2024 1st International Conference on Advances in Computing, Communication and Networking (ICAC2N) | 979-8-3503-5681-6/24/$31.00 ©2024 IEEE | DOI: 10.1109/ICAC2N63387.2024.10895291

Optimization and Performance Evaluation of Sensor-Based Smart Parking Systems: A Case Study Approach

Rachna Rathore
Dept. of Mathematics
Shrimant Madhav Rao Scindia University
Gwalior, India
rachnarathore1109@gmail.com

Abbasi Imtiaz Mohammed
Dept. of Commerce & management
Madhav University
Pindwara, India

G.Saranraj
Dept. of CSE
Dhanalakshmi Srinivasan college
Coimbatore, India
saranrajdsce@gmail.com

Anil Kumar
Dept. of EEE
Mangalayatan University
Aligarh, India
anil.sharma@mangalayatan.edu.in

Javalkar Dinesh Kumar
Dept. of ECE
Lingayas Vidyapeeth
Faridabad, India
dineshjavalkar@lingayasvidyapeeth.edu.in

Vaibhav Jaitwal
Dept. of CSE
Chandigarh University
Chandigarh, India
vaibhavjaitwal2003@gmail.com

***Abstract*—The abstract introduces a smart parking system designed to alleviate traffic congestion and save time by employing sensors, data protocols, and a live interface through mobile apps. The initial section of this paper provides an expository overview detailing the system's functionality and operation. Furthermore, the study validates the efficacy of smart parking solutions in enhancing convenience and efficiency through empirical analysis of randomized data.**

***Index Terms*—Iot Based Smart Parking System, Parking Challenges, Sensor Networks, Data Communication Protocols, Real-Time Parking Monitoring.**

I. Introduction

As cities continue to grow in population, they face a variety of issues, one of which is a lack of parking spots. This issue has been addressed by smart parking systems, which offer a more effective method of managing parking spaces. To simplify the parking process, these methods combine cutting-edge technologies like sensors, the Internet of Things (IoT), and mobile applications.

Fig. 1. Smart Parking Idea

979-8-3503-5681-6/24/$31.00©2024 IEEE

Both drivers and city authorities can benefit from smart parking systems in a number of ways. They decrease traffic congestion by cutting down on time they spent looking for parking slots, by saving time for drivers by giving them real-time information on parking spaces that are available, and enhance air quality by cutting down on time spent stuck in traffic. These technologies offer useful information to city authorities that can be used to enhance parking spot usage and improve traffic flow.

smart parking systems contribute to a more sustainable and eco-friendlier environment. By minimizing traffic congestion and optimizing parking space utilization, these systems help reduce fuel consumption and carbon emissions. Additionally, many smart parking systems incorporate features such as electric vehicle charging stations, encouraging the use of electric vehicles and supporting the transition to a greener transportation system.

It also provides valuable data and insights for city planners and administrators. By collecting data on parking usage patterns, peak hours, and demand trends, authorities can make informed decisions regarding parking infrastructure development, pricing strategies, and traffic management policies. This data-driven approach ensures more efficient resource allocation and enables cities to adapt to the evolving needs of their residents.

II. LITERATURE SURVEY

I. B. Asianuba and A. Aliyu (2023): The study presents an enhanced IoT-based smart parking system that improves parking space management, offering benefits like real-time monitoring and user-friendly interfaces for efficient space utilization

in urban areas [1]. Mohammad Kuraishi Z. (2023): This paper explores the transformative role of big data analytics and AI in optimizing supply chain management in Lithuania, emphasizing predictive analytics and operational efficiencies to drive industry growth [2]. M. Chandran et al. (2019): The authors propose an IoT-driven smart parking system that integrates sensor networks and real-time data processing, enhancing user experience and automating parking space allocation for urban convenience [3]. S. Rupani and N. Doshi (2019): This review critically evaluates IoT-based smart parking systems, highlighting key technologies like sensors, cloud computing, and machine learning algorithms that contribute to system efficiency and scalability [4]. Agarwal P. & Vij A. (2024): The paper investigates AI's challenges and opportunities within the Indian educational system, focusing on its potential to revolutionize teaching and learning processes, offering personalized education and improving accessibility [5]. Kaushik et al. (2024) introduced RhythmQuest, a framework leveraging hybrid deep learning methods for Indian music classification and prediction [6]. By integrating diverse musical features, the system improves accuracy in recognizing and forecasting musical patterns, promoting advancements in music analysis. Z. Qadir et al. (2018): This paper introduces a Zigbee-based IoT smart parking system designed for time and energy efficiency, emphasizing the use of low-power wireless communication for seamless vehicle tracking and parking management [7]. T. Sharma and P. Kaushik (2023): The authors employ sentiment analysis on Twitter data to reveal user opinions and emotions, demonstrating the power of natural language processing in understanding social media sentiment dynamics [8].

