Ray PP et al (2020) Blockchain for IoT-based healthcare: background, consensus, platforms, and use cases. IEEE Syst J 15(1):1–10. https://doi.org/10.1109/jsyst.2020.2963840. Accessed 27 Mar 2020
6. Vyas S et al (2019) Converging blockchain and machine learning for healthcare. IEEE Xplore. ieeexplore.ieee.org/document/8701230. Accessed 20 Aug 2021
7. Yaqoob S et al (2019) Use of blockchain in healthcare: a systematic literature review. Int J Adv Comput Sci Appl 10(5). https://doi.org/10.14569/ijacsa.2019.0100581. Accessed 21 Nov 2019
8. Nguyen DC, Ding M, Pathirana PN, Seneviratne A (2021) Blockchain and AI-based solutions to combat coronavirus (COVID-19)-like epidemics: a survey. IEEE Access 9:95730–95753. https://doi.org/10.1109/ACCESS.2021.3093633
9. Agbo C et al (2019) Blockchain technology in healthcare: a systematic review. Healthcare 7(2):56. https://www.mdpi.com/2227-9032/7/2/56/htm. https://doi.org/10.3390/healthcare7020056
10. Hölbl M et al (2018) A systematic review of the use of blockchain in healthcare. Symmetry 10(10):470. https://www.res.mdpi.com/symmetry/symmetry-10-00470/article_deploy/symmetry-10-00470-v2.pdf. https://doi.org/10.3390/sym10100470
11. Wang S et al (2018) Blockchain-powered parallel healthcare systems based on the ACP approach. IEEE Trans Comput Soc Syst 5(4):942–950. https://doi.org/10.1109/tcss.2018.2865526. Accessed 9 Sep 2019
12. Omar IA, Jayaraman R, Debe MS, Salah K, Yaqoob I, Omar M (2021) Automating procurement contracts in the healthcare supply chain using blockchain smart contracts. IEEE Access 9:37397–37409. https://doi.org/10.1109/ACCESS.2021.3062471
13. Zheng K, Liu Y, Dai C, Duan Y, Huang X (2018) Model checking PBFT consensus mechanism in healthcare blockchain network. In: 2018 9th International conference on information technology in medicine and education (ITME), 2018, pp 877–881. https://doi.org/10.1109/ITME.2018.00196
14. Goel U, Ruhl R, Zavarsky P (2019) Using healthcare authority and patient blockchains to develop a tamper-proof record tracking system. In: 2019 IEEE 5th intl conference on big data security on cloud (BigDataSecurity), IEEE Intl conference on high performance and smart computing, (HPSC) and IEEE Intl conference on intelligent data and security (IDS), 2019, pp 25–30. https://doi.org/10.1109/BigDataSecurity-HPSC-IDS.2019.00016
15. Yu Kun-Hsing et al (2018) Artificial intelligence in healthcare. Nat Biomed Eng 2(10):719–731. https://www.nature.com/articles/s41551-018-0305-z. https://doi.org/10.1038/s41551-018-0305-z
16. Dorado-Díaz P Ignacio et al (2019) Applications of artificial intelligence in cardiology. The future is already here. Revista Española de Cardiología (English Edition) 72(12):1065–1075. https://doi.org/10.1016/j.rec.2019.05.014. Accessed 12 Dec 2019
17. Faizal KZ, Alotaibi SF (2020) Applications of artificial intelligence and big data analytics in m-health: a healthcare system perspective. J Healthcare Eng. https://www.hindawi.com/journals/jhe/2020/8894694/
18. Reddy S et al (2018) Artificial intelligence-enabled healthcare delivery. J R Soc Med 112(1):22–28. https://doi.org/10.1177/0141076818815510
19. Noorbakhsh-Sabet N et al (2019) Artificial intelligence transforms the future of health care. Am J Med 132(7):795–801. https://doi.org/10.1016/j.amjmed.2019.01.017
20. Treiblmaier H et al (2020) Blockchain as a driver for smart city development: application fields and a comprehensive research agenda. Smart Cities 3(3):853–872. https://doi.org/10.3390/smartcities3030044. Accessed 12 Aug 2020
21. Angraal S et al (2017) Blockchain technology. Circul Cardiovasc Qual Outcomes 10(9). https://doi.org/10.1161/circoutcomes.117.003800
22. Chamola V, Hassija V, Gupta V, Guizani M (2020) A Comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AI, blockchain, and 5G in managing its impact. IEEE Access 8:90225–90265. https://doi.org/10.1109/ACCESS.2020.2992341

23. Firouzi F et al. (2021) Harnessing the power of smart and connected health to tackle COVID-19: IoT, AI, robotics, and blockchain for a better world. In: IEEE IoT J 8(16):12826–12846. https://doi.org/10.1109/JIOT.2021.3073904
24. Tanwar S, Bhatia Q, Patel P, Kumari A, Singh PK, Hong W (2020) Machine learning adoption in blockchain-based smart applications: the challenges, and a way forward. IEEE Access 8:474–488. https://doi.org/10.1109/ACCESS.2019.2961372
25. Sun J et al (2016) Blockchain-based sharing services: what blockchain technology can contribute to smart cities. Fin Innov 2(1). https://doi.org/10.1186/s40854-016-0040-y
26. Rajawat AS, Barhanpurkar K, Goyal SB, Bedi P, Shaw RN, Ghosh A (2022) Efficient deep learning for reforming authentic content searching on big data. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_26
27. Alam T (2021) Blockchain cities: the futuristic cities driven by Blockchain, big data and internet of things. GeoJournal. https://doi.org/10.1007/s10708-021-10508-0
28. Rajawat AS, Rawat R, Barhanpurkar K, Shaw RN, Ghosh A (2021) Blockchain-based model for expanding IoT device data security. In: Bansal JC, Fung LCC, Simic M, Ghosh A (eds) Advances in applications of data-driven computing. advances in intelligent systems and computing, vol 1319. Springer, Singapore. https://doi.org/10.1007/978-981-33-6919-1_5
29. Tagde P, Tagde S, Bhattacharya T et al (2021) Blockchain and artificial intelligence technology in e-Health. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-021-16223-0
30. Rajawat AS, Rawat R, Shaw RN, Ghosh A (2021) Cyber physical system fraud analysis by mobile robot. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_4
31. Yaqoob I, Salah K, Jayaraman R et al (2021) Blockchain for healthcare data management: opportunities, challenges, and future recommendations. Neural Comput Appl. https://doi.org/10.1007/s00521-020-05519-w
32. Rajawat AS, Barhanpurkar K, Shaw RN, Ghosh A (2021) Risk detection in wireless body sensor networks for health monitoring using hybrid deep learning. In: Mekhilef S, Favorskaya M. Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_54
33. Rejeb A, Treiblmaier H, Rejeb K et al (2021) Blockchain research in healthcare: a bibliometric review and current research trends. J Data Inf Manage 3:109–124. https://doi.org/10.1007/s42488-021-00046-2
34. Zhang G, Li T, Li Y et al (2018) Blockchain-based data sharing system for AI-powered network operations. J Commun Inf Netw 3:1–8. https://doi.org/10.1007/s41650-018-0024-3
35. Bedi P, Goyal SB, Rajawat AS, Shaw RN, Ghosh A (2022) A framework for personalizing atypical web search sessions with concept-based user profiles using selective machine learning techniques. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_23
36. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Multi-objective fuzzy-swarm optimizer for data partitioning. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_25
37. Garg C, Namdeo A, Singhal A, Singh P, Shaw RN, Ghosh A (2022) Adaptive fuzzy logic models for the prediction of compressive strength of sustainable concrete. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_47
38. Palimkar P, Bajaj V, Mal AK, Shaw RN, Ghosh A (2022) Unique action identifier by using magnetometer, accelerometer and gyroscope: KNN approach. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_48

39. Rawat R, Mahor V, Chirgaiya S, Shaw RN, Ghosh A (2021) Analysis of darknet traffic for criminal activities detection using TF-IDF and light gradient boosted machine learning algorithm. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_53
40. Rawat R, Rajawat AS, Mahor V, Shaw RN, Ghosh A (2021) Dark web—onion hidden service discovery and crawling for profiling morphing, unstructured crime and vulnerabilities prediction. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_57
41. Paul A, Sinha S, Shaw RN, Ghosh A (2021) A neuro-fuzzy based IDS for internet-integrated WSN. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_6
42. Rawat R, Mahor V, Chirgaiya S, Shaw RN, Ghosh A (2021) Sentiment analysis at online social network for cyber-malicious post reviews using machine learning techniques. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_9
43. Kumar A, Das S, Tyagi V, Shaw RN, Ghosh A (2021) Analysis of classifier algorithms to detect anti-money laundering. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_11
44. Rawat R, Rajawat AS, Mahor V, Shaw RN, Ghosh A (2021) Surveillance robot in cyber intelligence for vulnerability detection. In: Bianchini M, Simic M, Ghosh A, Shaw RN (eds) Machine learning for robotics applications. Studies in computational intelligence, vol 960. Springer, Singapore. https://doi.org/10.1007/978-981-16-0598-7_9

Towards the Sustainable Development of Smart Cities Through Cloud Computing

Tanweer Alam, Mohd Tajammul, and Ruchi Gupta

Abstract Smart cities are the most interesting, visible, and challenging usage of emerging technologies such as the Internet of Things (IoT), Cloud Computing, and Artificial Intelligence (AI). Everything in smart cities becomes connected to everything else. The emergence of smart cities solutions understands how cities thrive through service responses, data collection, analysis, and citizen communication. Everything can explore, strategize, and adjust in real-time through sensors and devices. Several services can be made available in cloud computing, and people of smart cities can use those services in real-time. A smart city can respond rapidly and smartly that necessitates human life, eco-friendly security, public protection, and city contributions, among the things. Cloud computing is now widely employed in a variety of fields. All information will be available on the cloud, and clients will access all communication at any time and everywhere they wish. What are the advantages of cloud computing in the construction of a smart city? It is also studied how cloud computing promotes the development of a smart city and what social conditions are appropriate for making full use of the infrastructure needed to build a smart city using the cloud. Cloud computing gives a new realistic technique to share resources and help as a form of navigation and application styles in terms of infrastructure and administrator. The global business machinery association and CISCO provide a high-level perspective of smart city statistics to adapt to the developments in smart cities. Governments worldwide are paying particular attention to IoT, AI, and cloud computing, and they have published practical instructions to promote emerging technologies and smart cities. In this chapter, the authors explore the roles of emerging technologies in smart cities.

