



A QR Code-Based Smart Vehicle Parking Management System for Automated Vehicle Authentication, Parking Slot Allocation, and Digital Payment

Harshita Telang¹, Sneha Dambhare², Prof. Bhagyashree Karmarkar³

¹Department of CSE-Data Science, Rajiv Gandhi College of Engineering Research and Technology, Chandrapur, Dr. Babasaheb Ambedkar Technological University, Lonere India,

harshitasunilt2005@gmail.com

²Department of CSE-Data Science, Rajiv Gandhi College of Engineering Research and Technology, Chandrapur, Dr. Babasaheb Ambedkar Technological University, Lonere India,

dambhahesneha130@gmail.com

³Assistant Professor, Department of CSE- DATA SCIENCE, Rajiv Gandhi college of Engineering Research and Technology, Chandrapur, Dr. Babasaheb Ambedkar Technological University, Lonere India,

bhagyashree1318s@gmail.com

ABSTRACT

The rapid increase in urban vehicles has made efficient parking management a major challenge, leading to traffic congestion, delays, and inefficient space utilization. This research proposes a QR Code Based Smart Vehicle Parking Management System that automates parking operations using QR code technology. Registered users receive a unique QR code for authentication at parking entry and exit points. The system automatically allocates parking spaces, records vehicle entry and exit, calculates parking fees, supports digital payments, and stores all parking data in a centralized database. The proposed solution reduces manual effort, improves security, minimizes waiting time, and enhances parking efficiency, making it suitable for smart cities, shopping malls, hospitals, airports, and educational institutions.

KEYWORDS: Artificial Intelligence, Legal Technology, Retrieval-Augmented Generation, Predictive Analytics, Bharatiya Nyaya Sanhita, Natural Language Processing, Fully Homomorphic Encryption, ECDSA, Legal Advisory Systems, Privacy-Preserving AI.

1. INTRODUCTION

Parking management has become a major challenge in urban areas due to the rapid increase in vehicles, resulting in traffic congestion, delays, and inefficient space utilization. Traditional parking systems rely on manual operations, leading to inaccurate record keeping, longer waiting times, and security concerns. This study proposes a **QR Code Based Smart Vehicle Parking Management System** that automates vehicle identification, parking slot allocation, entry-exit monitoring, and fee calculation using unique QR codes. Registered users are authenticated through QR code scanning, enabling secure and efficient parking operations with minimal human intervention. The system maintains a centralized database, supports automated payment processing, and provides

real-time parking management. By improving parking efficiency, reducing congestion, and enhancing user convenience, the proposed system offers a cost-effective solution for smart cities, shopping malls, hospitals, airports, and educational institutions.

2. CONTRIBUTION OF THE PAPER

The major contributions of this paper are:

1. The system uses QR-code-based vehicle identification combined with secure user authentication to ensure safe and reliable entry and exit for each vehicle.
2. It automates parking slot allocation and provides real-time monitoring of available spaces, significantly reducing waiting time during entry and exit.
3. Parking fees are calculated automatically, minimizing manual intervention and improving billing accuracy.
4. Compared to RFID-based systems, this QR-code approach offers a low-cost, easy-to-implement alternative while still enhancing overall parking efficiency, user convenience, and data management.
5. Its scalable design makes it suitable for deployment in diverse locations such as malls, hospitals, offices, and smart city infrastructure.

3. LITERATURE REVIEW / RELATED WORK / BACKGROUND STUDY

3.1 Evolution of Digital Legal Information Systems

Digital legal information systems have evolved from keyword-based legal databases to AI-powered platforms capable of semantic search, legal text mining, and contextual information retrieval, improving access to legal knowledge.

3.2 Large Language Models in Legal Applications

Large Language Models (LLMs) support legal reasoning, document summarization, and legal query answering. However, their tendency to generate hallucinated or inaccurate legal information limits their reliability in legal practice.

3.3 Retrieval-Augmented Generation (RAG)

Retrieval-Augmented Generation (RAG) enhances legal AI by retrieving verified legal documents from external knowledge bases before generating responses, thereby improving factual accuracy and reducing hallucinations.

3.4 Predictive Analytics in Legal Decision Support

Machine Learning-based predictive analytics estimates legal outcomes by analyzing historical case data, statutory provisions, and judicial patterns, enabling evidence-based legal decision support.