Hardik Tanti et al. (2020): This research focuses on the design and implementation of an IoT-based smart parking system, highlighting key components like sensors, communication protocols, and cloud integration for efficient parking management [9]. M. Mustari Syafiq Ismail et al. (2019): The paper describes an IoT-based smart parking system that utilizes sensor networks for real-time data collection, providing an intelligent solution for urban parking problems while enhancing user experience [10]. P. Kaushik et al. (2024): The research presents RhythmQuest, a hybrid deep learning model for classifying and predicting Indian music, showcasing AI's potential to enhance cultural data processing and classification in the music industry [11]. Review Paper on Smart Parking System (2024): This paper offers an overview of smart parking systems, discussing various IoT technologies, their applications, and challenges, and emphasizes the importance of automation and data analytics for efficient parking management [12]. D. Ashok et al. (2020): The study proposes an IoT-based smart parking system that utilizes cloud and sensor technologies for seamless vehicle tracking, enabling users to find available parking spaces quickly and reducing congestion [13]. M. Yadav et al. (2023): The research explores AI applications in human resources, focusing on automation of HR processes like recruitment and performance evaluation, improving workplace productivity and operational efficiency [14]. P. Sadhukhan (2017): This paper discusses an IoT-based electronic parking system, proposing a solution to parking challenges in smart cities by automating space allocation, reducing human intervention, and increasing operational efficiency [15]. D. Issrani and S. Bhattacharjee (2018): The paper provides a review of IoT-based smart parking systems, covering various technologies such as sensor networks, cloud computing, and data analytics to optimize urban parking infrastructure [16]. Prakash (2024): The article explores how blockchain technology can enhance supply chain transparency and efficiency, highlighting its potential to eliminate inefficiencies and ensure secure, traceable transactions across industries [17]. M. R. M. Veeramanickam et al. (2022): This study presents an IoT-based smart parking model utilizing Arduino UNO and FCFS scheduling, offering a practical solution for managing parking spaces efficiently in urban settings [18]. A. Khanna and R. Anand (2016): The paper explores an IoT-based smart parking system, focusing on using sensors and real-time data processing to offer automated parking solutions that reduce congestion and improve urban mobility [19].

R. Lookmuang et al. (2018): The research presents a smart parking system using IoT technology, focusing on improving parking space allocation and reducing traffic congestion through efficient sensor networks and communication protocols [20]. P. Solic et al. (2019): This paper evaluates the performance of smart parking sensors, providing insights into their effectiveness in real-time data collection and the impact on optimizing parking space availability and user experience [21]. The reviewed literature on IoT-based smart parking systems highlights significant advancements in both technology and application [22]. Many studies emphasize the role of IoT in improving parking space management, reducing urban congestion, and enhancing user convenience through real-time data processing and sensor networks [23]. The integration of IoT with cloud computing, machine learning, and energy-efficient technologies, such as Zigbee and Arduino, has proven to be a key factor in optimizing the overall efficiency of parking systems [24].

III. PROPOSED SYSTEM

A. COMPONENTS OF SMART PARKING SYSTEM

The raspberry pi is the world smallest pc with the special specs for connecting sensors with the cloud and app for easy interface work.

Connecting wires- These are electrical wires used to establish a connection between different components or parts of an electrical circuit. They are used to transmit electrical signals and power between various components of the system. They create a connection between different parts of the system, allowing them to communicate and interact with each other. These signals can be analog or digital and can carry information such as sensor readings or control signals.

IR sensors: it is a component used for the detecting the presence of an obstacle for a specific amount of distance and transmit the data to server.