T. Alam (✉)
Islamic University of Madinah, Madinah, Saudi Arabia
e-mail: tanweer03@iu.edu.sa

M. Tajammul
Department of Computer Science, Jamia Millia Islamia, New Delhi, India

R. Gupta
Ajay Kumar Garg Engineering College, Ghaziabad, Utter Pradesh, India
e-mail: guptaruchi@akgec.ac.in

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_13

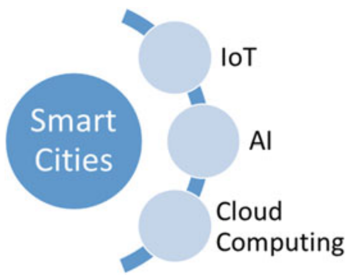
Keywords Cloud computing · Smart cities · AI · Urban development · IoT

1 Introduction

Around the world, city managers attempt to cultivate a positive presence and improve the number of useful contributions to their inhabitants, agencies, and tourists. Smart city projects are gaining popularity in several countries as mayors, businesses, and individuals collaborate to beautify their neighborhoods, cities, regions, and other locations worldwide. Revolutionary undertakings have developed after more than a decade of intellectual revolution, but few have had a troubling influence on the city's design. Because every large city is unique, there are only a few models to choose from. Leaders must remember various objectives to respond effectively: Always consider people's lifestyles and emphasize primary ambitions and desires. People shall grasp its project: cohesive, sustainable, and inclusive growth in metropolitan areas unless the definition of a smart big city varies. Figure 1 shows smart cities and emerging technologies.

A smart city collects facts, converts them into statistics, and uses the edge information to make decisions in the near or real-time to deliver better services to inhabitants, improve performance, and save costs. For example, a sensible city can reduce traffic congestion and pollution by strengthening transportation and equipment infrastructure. It can save energy by improving the [1, 2] utilization of luminaires to offer timely or event-based lighting utilizing real-time analytical sensors. Using real-time capture and sensory and observation data can provide prompt reactions to social protection issues. The ability to change how a city works and provide for future generations is readily limited, both technically and monetarily. Smart Cities are well-suited to take advantage of an increasing number of solutions that promise to advance transportation, defense, energy, fitness, training, property, and government provision. The foundations of smart cities many urban solutions rely on a mix of basic technology like computers, garages, databases, and warehouses and advanced technologies like virtual reality analytics, an IoT-enabled device, and AI [3, 4]. The most essential of the big city solutions is not the sensors in the ground; it is the sensor-rich data that allows cities to collect them, among other things. End cities driven by cloud computing are known as smart cities. Why are statistics so vital? When translated into records for

Fig. 1 Smart cities and emerging technologies



the sake of authentic papers. It explains what is efficient, ineffective, or desirable to modify to accomplish the metropolitan government's goals. The facts might be accumulated by employing a variety of approaches. Sensing, extracting statistics from present systems, and collecting external data feeds, for example, can all be used to aggregate data. Cities can use inhabitants as sensors to collect data beyond what is available from open sources, such as weather data and map records. Understanding cities is functional and can take appropriate action through a mathematical decision-making process by gathering, storing, and analyzing facts. Massive-scale computing also records statistics infrastructure to fulfill the needs of smart metropolis responses, allowing communities aiming to get rich to measure their assets in a secure, efficient, and timely manner.

1.1 Role of Information and Communication Technologies (ICT) in Smart Cities

Trading has increased through the ICT, and merits based on the ICT formation have continued in smart cities. More than a decade ago, research and development of future cities from the ICT period became a crucial strength in Korea. The omnipresent city call, smart city fence, and smart town consortium resulted in the first large-scale smart city effort. In 2013, the European Union launched a smart city initiative to promote good changes in future cities. It has hastened the development of smart cities around the world. By 2017, more than 250 smart cities have been build worldwide. The global market for identified city solutions and proposals will anticipate reaching $ 89 million by 2026. In computer and energy centers, cloud computing has expanded dramatically over the years, with the ability to change businesses into more responsive and faster than ever before [5]. Figure 2 shows the smart cities' main areas where cloud computing can play a vital role.

In recent times, people have started using power as soon as people connect our electrical gadgets to the power grid by attaching our plug to our electrical appliances in the store. The way energy is generated and used has improved, and as a result, significant changes in our lives, industry, and society have occurred [6, 7]. A smart city center aims to improve record infrastructure, combine information-sharing platforms, and deliver automated customer service through system performance and generation from one or more record sources. Following that, the community, company, and city management can enjoy a wide range of services. Similarly, cloud computing has revolutionized the manufacturing and consumption of computers. Things that were once impossible within the supernatural are now possible thanks to the cloud computing function. Cloud computing has provided a fantastic alternative to a variety of traditional indicators. Cloud computing has encouraged future cities to become more prominent, and the most crucial aspects of an extensive smart city are now more critical than ever [8, 9]. Cloud computing is essential in processing large amounts of data in smart cities. It is a significant issue in using the IoT in smart cities. It is

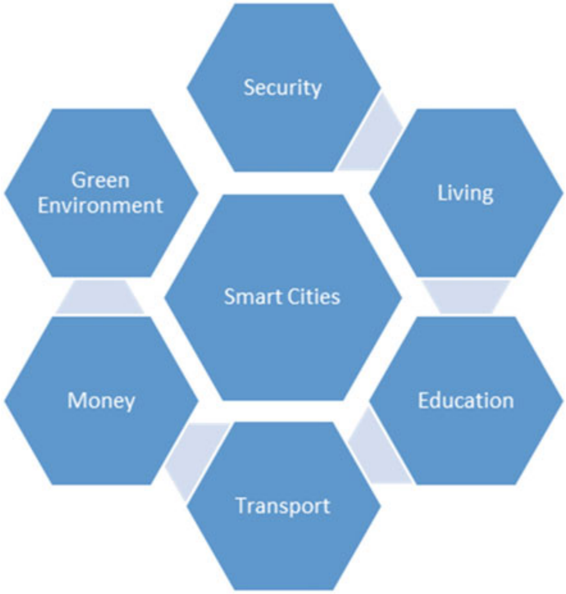


Fig. 2 Smart cities main areas

precious in intelligent processing that supports smart services in smart cities. Cloud computing is a foolproof approach to respond swiftly to the ever-changing dynamics of smart cities. It comes especially handy for dealing with surges in computing demand in smart cities.

1.2 Role of Cloud Computing in Smart Cities

Cloud computing can assist cities by developing new services more quickly while also improving existing services. Some of the areas where cloud computing can aid are as follows:

Speed

Cities may pass flyers rapidly and evaluate many solutions at a cheaper cost. When projects are cut down short of fliers and begin city operations, this helps to reduce risk.

Decrease the Number of Resources

AWS bring in 64%, according to the International Statistics Center. The research also revealed a 560% return on investment over five years and an 81.7% return on investment indefinitely.

Improved Security and Compliance

Cloud security on Amazon Web Services is a primary concern. Customers of AWS benefit from a reality center and network design tailored to the needs of the world's most sensitive security firms.

Off-the-Shelf Solutions

Cities can use a variety of off-the-shelf solutions that will be accessible on AWS by purchasing them directly from the AWS market with a few clicks. Smart Cities—Cloud computing is used to enable the final cities. Integration of data and analysis: The cloud can act as a freehub, allowing disparate systems to be linked together.

Integration of Data and Analysis

The cloud can act as a freehub, allowing the integration of different systems and recording sources.

Improved Skills

As responses get more complicated, high-level presentations like practical skills, system learning, and communication become more successful. Clients can minimize carbon emissions by up to 88 percent by operating in AWS by combining the appropriate amount of energy with a combination of low-energy power.

The rest of the chapter is organized as follows: Sect. 2 Migrating cities to the cloud, Sect. 3 Cloud computing's role in smart city development, Sect. 4 Layered Architecture, Sect. 5 Cloud computing in smart cities, Sect. 6 Opportunities of clod computing in smart cities, and Sect. 7 Examples of Smart cities solutions driven through emerging technologies.

2 Migrating Cities to the Cloud

Cloud computing works similarly to the Internet in that computation is distributed across a more significant number of shared machines than nearby computers or remote servers. The following are the primary characteristics:

1. The cloud machine features an automatic storing feature and advanced power control. When it is used, data storage and usage are no longer affected. When a single laptop inside a cloud device crashes, data storage and usage will be unaffected. As a result, using a cloud-based computer can provide us with a trustworthy and secure database.
2. Because all cloud device systems now work outside of the client, the need to process the capacity and location of the PC customer garage is minimal. Customer computer repair charges and computer gadget requirements are currently reduced because hardware and software are delivered through a cloud device controller [10–12]. As a result, the device is straightforward to operate.

3. Data and consumption can be shared due to the widespread use of cell phones to collect statistics and provide quick network improvements. Customers with a single laptop or digital device may always get the records and analytics they need from the cloud over the Internet. The entire mobile storage space inside the cloud machine is a demander and a mathematician.

Three exceptional carrier levels are available with cloud computing:

1. An infrastructure layer Access to device resources and services, such as computer equipment, archives, and voice exchange equipment, is provided by infrastructure as a client. As a result, every infrastructure, particularly computer and storage technology, can be used to provide customer care.
2. The middle layer, which is located above the infrastructure, casts a shadow on the platform layer. The platform as a provider is built on top of the infrastructure. It provides a platform for expanding all types of software programs, such as the exact program development area, a garage management device with almost no big data set, recording systems with great authentication, and some cloud-based computer systems [13, 14].
3. The devices are immediately linked to the consumer program, the software system as a platform system, and all sorts of usage options appear principally based on the cloud platform. Clients have a physical knowledge center in the first phase of cloud computing.

Although the server, Internet, and storage are physically focused, the statistical centers themselves are fragmented, and resources are scarce. Although the server, Internet, and storage are all physically focused, the statistical centers themselves are scattered, and resources cannot be pooled at this level. A digital reality center, where clients may quickly build a cloud and transform a physical location into a cloud, is required to visualize cloud computing. The public cloud between the digital center and the outside can assist computer installation with cloud connectivity, after which a request for valuable resources from consumers will be met in the default service model.

2.1 Cloud Solutions

A smart city is defined by a modern lifestyle and public control system that can intelligently collect major data and fill in details by integrating the city's statistics platform and sharing record-assisted production, including cloud material, cloud computing, and record infrastructure. As the most recent type of urbanization, smart cities fix communication lines between citizens, organizations, and government and immediate replies to all kinds of demands, such as livelihood, social security, metropolitan services, and business games, making cities more efficient. The smart technique of the town is to gather all the sources of truth in all the information gadgets that help the city function and lead them to a piece of fantastic information sharing device using internet materials and cloud computing [15, 16]. The fundamental challenge with the grant is compiling details of a vast city on a faraway information island. Due to a lack of productive standards for general information, integrating the data given in different departments is extremely difficult, and total distribution and communication is impossible. Due to a lack of sharing techniques, vast amounts of data generated from specialized departments could not be exchanged during the expansion of the metropolitan region, resulting in delays and statistical shortages. This condition could jeopardize the use of several data sources and the development of a smart big metropolis. Figure 3 shows the cloud services.