3.5 Privacy-Preserving Legal Computing

Privacy-preserving techniques such as Fully Homomorphic Encryption (FHE) enable secure processing of sensitive legal information without exposing user data, addressing confidentiality concerns in AI-driven legal systems.

3.6 Cryptographic Verification and Trust Management

Cryptographic methods, particularly the Elliptic Curve Digital Signature Algorithm (ECDSA), ensure the authenticity and integrity of AI-generated legal responses, enhancing user trust and system reliability.

3.7 Research Gap Identification

Existing legal AI systems continue to face challenges including hallucinated legal advice, limited explainability, inadequate predictive capabilities, and insufficient privacy protection. These limitations highlight the need for secure, explainable, and trustworthy AI-based legal advisory frameworks that integrate accurate retrieval, predictive analytics, and robust privacy mechanisms.

Features / Existing Systems	Legal Search Engines (Westlaw, LexisNexis)	AI Legal Chatbots	Legal Outcome Prediction Systems	Privacy-Preserving AI Systems	Proposed LAWBIT Framework
Legal Information Retrieval	✓	✓	✗	✗	✓
Natural Language Query Processing	✗	✓	✗	✗	✓
Retrieval-Augmented Generation (RAG)	✗	Limited	✗	✗	✓
Reduction of AI Hallucinations	✗	✗	✗	✗	✓
Case Outcome Prediction	✗	✗	✓	✗	✓
Explainable Legal Recommendations	Limited	Limited	Limited	✗	✓
Privacy Preservation	✗	✗	✗	✓	✓
Fully Homomorphic Encryption (FHE)	✗	✗	✗	Limited	✓
Cryptographic Verification (ECDSA)	✗	✗	✗	✗	✓
Support for Bharatiya Nyaya Sanhita (BNS)	Limited	Limited	✗	✗	✓
Zero-Trust Security Architecture	✗	✗	✗	Limited	✓
Integrated End-to-End Legal Assistance	✗	Partial	Partial	✗	✓

To address these limitations, the proposed LAWBIT framework combines verified legal retrieval, AI-driven consultation, privacy-preserving predictive analytics, and cryptographic trust mechanisms into a single Zero-Trust architecture. This integrated approach aims to provide accurate, secure, transparent, and accessible legal assistance while preserving user confidentiality and minimizing the risk of misinformation.