MQTT dashboard is a MACHINE TO MACHINE connection atmosphere based on connection and has standard based

Fig. 2. Raspberry Pi

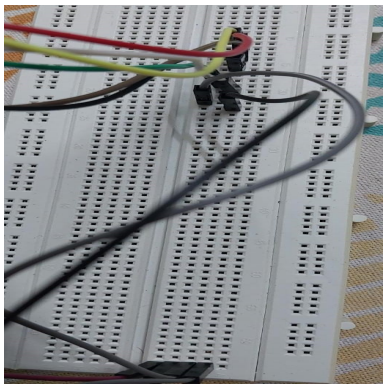

Fig. 3. Connecting Wires

Fig. 4. Infrared Sensor

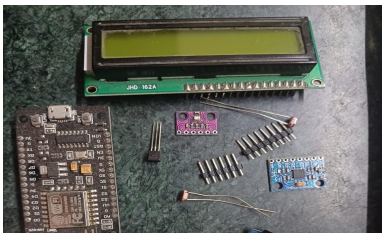

Fig. 5. Lcd Display

messaging atmosphere and the with some set of rules. Smart sensors using Iot devices, sensors, and wearables devices as basically device which are capable for transmit and receive data over a specified protocol with the resource constraint network with limited bandwidth.

LCD display it is used to display the free parking slot data for the user at the outside of the parking slot and 16*4 lcd has been used in this project.

IV. WORKING PRINCLIPLE OF SPS

The system is presented to use in smart parking system for Space Detection, to identify vacant spaces in the parking lot, the system should have sensors ot LCD display. The sensor ought to be able to determine whether a car is parked in a spot or not. And real time status is shown in app.

System Design The design of the system is to show case the architecture of the structure, For the system in which the sensors detect the motion of car as well as the send the data to the app and lcd display to show the live data of parking slots and the data is shared with the brokerage id with the help of the mqtt iot interface and the app mqtt dashboard.

1) System Architecture: The design goal is to create the system modules that will be using to build main system. this depicts the proposed system architecture how the system is working on which environment with the connectivity of this sensors and app.

The operator will 'ON' the system and wait till the connections done with app and lcd display. The real time data will be sent to app and display through mqtt interface. The user will be able to locate which slot is free for parking space.

Applications

Smart parking systems efficiently manage parking in densely populated urban areas by providing real-time parking availability information, optimizing parking space utilization, and reducing traffic congestion.

- Parking Enforcement and Security: These systems automate parking regulation enforcement by monitoring and detecting unauthorized parking. They integrate with enforcement agencies or ticketing systems and enhance security through surveillance and monitoring capabilities.
- IoT-enabled Smart Cities: Smart parking systems contribute to the development of smart cities by integrating with broader IoT infrastructure. They provide data for intelligent traffic management, support sustainability initiatives, and facilitate efficient transportation planning.
- Electric Vehicle (EV) Charging Integration: Smart parking systems integrate with EV charging infrastructure, enabling users to locate and reserve available charging stations. This facilitates seamless charging experiences for electric vehicle owners.

A. Advantages of smart parking system

Optimal Parking Efficiency Smart parking systems excel at maximizing the utilization of parking spaces by providing real-time information on availability. This minimizes the time spent searching for parking spots and enables drivers to quickly locate vacant spaces, resulting in improved parking efficiency.

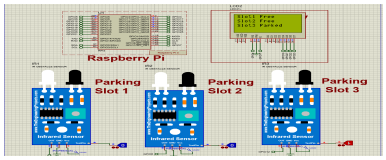

Fig. 6. Parking system working

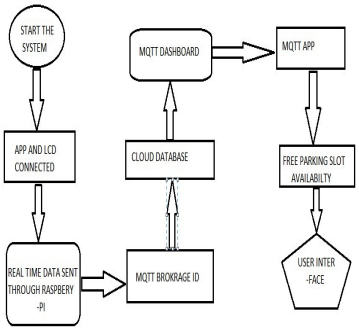

Fig. 7. Iot SPS Architecture Of Working

Improved Safety and Security Smart parking systems often incorporate video surveillance and advanced security measures to ensure the safety of parked vehicles and users. Real-time monitoring and alert systems promptly detect and respond to security incidents, bolstering safety and security within parking facilities.

Data-Driven Decision Making Smart parking systems collect and analyze data on parking occupancy, usage patterns, and user behavior. The derived insights from this data can inform decision-making processes. Parking operators can adjust pricing, allocate resources effectively, and plan infrastructure improvements based on the valuable information obtained.