1. As a result, combining records from various city agencies is critical in developing a smart city in addition to the integrated requirements for data building. Best of all, if the above two conditions are met, something extraordinary for sharing great records can be created, after which all people, businesses, and city dwellers will be able to locate smart carriers, and people will have a lovely city.
2. Making the communication infrastructure and reality more complete, building a platform for sharing information, and enabling all city sports members to access high-quality comfort services effectively and intelligently from smart city buildings and related smart devices are all key challenges in building a smart city.
3. A smart city system must have a cloud of city information. All city services must be provided through an integrated cloud platform. All assets may be shared

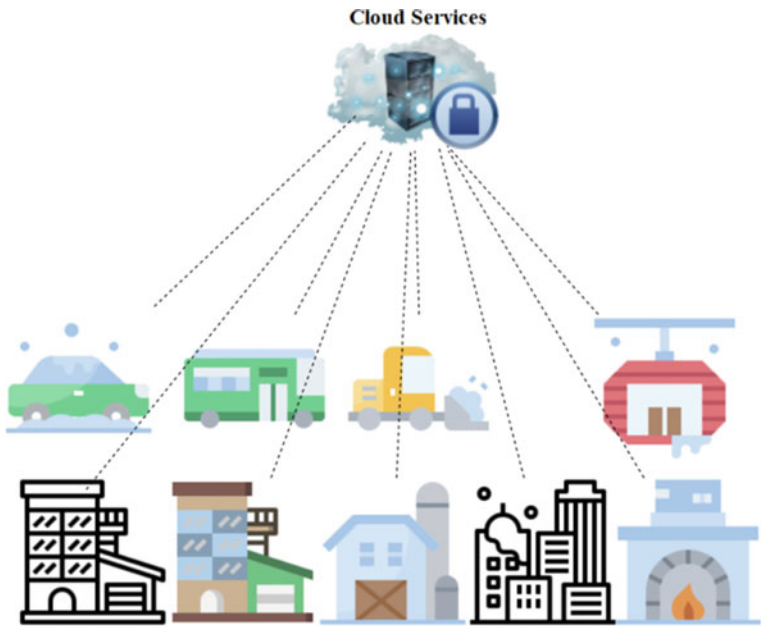


Fig. 3 Cloud services

between unusual portions of the device, and customers must be provided with a smart provider with visualization design experience.
4. As a result, a great metropolitan system based totally on computer processing should have a speaker that can connect all resources, communicate device numbers, and enable cloud-based interaction.
5. The cloud infrastructure, platform cloud, and awareness cloud components of the smart metropolis machine should be compatible with infrastructure as a carrier, platform as a service, and software system as a provider, respectively. As the lowest resource base, the cloud infrastructure provides essential physical resources such as servers, networks, and garage devices to meet mathematical needs.
6. The promotion of all contributions and records sources is the cloud of infrastructure. All independent cloud control firms build a pool of relevant infrastructure for cloud infrastructure in the form of a virtualization platform.
7. Finally, the purpose of suspension and cooperation is discovered. It sits in between the infrastructure cloud and the application cloud, the platform layer cloud, and the fundamentals of data exchange.

The platform layer's job is to manage local assets and integrate cloud infrastructure record resources via network recording and statistical transitions. Assets must be redesigned after integration, additional software obligations must be shipped, and resources must be employed economically and effectively. The cloud of resources is the top level of the overall cloud system, and it is where information is shared. The provision of a launch platform is a vital component of the app cloud. People can develop all kinds of governance issues in this layer to fulfill the demands of the city's sportspeople.

2.2 Urban Development

A smart city is equipped with basic infrastructure to provide the initial satisfying value of existence, a simple and long-lasting environment, and a few smart replies software. The main infrastructure, in this context, refers to ensuring water and energy delivery, sanitation and sustainable waste management, green urban mobility and public transportation, strong connection, e-governance, citizen involvement, and citizen safety and security via ICT [17–19]. Through a few significant regions: economic system, travel, environment, people, inhabitants, and government, a smart metropolis in the form of a developed urban environment promotes sustainable financial development and transcendent beauty.

Solid human resources, social security, and information technology infrastructure can thus help promote such critical regions. A smart city is a thought-provoking urban development that combines multiple records and creates online and IoT solutions in a convenient way to manage the city's resources. The city objects include, but are not limited to, information systems, routes, hospitals, power plants, water supply networks, waste management, regulatory enforcement, and various public services [20, 21]. Building a smart city has two goals: to promote good health through urban informatics and time and to increase the efficiency of charitable rewards.

ICT allows city officials to engage directly with the city's network and infrastructure, allowing them to communicate what is going on in the city, how it is changing, and how to give the best possible quality of life. A smart city would also be more prepared to meet challenges than a city with merely a "trade" connection with its residents. If you wish to lessen utilization, waste, and conventional money, a smart city is a metropolis that incorporates information and verbal exchange technology to increase the initial rate and performance of the city's offerings, such as energy, transportation, and resources.

2.3 Computing in the Cloud

A significant strain on your laptop is learning how to use cloud storage and acquire access to statistics and programs on the Internet. The cloud is merely a simplification of the Internet. Most computer gear and software that you use on your computer device or elsewhere in your organization's community is offered as a carrier by any other company and accessed online, generally in the proper way, through cloud computing. To one of the helpful individuals, the word "cloud computing" denotes several things. For some, it is just another way of explaining (record technology) "employee dismissal"; for others, it is a generic term for any computer carrier offered by the same network or community and inspects. Instead of being stuck on a computer, cloud computing allows you to save data on a remote (cloud) server [22, 23]. You can access your data from any web-enabled device, such as a smartphone, tablet, computer, or computer. Cloud computing is a much-needed service that has piqued the company's data centers' interest.

Types of Cloud

The cloud allowed the statistics center to be used as a network and computer resource that could be purchased and used conveniently and efficiently. Features, like other technologies, begin within a firm and spread through small business owners.

Public Clouds

The Internet is essentially the public cloud. Service providers utilize the Internet to develop software applications (also known as software-as-a-service) and storage accessible to the general public or the public cloud. Amazon elastic compute cloud (ec2), IBM's Blue Cloud, Sun Cloud, Google App Engine, and the Home Windows Azure Offer the platform that are all examples of public clouds. These types of clouds will deliver a first-class economy to customers, and they will be inexpensive to set up because the corporation will cover the costs of hardware, software, and bandwidth. It is a payment plan based in terms of utilization and optimum pricing.

Private Clouds

Non-public clouds are architectures that allow real-time real-world flexibility, speed, provisioning, automation, and monitoring. The non-public cloud policy does not advertise as-a-service offerings to external clients but rather reaps the benefits of cloud-building without giving up control of your data center.

Hybrid Clouds

Teams can use a hybrid strategy to control their own internally managed cloud while still relying on the broader public cloud as needed. For example, bulk applications or high-speed character packages can be moved to the comprehensive public cloud.

Cloud Computing Services

Cloud computing encompasses many computer components (from hardware to software) that a single solution cannot provide. Direct responses are most typically tailored to the individual's preferences and are intended to convert resources like genuine software. Cloud computing makes it possible to meet the demands of all individuals by utilizing various sorts of services. Infrastructure integration usually entails the following:

Infrastructure as a Service (IaaS)

Guarantees computer infrastructure, which is frequently viewed as a service. As a result, the end-user has complete control over the computer-generated process and can, for example, personalize it. Customization time is spent on delivering more clients and isolating oneself from the competition. Because several digital times can be shared with a single body device, customization time is utilized to deliver more consumers and isolate themselves from customers. Unlike buying portable servers, IaaS is billed on an app-by-app basis based on input costs.

Platform as a Service (PaaS)

Provides a computer platform and solution stack carrier. It hides all of the drawbacks of working with subpar hardware by giving all of the resources required to assist with the whole life cycle of developing and deploying web programs and services entirely online.

Software as a Service (SaaS)

SaaS is a software delivery model in which a corporation promises that others will use its software.

3 Cloud Computing's Role in Smart City Development

The smart town vision entails a distinct style of life based on extensive data from connected sensors, gadgets, and other devices. Chronic urban issues are safety, waste management, and tourism can be handled through statistics to achieve efficiency; however, all data wishes to go where it can be accessed and used without difficulty by all stakeholders, including individuals and the government. A smart digital platform is required to address this need [24–26]. The cloud carrier will aid in eliminating government retention, in which different departments lack a straightforward means of interacting and notifying the absolute priority of telecommunications. The cloud carrier will aid in removing government retention. Different departments lack a specific way of interacting and informing one other's absolute priorities, which appears to be a significant impediment to implementing smart cities [27–39]. As the ongoing protection of IoT devices has produced substantial security issues, protection is also a key component of a brand-new product. Cloud-based infrastructure, frameworks, and applications (IaaS, PaaS, SaaS) given by cloud platforms, as well as hurdles and providers to the use of cloud technology, as well as system and e-service changes as a result of their move to cloud environments Cloud computing, has the following characteristics.

3.1 Service Provider

Client can deliver goods in a variety of ways (e.g., garage, processing capacity, memory, bandwidth, etc.) to machines without requiring human connection with the cloud corporation.

3.2 Widespread Public Acceptance

Assets are available online and on various devices (e.g., cell phones, tablets, laptops, and workstations). Because the gene buyer cannot pinpoint the specific location of a given resource, there is a sense of local sovereignty. The role of cloud computing is in the creation of smart cities.

3.3 Rapid Development

The cloud environment allows the client to upgrade or reduce the cost of infrastructure more quickly. For the client, the abilities they must-have in the provision appear to be limitless and can be retained at any time. Cloud systems employ a lever-aging meter performance at a specified output level that is acceptable for the type of network company to reveal, control, and record the use of its assets. As a result, the buyer and the carrier have a defined relationship.

4 Layered Architecture

There are five straight layers and two vertical layers in the structure. Platform integration, information gathering, statistics and layout extraction, and platform integration generate standard, static data for smart cities requiring software in the top three layers. One of the design ideas here is to include contextual know-how in the odd tiers of the structure so that the arrogance of exact and final knowledge and relevant context statistics are always aligned. Figure 4 represents the layered architecture of cloud computing for smart cities.

4.1 Platform Integration Layer

The platform integration layer is a cyber architecture that ensures access to the information platform and is primarily based on a hybrid cloud environment. The record collection and analysis platform secures environmental data from various resources, including remote data storage, sensor networks, and citizen viewpoints, such as the National Weather Service. He works with smartphones in a cloud environment.