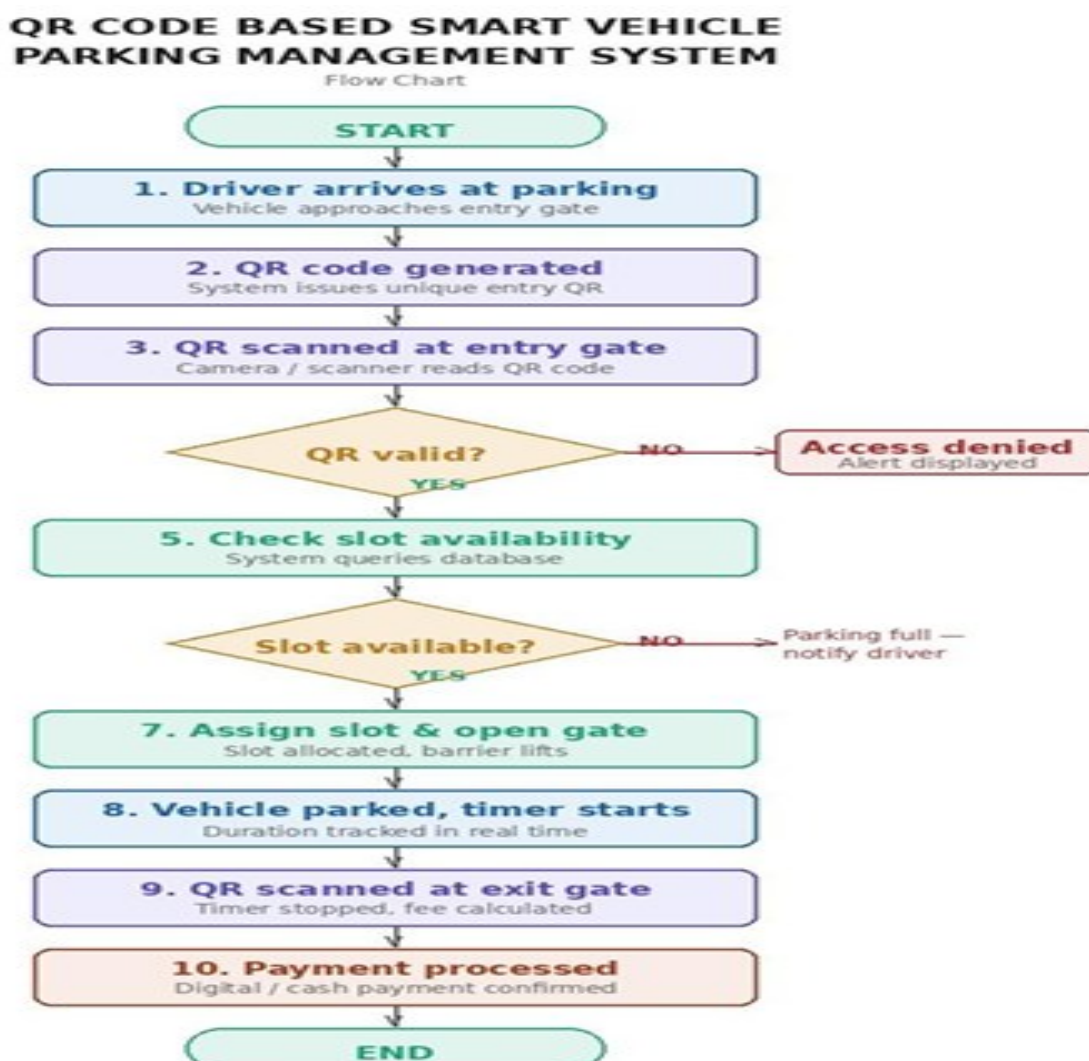
4. RESEARCH METHODOLOGY

- System Architecture
- The proposed system consists of:
 - User Registration Module
 - QR Code Generation Module
 - Parking Slot Management Module
 - QR Scanner Module
 - Database Management System
 - Payment Processing Module

Methodology Steps

1. User registers vehicle details in the system.
2. A unique QR code is generated for each vehicle.
3. At the parking entrance, the QR code is scanned.
4. The system verifies user information.
5. An available parking slot is assigned automatically.
6. Entry time is stored in the database.
7. During exit, the QR code is scanned again.
8. Parking duration and fee are calculated automatically.
9. Payment is processed.
10. Parking records are updated in the database

Flowchart



5. RESULTS AND DISCUSSION

Results

The QR Code Based Smart Vehicle Parking Management System was designed and implemented to automate parking operations and improve the overall parking experience for users. The developed system was tested under different parking scenarios to evaluate its performance, accuracy, security, and usability. The results obtained from the testing phase indicate that the system performs effectively in managing parking spaces and vehicle movements.

The system successfully generated a unique QR code for each registered vehicle and parking reservation. When a vehicle arrived at the parking facility, the QR code was scanned at the entrance gate. The system verified the vehicle information stored in the database and automatically granted access to authorized users. This process significantly reduced the time required for vehicle verification compared to manual checking methods.

The parking slot allocation module functioned efficiently by identifying vacant parking spaces and assigning them to users. Real-time updates of parking slot availability were reflected in the system database, enabling users to check available spaces before entering the parking area. This reduced the time spent searching for parking spaces and improved parking lot utilization.

The developed system accurately maintained records of vehicle entry time, exit time, parking duration, and parking charges. Automatic fee calculation based on parking duration eliminated human errors and ensured transparent billing. The generated reports provided useful information for parking administrators regarding occupancy rates, peak parking hours, and revenue generation.

The QR code scanning process demonstrated high accuracy and reliability during testing. The average scanning and verification time ranged between 2 and 5 seconds, enabling smooth vehicle movement through entry and exit points. The system also successfully detected invalid or expired QR codes and denied unauthorized access, thereby improving parking security.

Testing results showed that the system could effectively manage multiple users simultaneously without significant delays. Even during periods of high parking demand, the system maintained stable performance and continued to provide real-time updates regarding slot availability. This demonstrates the scalability of the proposed solution for use in large parking facilities.