Integration with Smart City Initiatives Smart parking systems seamlessly integrate into broader smart city initiatives, such as intelligent transportation systems. By sharing data with other smart city components like traffic management systems, they contribute to a more efficient and interconnected urban environment.

Revenue Tracking and Accountability Smart parking systems provide accurate and automated revenue tracking, minimizing the risks associated with revenue leakage or fraudulent activities. Detailed reports and transaction logs ensure transparency and accountability in parking operations.

V. METHODOLOGY

Our main method behind this system is to develop a system for the people to get easy parking slot through seeing by app for parking slots, by Choosing the IoT sensors: To Select the appropriate sensors for installation in the parking lot. These sensors can detect the presence of a vehicle in a parking spot using occupancy sensors, ultrasonic sensors, or magnetic sensors.

Communication network: Choose the communication network that will be used to send sensor data to the cloud. Wi-Fi, Bluetooth, and Lora WAN are examples of such technologies.

Set up the cloud platform: Create a cloud platform to collect and analyze sensor data. This platform should be capable of handling large amounts of data while also providing real-time analytics.

Create the user interface: an easy and accessible interface is developed with the help of mqtt dashboard so that the user can live status of the parking slots which are empty by a connection of internet.

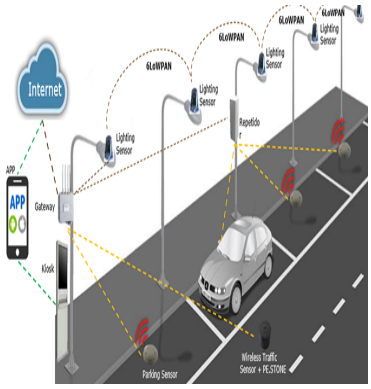

Fig. 8. Parking Structure

VI. FUTURE SCOPE OF SMART PARKING SYSTEM

Integration with Emerging Technologies: Smart parking systems can leverage emerging technologies like Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) to enhance their capabilities. By integrating IoT devices and sensors, real-time data on parking space availability can be obtained, while AI and ML algorithms can optimize parking space allocation and predict parking demand.

Smart Infrastructure and Connectivity: Future smart parking systems can benefit from the advancement of smart city infrastructure and connectivity. This includes integration with smart grids, intelligent transportation networks, and traffic management systems. Such interconnected infrastructure facilitates seamless communication, efficient traffic flow, and dynamic parking management.

Enhanced User Experience: Future developments will prioritize improving the user experience. This entails developing user-friendly mobile applications with intuitive interfaces, seamless booking and payment processes, real-time updates, and personalized parking recommendations. Augmented reality (AR) and virtual reality (VR) technologies can be incorporated to users in navigating parking areas.

A. Strategies to increase the efficiency of smart parking system

Enhanced Sensor Performance: Optimize the placement and calibration of parking sensors to improve accuracy and reliability. Regular maintenance and monitoring are essential to ensure optimal sensor performance. Exploring advanced

Fig. 9. Parking Management

Fig. 10. App Interface For The User To Get Real Time Information Of Parking Slots

sensor technologies, such as ultrasonic or laser-based sensors, can also enhance detection accuracy and reduce false readings.

Real-Time Data Updates: Ensure timely and accurate updates of parking space availability to users. Establish a robust communication network and minimize data transmission delays to provide real-time information on parking availability, reducing instances of outdated or incorrect data.

Dynamic Pricing Strategies: Implement dynamic pricing based on demand and availability to incentivize efficient parking behavior. Adjust parking rates dynamically, applying higher prices during peak hours or high-demand periods, encouraging shorter stays, and reducing congestion.

Streamlined Payment Process: Simplify the payment process by offering multiple convenient payment options, such as mobile payment apps, contactless cards, or prepaid parking passes. Integration with popular payment gateways ensures smooth and efficient transactions, minimizing delays and enhancing user satisfaction.

VII. Results

The enhanced Intelligent Vehicle Parking Systems are gaining popularity due to their real-time access to available parking spaces. Current systems lack features like parking space reservation and availability checks. This document aims to integrate parking lots with the internet and apps to streamline user interaction, reduce time spent, and improve cost efficiency. The paper demonstrates a reduction in vehicle fuel energy consumption through optimized vehicle exploration.