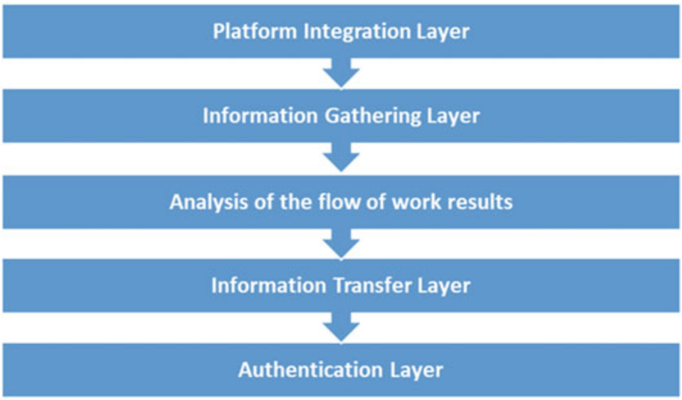


Fig. 4 Layered architecture

4.2 Information Gathering Layer

This layer also assures the accuracy of the information gathered and identifies the need for significant fact organization and fact purification. The context-aware feature is used to filter unrelated data and improve visibility and integration only in records that are connected to the context. The thematic layer organizes the data into software categories, plays the layout, and updates other layers' statistics and network lists. A carrier construction layer is required to build workflow, identify data resources, and process additives required to maximize workflow.

4.3 Analysis of the Flow of Work Results

This layer can also be used to do an essential analysis of the flow of work results. The rest ensures the maintenance of a knowledge base and various tactics that may be utilized to analyze certain professional frameworks in the application components. And only contributions relating to the substance of workflow construction and real-world technology are used to present something that understands the context. For specific assistance center machines that feature simulations and visual maps to perform optional content testing, the application provider layer uses the results from the application builder layer.

4.4 Information Transfer Layer

Furthermore, this layer enables participants to use existing gears while also expanding the new application area for specific components and services (saas stage) in order to suit the contextual needs of users to leave. The management and integration layer is responsible for transferring filtered records and statistics between layers. It ensures that the results being sent from one layer to the next are accurate in terms of performance and in line with context.

4.5 Authentication Layer

Additionally, there is a desire to control changes that occur in irregular layers and to limit the number of statistics where the fundamental structure necessitates greater management. The security layer guarantees that information provided by authorized users is properly authenticated, authorized, and tested. It also assures those stand-alone users may analyze and receive context statistics from the cloud environment with ease of customization and prediction.

5 Cloud Computing in Smart Cities

Cities that are smart enough to be highly crucial to those "ideal communities" can be funded with 5 g, but they will also rely on other technologies to improve their performance. This is where cloud computing comes into play [30, 31]. Cities will create and collect so many records that six billion people will live in smart cities by 2045 that more computer power may be necessary. The visual infrastructure of smart cities will be provided by cloud production: in a word, the city cloud will be viewed as a data storage and testing system that will be utilized for everything from reliable autos to farms. The cloud promises increased flexibility for companies with a wide range of bandwidth requirements and improved security. People who use clouds are naturally low maintenance (since the computer industry will utilize it and transmit any critical updates), and it is much more convenient: if you lose a device or computer. You can retrieve information stored in the cloud if you lose a device or computer, for example.

1. The cloud also provides for quick record transmission between colleagues and employees and secure access so that you can sketch from anywhere. Enterprises can run without money, particularly in the areas where they operate. Small business is a city engine, states the main forbid piece.
2. However, clouds in a smart city do not imply that the city is performing effectively. Data can be saved, evaluated, and used by management and government to take constructive action soon.
3. However, in the long term, specific records and a pushed-up comprehension of data from a single cloud can be offered to cloud vendors in other cities, paving the way for the advent of a "template" control machine capable of rehabilitating a "regular" city. People may count on the construction of full networks of smart cities that deliver borders, pool statistics, and insights and evolve in real-time, while a fast-paced project must take the required steps to build a smart, single city.
4. Future cities will improve the lives of their citizens; otherwise, their existence would be redundant. However, people may be already underestimating the number of smart cities capable of doing this.
5. While the consulting firm set a record for how the city's current plans affect citizens' lives, the author now expresses his surprise at the enormous size of the powerful influence in some of the existing indicators—and why mobility, public safety, and environmental standards are no longer working so well.
6. According to the document, smart cities reduce city-based homicide, promote public health, and positively influence the environment. As a result, what appears to be clean is not the best thing that the clever cities are close to, but they are the ones that reject the betterment of human life. The most important thing for those cities to do is to adopt cloud computing as a dependable, pleasant, and powerful tool to store, analyze, and assess data.

7. Smart Cities are a network of communication technology that communicates, transmits, and investigates data that is critical to the running of a city. Such technology is now required in all aspects of municipal infrastructure and transportation, energy, economic and social development, site visits, the environment, and health.
8. In the real world, installing the IoT and cloud computing together is critical if smart cities are to perform seamlessly across all sectors of the public and private sectors. In reality, proving that smart cities can mix each IoT and cloud to generate superior results may be a long way off.
9. In other words, apart from cloud computing, it is feasible to offer social safety, promote the use of green energy, and build a cohesive society by picturing intelligent cities that are capable of managing everything from trash management to traffic congestion.
10. People are currently investigating the advantages of cloud-based technology and several cloud-based initiatives that are likely to deliver a popular trade. Everyone will benefit from cloud computing in smart cities. When people look at cloud computing platforms, there are a few advantages that smart cities should consider. Cities are no longer just assisting in the production of a host of digital infrastructure.
11. While cities construct digital infrastructure, they are increasingly helping to create a more secure environment and assisting in producing a variety of vital facts in public and private organizations. Smart cities must also improve performance, promote transparency, and develop new methods for residents to interact with cities and businesses. Cloud has its plans and benefits that are distributed legally.

6 Opportunities of Cloud Computing in Smart Cities

6.1 Information Management

One of the most essential areas for smart cities to develop is the integration of records and mines. Even in a large smart city, processing, assembling, analyzing, and dealing with data are a way of life. The cloud is critical for making some changes appear consistent and appropriate. Cloud computing advances have made it possible to install and retrieve data more quickly [32, 33].

6.2 Sustainability

For example, given that smart cities are not known for their robust functionality, cloud computing's position is highly effective. Smart cities make use of assets that have a direct environmental impact. To combat this problem, towns are looking into long-term solutions that involve selection, planning, design, control, and prevention. Cities are researching sustainable methods to combat this plague, including selection, planning, design, management, and resource provision, to guarantee that those designs are in line with sustainability concepts. Cloud computing also acts as the foundation for supplying cities with long-term infrastructure. The network's ability to deliver a wide range of programs and programs has been substantially enhanced by introducing cloud-based technology. Delivering a major metropolitan package into the bush can enhance how facts are applied while also making life forms easier for citizens. Furthermore, enterprises that operate in smart cities have become part of a long-term model.

6.3 Financial System

When new technologies are developed to assist smart cities, they have long-term implications for the economic system's development. Partnerships between cities and businesses have the potential to attract large sums of money. Businesses, as well as the community, can benefit from the amassed data. They can see their role in a larger population and provide an active provider.

6.4 Cost Reductions

The entire concept of establishing a smart city will fail if communities are unable to decrease operating costs. Building smart cities are critical for lowering city operating costs and providing people with high-quality services. To put it another way, cloud-based packages and services have the potential to reduce costs.

6.5 Citizens Use a Cloud-Based App to Pay for Their Travel

The major city of La County's transportation authority (l. A. Metro) is changing the way consumers pay for their travels. People can use a tap card gadget to pay for subway rides in Los Angeles. This smart card system replaces 27 organizations at 99 train stations and 3800 buses in the Los Angeles region. Metro's machine has been created, including adding a cloud-based solution from the merchant cloud. Rather than spending half a billion dollars on security is to construct an entirely new system. Metro has opted for a hybrid approach, combining the existing price gateway with the commercial personnel.

People can pay for their wish to travel with a single account thanks to a new gadget known as tapforce. Metro Chicago has replaced its CRM control system with cloud providers, advertising, and vendor-provided network cloud. Clients can add value to their faucet/account cards, view travel history, order new play cards, and join new product-type programs using tapforce's cloud generation. Furthermore, the cloud-based machine provides discounts or lowers trip costs. For the most personalized accounts, miles function as a single point blocking the entrance to charging different trip possibilities. This is the first step, which is made possible by l. Metro allows consumers to link their account to their tap account.

In 2019, l. Metro wants to connect a cash-in-transit parking machine, electric vehicle charger, scooter sharing, small travel, and hiking in the same way.

6.6 Smart Council's

According to the Smart Council's new center, Arizona nation university has joined with AWS services to increase the visual appeal of brilliant city designers. The goal is to open doors to new options, reduce cases, enhance personnel, and facilitate community input sharing. As a result of this collaboration, the state of Arizona developed an AWS-powered smart town cloud innovation center (CIC). The initiative focuses on the development of intelligent communities in Phoenix. The Amazon Web Services cloud solution will aid in the resolution of significant issues in the vicinity of networks. Some city planners, health administrators, and college funders are on the verge of solving problems, including private automobile management, health management, urban sustainability, and more. To address the limitations of virtual infrastructure, the smart metropolis CIC has limitless power. One Arizona innovation center uses cloud deployment, AI, and a learning program to reuse the globe.

6.7 Robotics Testing on the Cloud

A robot maker, a service application from Amazon Web Services (AWS), has been released to assist developers in testing robotics packages. Builders can use the device to create, monitor, and launch intelligent robotic packages. Robotic running gadgets, an open-source software framework for robots, are the focus of Robomaker, a cloud-based service. AWS resources like as gadget reading, tracking, and analytics are included throughout the device. AWS resources like as gadget reading, tracking, and analytics are included throughout the device. This device collaborates with robots to stream records, communicate, navigate, detect, and test. In addition to the AWS, the cloud-based robot maker can minimize complexity and time in developing robotic applications, trials, and deployments. The goal is to create a simple cloud-based app that makes it easier for developers to navigate, test, and submit ideas in a network of developer tools. Overall, it helps them to put their time to better use rather than wasting months attempting to set up experimental infrastructure. Overall, it frees up their time to focus on additional improvement rather than wasting months trying to set up experimental infrastructure. Each cutting and growth technique can benefit from Robomaker's increased visibility and development.

7 Examples of Smart Cities Solutions Driven Through Emerging Technologies

Some instances are as follows.

7.1 Newport in Wales, United Kingdom

Newport in Wales, United Kingdom, in a few months, issued replies to improve air quality, flood control, and trash management, vs. a year or more with typical server infrastructure. Newport is a vibrant community that uses foresight technology to help restore its economy and improve its residents and visitors [34].