Discussion

The results obtained from this study demonstrate that the QR Code Based Smart Vehicle Parking Management System provides an efficient and practical solution to the challenges associated with traditional parking systems. Conventional parking management often involves manual processes, including ticket issuance, vehicle verification, slot allocation, and fee collection. These processes are time-consuming, labor-intensive, and prone to human error. The proposed system addresses these challenges through automation and digital technology.

One of the most significant findings of this study is the reduction in vehicle waiting time. In traditional parking facilities, drivers often spend considerable time waiting at entry points and searching for vacant parking spaces. By using QR codes for vehicle authentication and real-time slot management, the developed system streamlines the parking process and minimizes delays. This improvement enhances user experience and increases operational efficiency.

The real-time parking slot monitoring feature proved to be particularly beneficial. Users could access information about available parking spaces before arriving at the parking area. As a result, unnecessary vehicle movement within the parking facility was reduced. This not only saves time for drivers but also decreases fuel consumption and vehicle emissions, contributing to environmental sustainability.

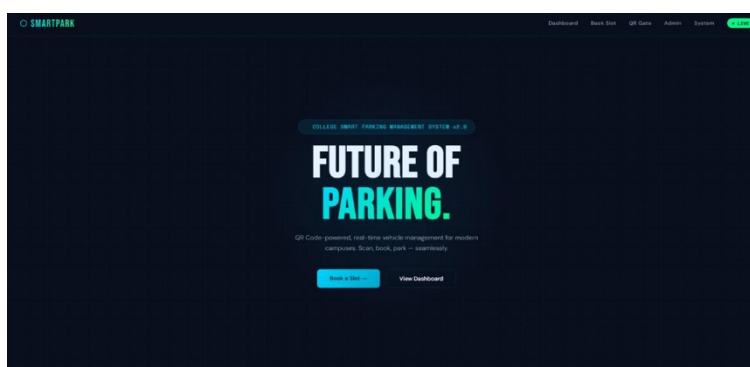
Another important aspect observed during system evaluation was enhanced security. Each QR code generated by the system contains unique identification information linked to a specific vehicle and parking reservation. Unauthorized vehicles without valid QR codes cannot gain access to the parking facility. Furthermore, the system maintains a digital record of all vehicle movements, making it easier to track and monitor parking activities. This feature can assist in preventing vehicle theft, unauthorized parking, and security breaches.