VIII. Conclusion

The implementation of a smart parking system holds the promise of transforming the parking industry. It aims to enhance the parking experience for drivers by offering greater efficiency and convenience while optimizing the utilization of parking spaces. In urban settings, the incorporation of diverse technologies like sensors, data analytics, and mobile applications can enhance parking management and alleviate traffic congestion.

According to current research and case studies, smart parking systems have a positive impact on reducing parking search time, reducing traffic congestion, and improving overall parking experience for users. Furthermore, these systems provide parking operators with valuable data insights that allow them to optimize parking resources, increase revenue, and reduce operating costs. While smart parking systems have yielded promising results, there are still obstacles to overcome, including initial investment costs, system maintenance, and potential privacy concerns. More research is needed to investigate the long-term effects and scalability of smart parking systems in order to ensure their long-term viability and success.

References

[1] I. B. Asianuba and A. Aliyu, “An Improved IOT Smart Parking System,” International Journal of Recent Engineering Science, vol. 10, no. 2. Seventh Sense Research Group Journals, pp. 7–12, Apr. 30, 2023. doi: 10.14445/23497157/ijres-v10i2p102.

[2] Mohammad Kuraishi Z. (2023). Role of Analytics in Supply Chain Management Industry in Lithuania: Big Data Analytics & AI. International Journal for Global Academic & Scientific Research 2(4) 13–22. Doi.: 10.55938/ijgasr.v2i4.65

[3] M. Chandran et al., “An IoT Based Smart Parking System,” Journal of Physics: Conference Series, vol. 1339, no. 1. IOP Publishing, p. 012044, Dec. 01, 2019. doi: 10.1088/1742-6596/1339/1/012044.

[4] S. Rupani and N. Doshi, “A Review of Smart Parking Using Internet of Things (IoT),” Procedia Computer Science, vol. 160. Elsevier BV, pp. 706–711, 2019. doi: 10.1016/j.procs.2019.11.023.

[5] P. Agarwal and A. Vij, “Assessing the Challenges and Opportunities of Artificial Intelligence in Indian Education,” International Journal for Global Academic & Scientific Research, vol. 3, no. 1. International Consortium of Academic Professionals for Scientific Research, pp. 36–44, Apr. 04, 2024. doi: 10.55938/ijgasr.v3i1.71.

[6] P. Kaushik, S. P. Singh Rathore, K. Chahal, S. Saraf, G. Singh Chauhan, and P. Kumar, ’RhythmQuest: Unifying Indian Music Classification and Prediction with Hybrid Deep Learning Techniques,’ 2024 IEEE International Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI), Gwalior, India, 2024, pp. 1-6, doi: 10.1109/IATMSI60426.2024.10503056.

[7] Z. Qadir, F. Al-Turjman, M. A. Khan, and T. Nesimoglu, “ZIGBEE Based Time and Energy Efficient Smart Parking System Using IOT,” 2018 18th Mediterranean Microwave Symposium (MMS). IEEE, Oct. 2018. doi: 10.1109/mms.2018.8611810.

[8] T. Sharma and P. Kaushik, “Leveraging Sentiment Analysis for Twitter Data to Uncover User Opinions and Emotions,” International Journal on Recent and Innovation Trends in Computing and Communication, vol. 11, no. 8s. Auricle Technologies, Pvt., Ltd., pp. 162–169, Aug. 18, 2023. doi: 10.17762/ijritcc.v11i8s.7186.

[9] Hardik Tanti, Pratik Kasodariya, Shikha Patel, and Dhaval H Rangrej, “Smart Parking System based on IOT,” International Journal of Engineering Research and, vol. V9, no. 05. ESRSA Publications Pvt. Ltd., May 09, 2020. doi: 10.17577/ijertv9is050041.

[10] M. Mustari Syafiq Ismail et al., “IoT Based Smart Parking System,” Journal of Physics: Conference Series, vol. 1424, no. 1. IOP Publishing, p. 012021, Dec. 01, 2019. doi: 10.1088/1742-6596/1424/1/012021.

[11] “Review Paper on Smart Parking System,” International Research Journal of Modernization in Engineering Technology and Science. International Research Journal of Modernization in Engineering Technology and Science, Feb. 13, 2024. doi: 10.56726/irjmets49258.