7.2 Citytouch

Citytouch is a lighting control system for public areas. Cities can utilize Citytouch to see how much energy traffic lights consume, and which need to be updated. By monitoring, responding, and balancing its mild management device with city touch, cities may make better judgments and employ resources. More than 600 clients use city touch to control their streetlights in 35 countries, including major cities such as Los Angeles and Buenos Aires [35].

7.3 Xaqt Solution

There is a smart city solution called Xaqt. Kansas City, Missouri, is one of the most technologically advanced cities in the United States. A $ 15 million public-private cooperation near Kansas Twin Road Hall supported 328 wireless deliveries, 178 traffic lights that could strike traffic types and open parking spots, and 25 video kiosks, as well as pavement sensors, video cameras, and numerous devices. An almost ubiquitous city network of fiber-optic record networks connects everything. Xaqt, an AWS partner, has created an authentic platforms platform for AWS to deliver urban statistics and expertise to policymakers to assist them in enhancing the performance of the central city [36].

7.4 Spectrum by Miovision

Spectrum by Miovision, based in the Ontario water space in Canada, offers a comprehensive system that includes facts, communications, and technology that should have remotely controlled traffic alerts. The spectrum SmartLink and hardware interface work seamlessly together and are safeguarded by existing guest hardware and software. Miovision indications, a cloud-based system for remote monitoring and control of the site's visitor network, are included in Spectrum. The Miovision Statistics platform serves 1000 clients in 50 different locations across the world. People living in sensory and traffic sensors are more connected than ever, and high-speed connectivity opens up new possibilities. Cities can now rely on the information given by residents because to high-speed connectivity. When citizen data is combined with sensor data, it can assist deliver more intelligence, better understand residents' requirements, and ultimately provide more advanced services [37].

7.5 Petajakarta for Smart Infrastructure

Petajakarta provides a mobile map and flood information for Jakarta, Indonesia's capital city. We, the 28 million citizens of Jakarta, are equivalent to the actual flood figures in the flood-affected region worldwide. Researchers can add current water scales with water sensing devices to the mix, like how state-enabled mobile devices collect and disseminate personal information. Researchers can integrate current water scales with water sensing devices into Jakarta's road network's most cost-effective surveillance system [38].

7.6 Moovit Urban Mobility App

Moovit, an Israeli startup, is redefining the transportation game by providing individuals with real-time information to get where they need to be on time. Moovit guides shift passengers to healthier, greener routes and make it easier for locals and tourists to navigate the industry's cities with schedules, trip plans, navigation, and over-the-counter reports. Approximately 80 million people use the award-winning Moovit app in over 1500 places across 78 countries. Local governments are beginning to embrace voice-based communication generation as a tool to generate information about donations that are readily available to citizens as voice-based communication creation becomes more time-consuming [39].

7.7 Amazon Auxiliary Voice Generation

Las Vegas is a city in the state of Nevada. Many Alexa skills have been developed in Las Vegas, one of the major cities, to coordinate the use of the Amazon Auxiliary voice generation, allowing citizens the power to invite practically parks, elections, community calendars, and dignified architecture lets in. The Amazon Echo system is also used in Las Vegas for virtual visual broadcasting. Users may be able to query an accurate layout picture and view it on their device's screen. Grand river transit inside the waterloo area, Ontario, Canada, has altered the software interactive voice response software for bus passengers to access bus arrival records by sending an application filed in AWS due to the flow of the main river near Waterloo, Ontario Canada. This solution works in conjunction with the real-time service, allowing customers to drive to various bus stops. Citizens can find out when the next bus will arrive at their station to assist them in planning their journey [40].

7.8 Virtual Georgia Services

Virtual Georgia services in the Kingdom of Georgia aim to enjoy people looking for national data and donations. Customers do not have to access content systems, display screen readers, or compliance difficulties to get the numbers they want because voice assistants answer questions aloud. Residents with a phone, tablet, or another incompatible device can ask various inquiries connected to Georgia state services, such as renewing their driver's license or obtaining a fishing license, by asking the Georgia gov, the brand-new Alexa. A provided computer, comparable computing, and grid computing are all examples of cloud computing [41].

8 Discussion

Human settlements are growing larger, and their living conditions are rising as a result of smart cities. People can have access to the records they require and make changes as needed. They live in a world that is incredibly high-tech and efficient in this sense. They can also operate and direct any smart gadget from anywhere in the world, whether it's at home, in his car, or at work. Similarly, government agencies can control diverse parts of the city beyond forecasting and taking precautionary measures on the path to smart plans. Health, military, trade, environment, agriculture, labor, and transportation facilities are offered for financial and social benefits [42–44]. These clever programs necessitate infrastructure. There are numerous techniques available. These clever programs necessitate infrastructure. There are numerous technical and financial goals and gadget servers that develop systems that can communicate statistics, servers where this information can be saved, and the storage and protection of those servers. Cloud computing appears during this period.

Cloud computing, a relatively new technological technology, refers to network-based services that may be accessed by computers and other devices at any time and give shared commodities to clients. There are no network-related concerns with cloud computing, servers, garage regions, data information, and numerous support services, making smart city integration and statistical trading incredibly efficient. The efficiency of cloud computing in smart cities can be explained in this scenario. New features in these two areas will be tested using high-quality literature. Smart house constructors consider views. The expansion of cloud computing and the advancement of smart cities has ushered in a new era of innovation. With the support of organizations and individuals, smart company architecture is becoming more widely acknowledged. Hundreds of smart devices collect data to develop smart cities and give statistical change that can be saved in cloud structures. This makes exchanging data for certain structures simple. However, all the procedures linked with this device must be thoroughly examined to ensure that all of the data obtained is on the same platform. While an effective cloud device will make everything more accessible, an inactive cloud machine will simplify all records. Modern cloud-based research on smart cities is combined with the features of s in this experiment.

A smart metropolis is a place where traditional networks and services, city dwellers, and commercial companies are made more efficient via the use of virtual communication and mathematical technology, in line with the European currency. As seen in Fig. 1, some of the programs found in smart cities are as follows. Smart industry, smart security, smart energy, smart people, smart living, smart house, smart travel, smart management, and smart marketing are all terms that come to mind when thinking about smart technology. The goal of a smart town is to promote citizen visibility by constructing sustainable routes. With this in mind, the concept of a smart city should be viewed as a vision that encompasses economic, practical, and criminal concerns rather than a purely theoretical one. The smart town program's major goal is to assure urban sustainability, encourage sports participation, and improve living conditions. Cloud computing is a standard network-based offering that can be used by computer programs and other gadgets at any time and exposes shared assets amongst users, ushering in a new era of learning. Cloud computing allows consumers to use their devices from anywhere on the Internet. With its success in affordability, international rating, speed, overall performance, efficiency, security, and dependability, the cloud computing is becoming a part of the technology in smart cities solutions. It is not difficult to access cloud computing, servers, repositories, information, and many other software services.

9 Conclusion

Some of the core concepts of a smart city and cloud computing are covered in this chapter. What should have the fundamental qualities, the fundamental needs of a smart city are also addressed. It is also considered how cloud computing may be used to establish a smart city and what type of network is most suited for making full use of the infrastructure required to create a smart city with the help of the cloud. There is a 7-layer content structure in this article, and this masterpiece shows how vast numbers of records can be saved in the cloud, how many applications can be accessed appropriately through a record garage, and how information can be retrieved on demand. With the use of clouds, people will be able to observe numerous shipments that can arrive anywhere and at any moment. The Internet's ability to provide services has been substantially enhanced thanks to advances in cloud computing technologies. A new service model and network platform may be necessary to make the computer a better recording resource management platform. Cloud computing in significant cities can unify city-data resources and eliminate the need for information. The use of cloud computing in significant cities can connect city-data resources and eliminate the information problem that has long plagued the management of help records: a single island. The application of cloud computing to intelligent medical, smart transport, and logical planning will improve statistics in all types of metropolitan activities and make life easier for people.

References

1. Khan Z, Kiani SL (2012) A cloud-based architecture for citizen services in smart cities. In: 2012 IEEE Fifth international conference on utility and cloud computing, pp 315–320. IEEE
2. Lai KL, Chen JIZ, Zong JI (2021) Development of smart cities with fog computing and Internet of things. J Ubiquitous Comput Commun Technol (UCCT) 3(01):52–60
3. Manimuthu A, Dharshini V, Zografopoulos I, Priyan MK, Konstantinou C (2021) Contactless technologies for smart cities: big data, IoT, and cloud infrastructures. SN Comput Sci 2(4):1–24
4. Alam T (2021) Cloud computing and its role in the information technology. IAIC Trans Sustain Dig Innov (ITSDI) 1:108–115
5. Iatrellis O, Panagiotakopoulos T, Gerogiannis VC, Fitsilis P, Kameas A (2021) Cloud computing and semantic web technologies for ubiquitous management of smart cities-related competences. Educ Inf Technol 26(2):2143–2164
6. Meqdad MN (2021) Smart cities: understanding policies, standards, applications and case studies. Int J Electr Comput Eng (IJECE) 11(4):3137–3144
7. Deepa R (2021) A role of an edge computing technologies for the internet of things in smart cities. Turk J Comput Math Educ (TURCOMAT) 12(9):1321–1330
8. Salkuti SR (2021) Smart cities: understanding policies, standards, applications and case studies. Int J Electr Comput Eng 11(4):2088–8708
9. Zhong Y, Sun L, Ge C (2021) Key technologies and development status of smart city. J Phys Conf Ser 1754(1):012102. IOP Publishing
10. Patel V, Shah D, Doshi N (2021) Emerging technologies and applications for smart cities. J Ubiquitous Syst Pervas Netw 15(02):19–24
11. Paul, B., & Chettri, S. K. (2021). Smart City: Recent Advances and Research Issues. Inventive Systems and Control, 77–92.