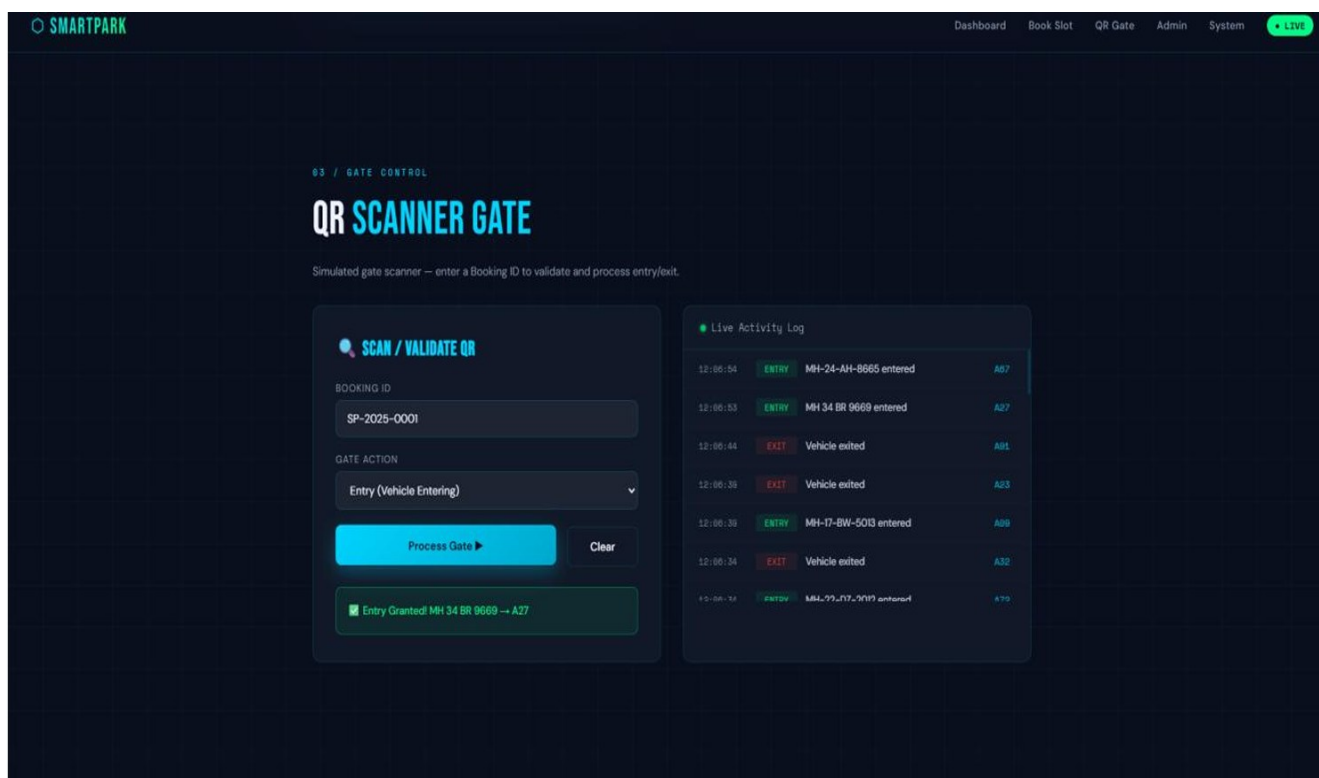
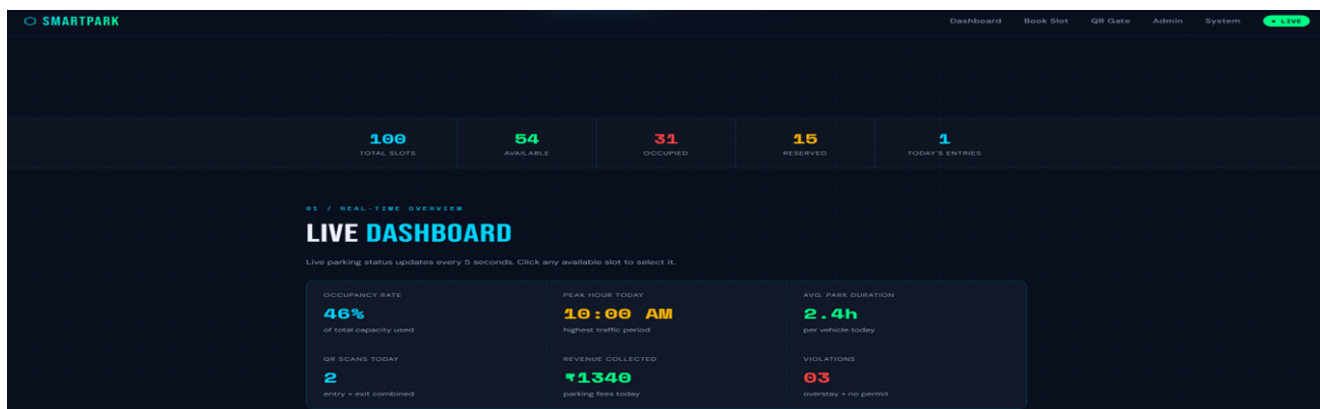
The automated billing functionality also contributed significantly to system effectiveness. Traditional parking systems often require manual calculation of parking charges, which can lead to errors and disputes. In the proposed system, parking fees are calculated automatically based on entry and exit times recorded in the database. This ensures accurate billing and improves transparency between parking operators and users.

The study further revealed that QR code technology is a cost-effective solution for smart parking management. Compared with technologies such as RFID, biometric authentication, and advanced sensor networks, QR codes require relatively low implementation and maintenance costs. Since most users already possess smartphones capable of displaying QR codes, additional hardware requirements are minimal. This makes the system suitable for deployment in educational institutions, shopping malls, hospitals, railway stations, airports, corporate offices, and public parking facilities.

The scalability of the system was another important observation. The system handled multiple users and parking transactions efficiently during testing. As parking demand increases, the system can be expanded by integrating additional parking zones, cloud-based databases, and network infrastructure. This flexibility allows the solution to be adapted for both small and large parking environments.