[12] D. Ashok, A. Tiwari and V. Jirge, ”Smart Parking System using IoT Technology,” 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), Vellore, India, 2020, pp. 1-7, doi: 10.1109/ic-ETITE47903.2020.457.

[13] M. Yadav, M. Kakkar, and P. Kaushik, “Harnessing Artificial Intelligence to Empower HR Processes and Drive Enhanced Efficiency in the Workplace to Boost Productivity,” International Journal on Recent and Innovation Trends in Computing and Communication, vol. 11, no. 8s. Auricle Technologies, Pvt., Ltd., pp. 381–390, Aug. 18, 2023. doi: 10.17762/ijritcc.v11i8s.7218.

[14] P. Sadhukhan, ”An IoT-based E-parking system for smart cities,” 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Udupi, India, 2017, pp. 1062-1066, doi: 10.1109/ICACCI.2017.8125982.

[15] D. Issrani and S. Bhattacharjee, ”Smart Parking System Based on Internet of Things: A Review,” 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), Pune, India, 2018, pp. 1-5, doi: 10.1109/ICCUBEA.2018.8697348.

[16] Prakash, “Blockchain Technology for Supply Chain Management: Enhancing Transparency and Efficiency,” International Journal for Global Academic & Scientific Research, vol. 3, no. 2. International Consortium of Academic Professionals for Scientific Research, pp. 01–11, Jul. 02, 2024. doi: 10.55938/ijgasr.v3i2.73.

[17] M. R. M. Veeramanickam, B. Venkatesh, L. A. Bewoor, Y. W. Bhowte, K. Moholkar, and J. L. Bangare, “IoT based smart parking model using Arduino UNO with FCFS priority scheduling,” Measurement: Sensors, vol. 24. Elsevier BV, p. 100524, Dec. 2022. doi: 10.1016/j.measen.2022.100524.

[18] A. Khanna and R. Anand, ”IoT based smart parking system,” 2016 International Conference on Internet of Things and Applications (IOTA), Pune, India, 2016, pp. 266-270, doi: 10.1109/IOTA.2016.7562735.

[19] R. Lookmuang, K. Nambut and S. Usanavasin, ”Smart parking using IoT technology,” 2018 5th International Conference on Business and Industrial Research (ICBIR), Bangkok, Thailand, 2018, pp. 1-6, doi: 10.1109/ICBIR.2018.8391155.

[20] P. Solic, T. Perkovic, T. Konsa, H. Zargariasl, and L. Patrono, “Smart Parking Sensor Performance Evaluation,” 2019 International Conference on Software, Telecommunications and Computer Networks (SoftCOM). IEEE, Sep. 2019. doi: 10.23919/softcom.2019.8903827.

[21] Anand, A. Pandey, S. Mehndiratta, H. Goyal, P. Kaushik and R. Rathore, ”Smart AI basedVolume Control System: Gesture Recognition with OpenCV & Mediapipe Integration,” 2023 International Conference on Smart Devices (ICSD), Dehradun, India, 2024, pp. 1-6, doi: 10.1109/ICSD60021.2024.10751362.

[22] S. Sikarwar, M. F. Afzal, S. Kumar, S. Kumar, S. P. S. Rathore and G. Kaur, ”Improving Parking Management: Leveraging IoT to Empower Smart Environments,” 2023 International Conference on Smart Devices (ICSD), Dehradun, India, 2024, pp. 1-7, doi: 10.1109/ICSD60021.2024.10751449.

[23] S. P. S. Rathore, N. Anute, H. Raje, D. S. Ubale, A. P. Narkhede and P. Kaushik, ”Segmentation Study on Bank Customers Based on RNN,” 2023 International Conference on Smart Devices (ICSD), Dehradun, India, 2024, pp. 1-6, doi: 10.1109/ICSD60021.2024.10751183.

[24] V. Sharma, P. Agarwal, H. Y. Shaikh, R. M. Lenka, S. K. Manjhi and R. Rathore, ”Smart Next-Generation Revenue Growth: A Methodology for Partitioning Customers Utilizing the K-Means Algorithm and RFM Model,” 2023 International Conference on Smart Devices (ICSD), Dehradun, India, 2024, pp. 1-6, doi: 10.1109/ICSD60021.2024.10751627.