12. Rajkumar K, Hariharan U (2021) Impact of IoT-enabled smart cities: a systematic review and challenges. Digital Cities Roadmap: IoT-Based Architecture and Sustainable Buildings 253–292
13. Dominiković I, Ćukušić M, Jadrić M (2021) The role of artificial intelligence in smart cities: systematic literature review. In: International conference on data and information in Online, pp 64–80. Springer, Cham
14. Alam T, Khan MA, Gharaibeh NK, Gharaibeh MK (2021) Big data for smart cities: a case study of NEOM city, Saudi Arabia. In: Smart cities: a data analytics perspective, pp 215–230. Springer, Cham
15. Stone M, Aravopoulou E, Knapper J, Evans G (2021) Smart cities and smart transport. The Routledge Companion to Marketing Research
16. Carrillo E, Benitez V, Mendoza C, Pacheco J (2015) IoT framework for smart buildings with cloud computing. In: 2015 IEEE First international smart cities conference (ISC2), pp 1–6. IEEE
17. Petrolo R, Loscri V, Mitton N (2014) Towards a smart city based on cloud of things. In: Proceedings of the 2014 ACM international workshop on wireless and mobile technologies for smart cities, pp 61–66
18. Alam T, Benaida M (2018) The role of cloud-MANET framework in the internet of things (IoT). Int J Online Biomed Eng (iJOE) 14(12):97–111
19. Alam T, Benaida M (2018) CICS: cloud-internet communication security framework for the internet of smart devices. Int J Interact Mob Technol (iJIM) 12:6
20. Clohessy T, Acton T, Morgan L (2014) Smart city as a service (SCaaS): a future roadmap for e-government smart city cloud computing initiatives. In: 2014 IEEE/ACM 7th international conference on utility and cloud computing, pp 836–841. IEEE
21. DENER M (2019) The role of cloud computing in smart cities. Eurasia Proc Sci Technol Eng Math 7:39–43
22. Agarwal N, Agarwal G (2017) Role of cloud computing in development of smart city. In: National conference on road map for smart cities of Rajasthan (NC-RMSCR)
23. Yang C, Huang Q, Li Z, Liu K, Hu F (2017) Big Data and cloud computing: innovation opportunities and challenges. Int J Dig Earth 10(1):13–53
24. Bedi P, Goyal SB, Rajawat AS, Shaw RN, Ghosh A (2022) A framework for personalizing atypical web search sessions with concept-based user profiles using selective machine learning techniques. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_23
25. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Smart luminaires for commercial building by application of daylight harvesting systems. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_24
26. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Multi-objective fuzzy-swarm optimizer for data partitioning. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_25
27. Rajawat AS, Barhanpurkar K, Goyal SB, Bedi P, Shaw RN, Ghosh A (2022) Efficient deep learning for reforming authentic content searching on big data. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_26
28. Das S, Das I, Shaw RN, Ghosh A (2021) Advance machine learning and artificial intelligence applications in service robot. Artif Intell Fut Gener Robot 83–91. https://doi.org/10.1016/B978-0-323-85498-6.00002-2
29. Singh P, Sammanit D, Krishnan P, Agarwal KM, Shaw RN, Ghosh A (2021) Combating challenges in the construction industry with blockchain technology. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_56

30. Rawat R, Rajawat AS, Mahor V, Shaw RN, Ghosh A (2021) Dark web—onion hidden service discovery and crawling for profiling morphing, unstructured crime and vulnerabilities prediction. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_57
31. Rajawat AS, Rawat R, Mahor V, Shaw RN, Ghosh A (2021) Suspicious big text data analysis for prediction—on darkweb user activity using computational intelligence model. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_58
32. Rawat R, Mahor V, Chirgaiya S, Shaw RN, Ghosh A (2021) Sentiment analysis at online social network for cyber-malicious post reviews using machine learning techniques. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_9
33. Kumar A, Das S, Tyagi V, Shaw RN, Ghosh A (2021) Analysis of classifier algorithms to detect anti-money laundering. In: Bansal JC, Paprzycki M, Bianchini M, Das S (eds) Computationally intelligent systems and their applications. Studies in computational intelligence, vol 950. Springer, Singapore. https://doi.org/10.1007/978-981-16-0407-2_11
34. https://www.newport.gov.uk/en/About-Newport/About-Newport.aspx
35. https://www.lighting.philips.com/main/systems/lighting-systems/citytouch
36. https://www.xaqt.com/
37. http://www.mikeontraffic.com/miovision-spectrum/
38. https://www.nesta.org.uk/feature/10-people-centred-smart-city-initiatives/petajakarta/
39. https://moovit.com/
40. https://aws.amazon.com/polly/
41. https://dds.drives.ga.gov/
42. Tanweer A (2021) Cloud-based IoT applications and their roles in smart cities. Smart Cities 4(3):1196–1219. https://doi.org/10.3390/smartcities4030064
43. Tanweer A (2021) IBchain: Internet of things and blockchain integration approach for secure communication in smart cities. Informatica 45(3): https://doi.org/10.31449/inf.v45i3.3573
44. Tanweer A (2021) Blockchain cities: the futuristic cities driven by blockchain big data and internet of things. GeoJournal. https://doi.org/10.1007/s10708-021-10508-0

Anomalies Detection on Attached IoT Device at Cattle Body in Smart Cities Areas Using Deep Learning

Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Rabindra Nath Shaw, Ankush Ghosh, and Sambhav Aggarwal

Abstract The anomalies detection on attached IoT devices on cattle in Smart Cities Areas using deep learning that help administrator to identify the unauthorized accessing of attached IoT device on Cattle Body. In this research work, we proposed deep learning techniques by real-time monitoring for extracting data and comparing current temperature, up temperature, down temperature humidity. In this research work main objective is to develop cattle farming technologies in Smart Cities Areas for smarter, Secure, and use the Internet of Things, alias IoT, to keep track of system behaviour and unauthorized accessing. Each object is labelled with a portable gadget. Our proposed wearable interface and sink node are architecturally based on the cloud system. Early detection of malicious and illicit access recognition of abnormalities to design IoT based smart sensor system for securing cattle body area network environment using deep learning.

Keywords Anomalies detection · Smart sensor system · IoT device · Deep learning · Smart city

---

A. S. Rajawat
Department of Computer Science Engineering, Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, India

P. Bedi
Computer Science and Engineering, Lingaya's Vidyapeeth, Faridabad, Haryana, India

S. B. Goyal
City University, Petaling Jaya, Malaysia

R. N. Shaw
Department of Electrical, Electronics and Communication Engineering, Galgotias University, Greater Noida, India
e-mail: r.n.s@ieee.org

A. Ghosh (✉)
School of Engineering and Applied Sciences, The Neotia University, Sarisha, West Bengal, India

S. Aggarwal
Department of Computer Science Engineering, Maharaja Agrasen Institute of Technology, New Delhi, India

V. Piuri et al. (eds.), *AI and IoT for Smart City Applications*, Studies in Computational Intelligence 1002, https://doi.org/10.1007/978-981-16-7498-3_14

1 Introduction

The smart city farmers can observe cattle activities such as walking grazing time, standing and sleeping in order to prognosticate the health of the cattle. To monitor the behaviour of the cattle [1], however, it is impossible to monitor such behaviour, especially to raise many animals, all the time. This chapter proposes therefore to characterize the conduct of the animal by using an accelerometer output signal in terms of magnitude and standard deviation. To compute the body temperature (Increase in body temperature (IBD)), Decrease in body temperature (DBT)) when classifying actions as two categories, the scale of each axis is used: (1) Increase in body temperature (IBD) and (2) Decrease in body temperature (DBT). Whereas standard Y-axis deviation is used to notify walking and standing behaviours. Two cattle were tested for classification results and each behaviour was measured precisely in comparison with human observers. The result is that each behaviour's length is very small. Number of researcher suggested a general intelligent body temperature program to investigate and analyse several issues in the analysis of animal behaviour, in particular in cow comportments. The owners' concerns about food quality and safety, cattle health events are of great importance in food production. Every significant difference in the grazing cycle exposed the deficiency indicated by the farmer's concern. Thus, they can be used as an input to an early warning system (up and down temperature). The most important problems affecting the animal health are abortion and internal parasites, or lameness. The diseases have been observed in this study to have a highly negative effect on livestock safety and farmers' productivity. Our proposed technique work for Anomalies Detection on Attached IoT Device at Cattle Body [2] in Smart Cities Areas.

Using Deep Learning thus environmental conditions such as drought, heat and plant contaminants may create a problem. Diverse work has been focused on the introduction of IoT based smart sensor system for cattle body temperature to understand specific Anomalies behavioural [3] factors and transform them into appropriate anomalies behavioural patterns (standing, driving, sleeping, and weeding). The rest of the chapter is formatted in the same manner. Section 2 of the research chapter shares the existing infrastructure and Anomalies behavioural Detection on Attached IoT Device. Additionally, Sect. 3 discusses the Body temperature Sensor, and Sect. 4 discusses the Decrease in Body Temperature. Section 5 discusses the Proposed System. Section 6 has simulation results based on experimental validation. The last section contains the entire proposed system's conclusion.

2 Related Work

The development of health monitoring system played a vital role in detection of diseases [4]. Wireless Sensors Networks (WSN) are used to collect the data from various sensors and can be used to assess the body weight, detection of diseases etc.

Zigbee based animal monitoring system developed for monitoring rumination, stress level and humidity index. The sensors are used to measure the density of milk which is extracted from cow, goat [5]. WSNs collect the numerous physiological signals from cattle's and stored them into structured cloud server. The diseases that can be detected in the cattle are Mastitis, Lameness, Cyclic Ovarian Disease, Milk Fever and Retained Placenta [6]. Every cattle disease shows certain symptoms which can be detected using smart sensors and thus providing early treatment will save cattle life and cost-effectives [7]. The data mining and data analytics helps us to understand abnormalities in the physiological signals and generates an alert system. Global Positioning System (GPS) also used to understand the precise location of cattle if the farm is of large size. Thus, cattle health monitoring system is cost-effective, integrated and robust system for checking cattle health [8].

3 Body Temperature Sensor

The usual cattle temperature is 38.5–39.5 °C. Body temperature-related diseases between 36–38.5 °C are milk fever, poisoning, indigestion etc. Anthrax, pneumonia, and foot-and-mouth illness arise when the temperature is higher than 41 °C. Complex heat sink geometry is ignored, and we discuss that it only leads to improved heat dissipation field. Temperature finding will be simple Based on energy dissipated as heat as cattle are fully separated. The association between energy Q and body temperature is

$$Q = mc\Delta Temp \tag{1}$$

$$Hnet = \frac{T_h - T_m}{L_h} \tag{2}$$

$$Q_t = kA\frac{\Delta Temp}{L_H} \tag{3}$$

On differentiating the terms both sides,

$$P = \frac{dQ_{net}}{dt} = d\left(kA\frac{\Delta Temp}{L_H} * mc\right)\Big/ dt \tag{4}$$

We defined P as the net energy difference, or (with a constant L_H for latent heat) as the temperature above the temperature of the environment. The above equation only reflects the conservation of energy.

An animal dies from fever as the body core temperature rises. Here the body begins a mechanism through which it can better resist dangerous attackers including viruses, bacteria and parasites. Stress and extreme scarcity often express rapidly by shifts in body temperature. Fever is the body's innate defensive mechanism and should not necessarily be deemed harmful. An increased body temperature helps enhance some organism processes. Farmers must therefore be vigilant to ensure that steps are taken immediately to help the animal or that the animal is subsequently handled. A local-infected claw joint can also cause fever when pus bacteria break through the bloodstream. Heating during regular activity (heat pulse on), P is non-zero. Equation (5) is a differential equation, which has the following solution.

$$T(t) = Be^{\frac{-kA}{cL_H}} + \frac{PL}{A}[e^{-kA} - 1] \tag{5}$$

Let the $B = T(0)$, $\frac{L}{kA} = \propto$, $mc = C_t$

$$T(t) = \frac{P}{\propto}(1 - e^{-t/\propto C_t)} \tag{6}$$

Decrease in Body Temperature

If the animal has low body temperature, this indicates the mechanisms in the body do not function normally. For a prolonged amount of time, the body attempts to resist temperature decline. Muscle tremors cause heat to be generated to mitigate hypothermia, but when the body can no longer compensate for heat loss, body temperature drops dramatically. Low body temperatures will easily endanger life. It needs urgent help. Cows with parturient paresis (milk fever) are especially prone to enter a risky stage rapidly. Measures involve calcium supplements, infusions, infrarot lamps, covers, switching to another safe or thick/dry litter component.

There is no heat inflow, P = 0

$$P = \frac{dQ}{dt} = 0 = mc\frac{d[T(t)]}{dt} \tag{7}$$

On integration the equation,

$$mc\frac{d[T(t)]}{dt} = -kA/L\ {}_H \int_0^T kA/mcL_H \tag{8}$$

Exponentiation of both sides results in:

$$T(t) = T_0(e^{-t/\propto C}) \tag{9}$$

A direct comparison can be found between comparable characteristics. A switch to an electronic circuit may be achieved to overcome complex cases (Advanced Micro Devices).

4 Proposed Algorithm

Algorithm for Cattle Anomaly Detection for temperature

Step-1: Measure the temperature recordings from the temperature sensor.
Step-2: Categorize the temperature readings according to the threshold value.
Step-3: If the temperature readings (anomalies found) which are above or below the threshold value using proposed deep learning architecture

Start: Alert System
Display the Cattle-ID on the system.
Repeated Notification messages for a proper health check-up.
Stop.

Step-4: Stop.

A. *Deep Learning*
In the proposed model, we have used Multi-layer perceptron ANN model for classification [9] of dataset. The model contain m input layer which are connected to n number of hidden layers. The output for input layer act as input for hidden layer. Also, the output from hidden layer act as input for output layer which is also known as Transfer function. Generally, sigmoid function is used and this function is non-linear in nature. MLP-ANN is used for composite regression applications. The MLP-ANN architecture follow one way architecture, from input to output and these networks are straight-forward networks. It is generally considered as an arrangement of connections between neurons in differentiated layers. MLP-ANN initiates the learning process, and it stops until the error minimization benchmarks are extended. The desired output, produced output, total number of observation are Y, Y' and T respectively. The other part of data-set should be validated to test the performance of developed ANN model (Fig. 1 and Table 1).

B. *Data Collection*
Data is collected from multiple sensors placed at IoT device [10] attached to Cattle body. Moreover the model's Anomalies prevention features are restricted to identifying data irregularities at device stage, not network layer. This model would not identify any Anomalies that may alter hardware or IoT computer programme addresses [11–13]. The data is collected from a wide range of sensors and then this real-time data stored in the cloud server. After which data is extracted and pre-processing of the data takes place [14, 15]. After the pre-processing, the implementation of renowned architecture Multi-layer perceptron for Artificial Neural Network (MLP-ANN) is implemented for classification purpose [16–18]. If the measured temperature is not in the temperature threshold value and an alert message will be generated [19–21]. Hence, this alert message will show inform to the user that cattle's health problems.

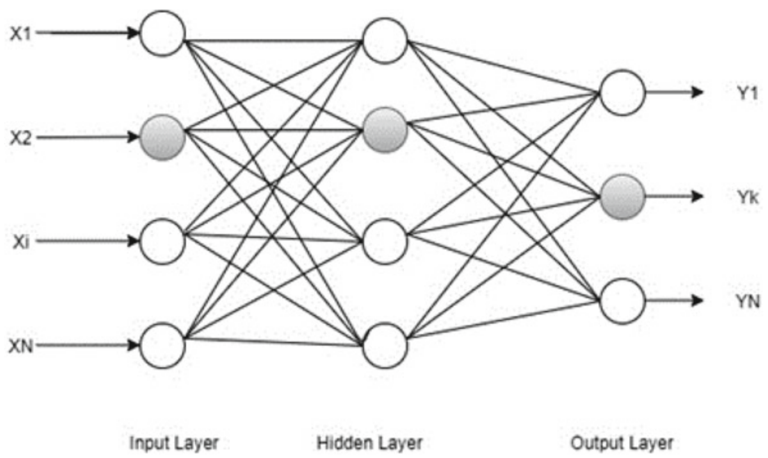


Fig. 1 Multi-layer perceptron for artificial neural network (MLP-ANN) model

Table 1 Examples of some common transfer functions

Transfer function	Detention
Linear	$f(x) = x$
Segmoid	$f(x) = \frac{x}{1+e^{-x}}$
Hyperbolic	$f(x) = \frac{(e^{x})-(e^{-x})}{1+e^{-x}}$
Hard limit	$f(x) = \begin{pmatrix} 0, & x < 0 \\ 1, & x \geq 0 \end{pmatrix}$
Symmetric hard limit	$f(x) = \begin{pmatrix} -1, & x < 0 \\ 1, & x \geq 0 \end{pmatrix}$

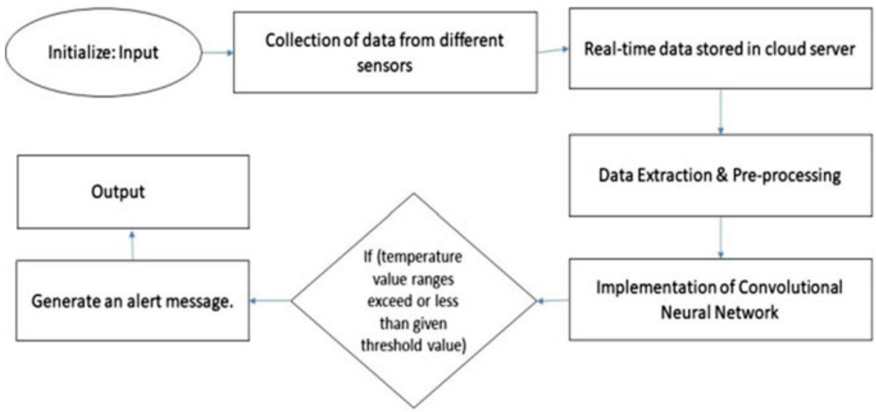


Fig. 2 Data-flow diagram of system architecture

Both wearable gadget and end hub are structured dependent on gadget to cloud design [22], and it is appeared in Fig. 2. The stream outline for early discovery of disease by wearable gadget is appeared in Fig. 2.

C. *Evaluation of parameters for cattle monitoring system*
Smart module: the internal heat level of dairy animals ranges from 38.0 to 39.3 °C in the centre. Standard core stable bovine internal heat point will be 38.6 °C. Condition is said to be comfort for dairy cattle when air temperature is between 10 °C and 20 °C and relative stickiness is between 40 and 80%. When the temperature of the condition reaches the internal heat level of the dairy animals, it will make cows heat trouble. This will diminish the wellbeing of cows [23] and the production of milk. Fortunately, the highest temperature reported in India is 34 °C. And steers will feel the discomfort of an immaterial infection. This can be effectively overwhelmed by changing the sustaining framework, maintaining perfect and dry place for steer

$$TH_{Index} = (1.8T_{ambient} - \big((1 - R_{humidity}\big) * (T_{ambient} - 14.3)\big) + 32) \quad (10)$$

The following variables mentioned in above equation are as follows:

TH_{Index}	Temperature Humidity (%)
$R_{Ambient}$	Ambient Temperature (%)
$R_{humidity}$	Relative Humidity (%)

Equal filter system for 3.5 L of shower water per cow will be enforced for a period of 3 min. In inscribing end it will be finished for this ideal time for filter operation. After that no water showering to relate the dairy cattle for the next 12 min. This cure operation decreases the internal heat intensity of the cows' core by 1.7 °C under heat exposure and further builds up 0.79 kg/day of milk production per steering. It will also consistently record the power utilization of the ventilation framework in terms of watts-hours. By this guideline in mind, the microcontroller understands [24] the level of flow of water and the valve of impulse as needed. It will also measure water use for steers who nourish need in a day's term of litters. This module ensures water is accessible to navigates whenever necessary.

5 Experimental Results

Our proposed framework, a test structure comprising various analysis units regarding practices of specific concerns. Initially, the creature right now, conduct will be recorded utilizing both continuous systems. The subsequent practices will be measured from these reports. Specific observation of entity [25] actions will be done according to requirements.

Target 1: The body condition scores of dairy cattle, the execution of heat identification and Anomalies behaviour Detection the development of calving processes will be measured and dissected by using body temperature prediction techniques, such as highlights of the base subtraction, position, form and activity, complex classifiers, and sequential simple leadership approach. The different locations are sketched out right now are as follows:

(1) Enhancing the actions and health of dairy cattle by early detection of odd shifts in the pattern of personal behaviour of steers.
(2) Determining the importance of human-creature relations and milk yield of dairy cows by maintaining the body condition scores at normal control stages,
(3) Carrying out warmth discovery of cows with high accuracy at responsive.

Target 2: Research for target 2 secured an assortment of points including the cooperation among sustenance, conduct and prosperity. Essentially, the body condition scoring will be performed by utilizing gathered information.

Target 3: Experiments exploring the effect of the new measurement of temperature exploration so that both productivity and wellbeing are increased. Wearable device constant readings the ongoing measurements of steering centre internal heat point, standing time, lying time.

Result Analysis

In Fig. 3, the three parameters are considered for measurement of temperature are Low temperature, High temperature and normal temperature. The normal temperature for different cattle varies according to the body size, weight ratio, diet intake etc. For example, the range of normal temperature for cow is 37.8–39.2 °C and if the value exceeds the threshold value the irregular distortion will be observed (Fig. 4). Additionally, the value of temperature measurement is less than the minimum threshold value then the irregular distortion has been observed (Fig. 5). It is also observed that

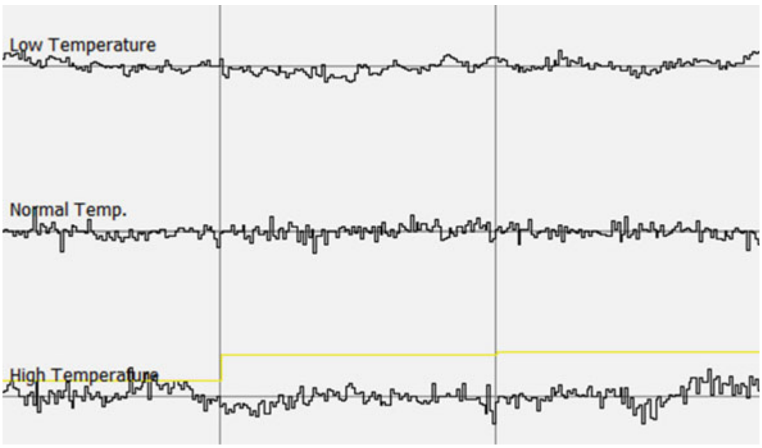


Fig. 3 Standard temperature measurements for Cattle health monitoring system

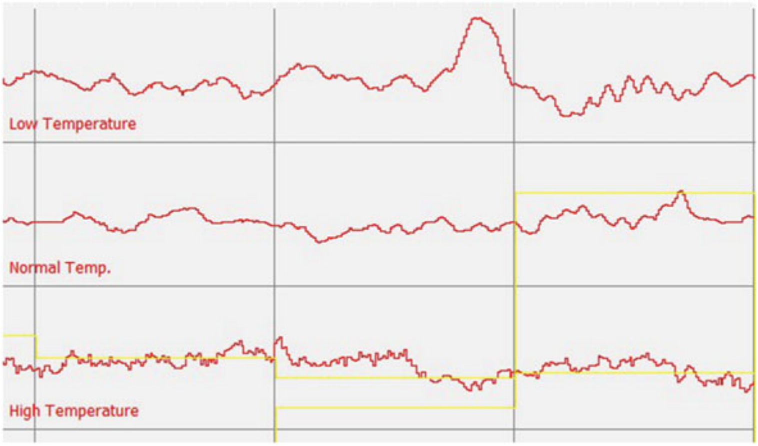


Fig. 4 Temperature measurement below the threshold value for Cattle health monitoring system

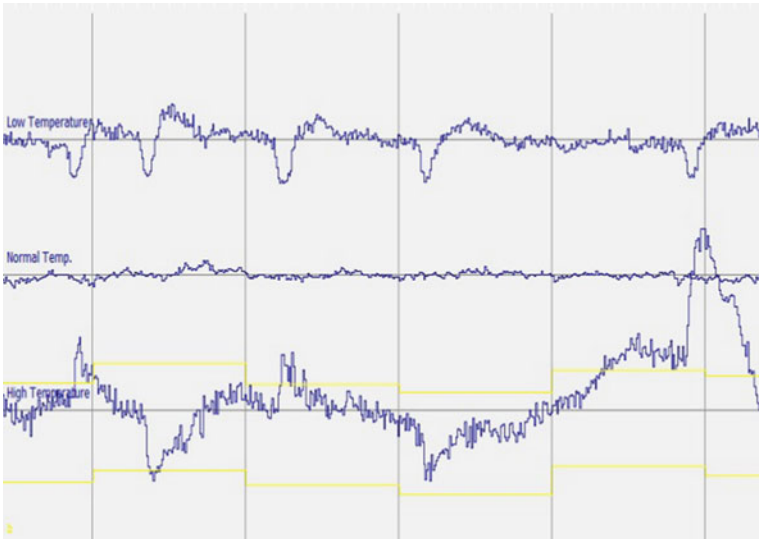


Fig. 5 Temperature measurement above the threshold value for Cattle health monitoring system

normal temperature parameter remains unchanged when the cattle body temperature's is exceeding the threshold value (Fig. 5: high temperature) or less than threshold value (Fig. 4: low temperature).

6 Conclusion

The research work proposed only one reasonable solution to modelling such a complex method as Anomalies Detection on attached IoT Device at Cattle Body in smart cities Using Deep Learning. The main focus of IoT based smart sensor system for cattle body temperature prediction using deep learning is creating technique for more handling prior-stage illness, anomalies, calving period and illnesses using the Internet of Things. To develop a deep learning model which is capable of detecting the body temperature parameters responsible for different types of diseases. Thus, early prediction of such diseases helps in increasing the life expectancy of cattle. In the future work we will work on different parameter for early detection of disease.

References

1. Sharma B, Koundal D (2018) Cattle health monitoring system using wireless sensor network: a survey from innovation perspective. IET Wirel Sens Syst
2. Mhatre V, Vispute V, Mishra N, Khandagle K (2020) IoT based health monitoring system for dairy cows. In: 2020 Third international conference on smart systems and inventive technology (ICSSIT), Tirunelveli, India, 2020, pp 820–825. https://doi.org/10.1109/ICSSIT48917.2020.9214244
3. Akhigbe BI, Munir K, Akinade O, Akanbi L, Oyedele LO (2021) IoT technologies for livestock management: a review of present status, opportunities, and future trends. Big Data Cogn Comput 5(1):10. https://doi.org/10.3390/bdcc5010010
4. Belhadi A et al (2021) Deep learning for pedestrian collective behavior analysis in smart cities: a model of group trajectory outlier detection. Inf Fus 65:13–20. https://doi.org/10.1016/j.inffus.2020.08.003. Accessed 15 Sep 2021
5. Ren K et al (2021) Tracking and analysing social interactions in dairy cattle with real-time locating system and machine learning. J Syst Arch 116:102139. https://doi.org/10.1016/j.sysarc.2021.102139
6. Harikrishnan R, Gaikwad MM (2021) IOT solutions for farmers on livestock management in smart city: a bibliometric survey. Libraries at University of Nebraska-Lincoln Library Philosophy and Practice (e-journal) Summer
7. Akbar MO, Khan MSS, Ali MJ, Hussain A, Qaiser G, Pasha M, Pasha U, Missen MS, Akhtar N (2020) IoT for development of smart dairy farming. J Food Qual 2020, Article ID 4242805, 8 p. https://doi.org/10.1155/2020/4242805
8. Ahmad Z, Khan AS, Nisar K, Haider I, Hassan R, Haque MR, Tarmizi S, Rodrigues JJPC (2021) Anomaly detection using deep neural network for IoT architecture. Appl Sci 11(15):7050. https://doi.org/10.3390/app1115705
9. Sharma A et al (2021) Machine learning applications for precision agriculture: a comprehensive review. IEEE Access 9:4843–4873. https://doi.org/10.1109/access.2020.3048415. Accessed 22 Jan 2021
10. Jh, Park, Salim MM, Jo JH et al (2019) CIoT-net: a scalable cognitive IoT based smart city network architecture. Hum Cent Comput Inf Sci 9:29. https://doi.org/10.1186/s13673-019-0190-9
11. Ilyas QM, Ahmad M (2020) Smart farming: an enhanced pursuit of sustainable remote livestock tracking and geofencing using IoT and GPRS. Wirel Commun Mob Comput 2020, Article ID 6660733, 12 p. https://doi.org/10.1155/2020/6660733
12. Banerjee A et al (2022) Construction of effective wireless sensor network for smart communication using modified ant colony optimization technique. In: Bianchini M, Piuri V, Das S,

Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_22

13. Goyal SB, Bedi P, Rajawat AS, Shaw RN, Ghosh A (2022) Smart luminaires for commercial building by application of daylight harvesting systems. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_24
14. Rajawat AS, Barhanpurkar K, Goyal SB, Bedi P, Shaw RN, Ghosh A (2022) Efficient deep learning for reforming authentic content searching on big data. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_26
15. Garg C, Namdeo A, Singhal A, Singh P, Shaw RN, Ghosh A (2022) Adaptive fuzzy logic models for the prediction of compressive strength of sustainable concrete. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_47
16. Palimkar P, Bajaj V, Mal AK, Shaw RN, Ghosh A (2022) Unique action identifier by using magnetometer, accelerometer and gyroscope: KNN approach. In: Bianchini M, Piuri V, Das S, Shaw RN (eds) Advanced computing and intelligent technologies. Lecture notes in networks and systems, vol 218. Springer, Singapore. https://doi.org/10.1007/978-981-16-2164-2_48
17. Rajawat AS, Rawat R, Barhanpurkar K, Shaw RN, Ghosh A (2021) Robotic process automation with increasing productivity and improving product quality using artificial intelligence and machine learning. Artif Intell Fut Gener Robot, 1–13. https://doi.org/10.1016/B978-0-323-85498-6.00007-1
18. Das S, Das I, Shaw RN, Ghosh A (2021) Advance machine learning and artificial intelligence applications in service robot. Artif Intell Fut Gener Robot 83–91. https://doi.org/10.1016/B978-0-323-85498-6.00002-2
19. Sharma P, Chandan S, Shaw RN, Ghosh A (2021) Vibration-based diagnosis of defect embedded in inner raceway of ball bearing using 1D convolutional neural network. Artif Intell Fut Gener Robot 25–36. https://doi.org/10.1016/B978-0-323-85498-6.00011-3
20. Rajawat AS, Rawat R, Barhanpurkar K, Shaw RN, Ghosh A (2021) Depression detection for elderly people using AI robotic systems leveraging the Nelder–Mead Method. Artif Intell Fut Gener Robot 55–70. https://doi.org/10.1016/B978-0-323-85498-6.00006-X
21. Huneria HK, Yadav P, Shaw RN, Saravanan D, Ghosh A (2021) AI and IoT-based model for photovoltaic power generation. In: Mekhilef S, Favorskaya M, Pandey RK, Shaw RN (eds) Innovations in electrical and electronic engineering. Lecture notes in electrical engineering, vol 756. Springer, Singapore. https://doi.org/10.1007/978-981-16-0749-3_55
22. Wolfert S et al (2017) Big data in smart farming—a review. Agric Syst 153:69–80. https://www.sciencedirect.com/science/article/pii/S0308521X16303754. https://doi.org/10.1016/j.agsy.2017.01.023
23. Xu B et al (2020) Livestock classification and counting in quadcopter aerial images using mask R-CNN. Int J Rem Sens 41(21):8121–8142. https://doi.org/10.1080/01431161.2020.1734245. Accessed 15 Sep 2021
24. Alrashdi I, Alqazzaz A, Aloufi E, Alharthi R, Zohdy M, Ming H (2019) AD-IoT: anomaly detection of IoT cyberattacks in smart city using machine learning. In: 2019 IEEE 9th annual computing and communication workshop and conference (CCWC), 2019, pp 0305–0310. https://doi.org/10.1109/CCWC.2019.8666450
25. Rajawat AS et al (2021) Fusion protocol for improving coverage and connectivity WSNs. IET Wirel Sens Syst 11(4):161–168. https://doi.org/10.1049/wss2.12018. Accessed 21 Aug 2021