Despite its advantages, the study identified certain limitations. The system depends on stable internet connectivity and functional QR code scanners. Technical failures such as network interruptions, scanner malfunctions, or damaged QR codes may temporarily affect system performance. Additionally, some users who are unfamiliar with digital technologies may initially face difficulties using mobile applications and QR code-based services. Proper user training and technical support can help overcome these challenges.





SMARTPARK Dashboard Book Slot QR Gate Admin System **LIVE**

03 / GATE CONTROL

QR SCANNER GATE

Simulated gate scanner — enter a Booking ID to validate and process entry/exit.

SCAN / VALIDATE QR

BOOKING ID

SP-2025-0001

GATE ACTION

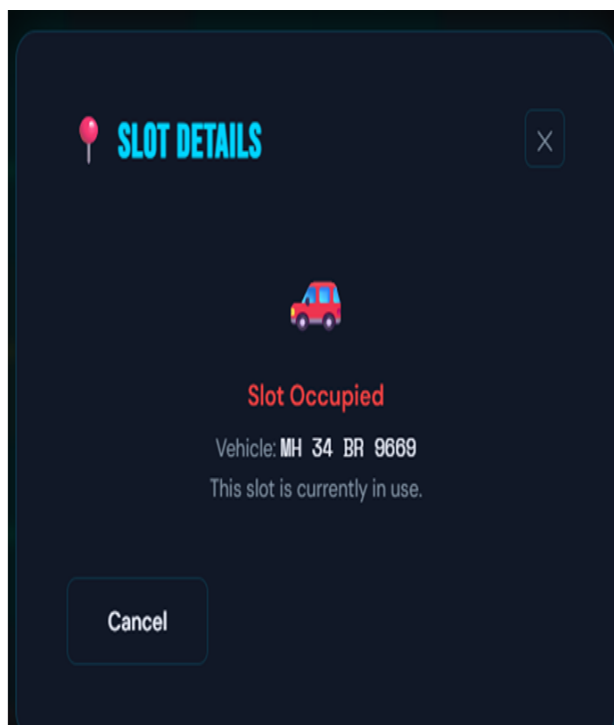
Entry (Vehicle Entering)

Process Gate ▶ Clear

Entry Granted! MH 34 BR 9669 → A27

Live Activity Log

Time	Action	Vehicle ID	Gate
12:06:54	ENTRY	MH-24-AH-8665 entered	A67
12:06:53	ENTRY	MH 34 BR 9669 entered	A27
12:06:44	EXIT	Vehicle exited	A01
12:06:39	EXIT	Vehicle exited	A23
12:06:39	ENTRY	MH-17-BW-5013 entered	A09
12:06:34	EXIT	Vehicle exited	A32
12:06:10	ENTRY	MH-22-LT-7013 entered	A79



04 / RECORDS

ACTIVE BOOKINGS

BOOKING ID	VEHICLE NO.	NAME	SLOT	TYPE	DURATION	FEE	STATUS
SP-2025-0001	MH 34 BR 9669	VIVEK RAUT	A27	2W	1h	₹20	ACTIVE

04 / RECORDS

ACTIVE BOOKINGS

BOOKING ID	VEHICLE NO.	NAME	SLOT	TYPE	DURATION	FEE	STATUS
SP-2025-0001	MH 34 BR 9669	VIVEK RAUT	A27	2W	1h	₹20	EXPIRED

03 / GATE CONTROL

QR SCANNER GATE

Simulated gate scanner — enter a Booking ID to validate and process entry/exit.

SCAN / VALIDATE QR

BOOKING ID

SP-2025-0001

GATE ACTION

Exit (Vehicle Leaving)

Process Gate ▶

Clear

Exit Processed! Fee: ₹20. Have a safe journey!

Live Activity Log

12:19:04	EXIT	MH 34 BR 9669 exited	A27
12:19:04	EXIT	Vehicle exited	A40
12:18:59	EXIT	Vehicle exited	A04
12:18:59	ENTRY	MH-24-RI-5718 entered	A80
12:18:54	ENTRY	MH-21-ZM-6867 entered	A59
12:18:48	ENTRY	MH-20-BW-3889 entered	A85
12:18:20	EXIT	Vehicle exited	A54

6. CONCLUSION AND FUTURE SCOPE

Conclusion

The QR Code Based Smart Vehicle Parking Management System offers an effective solution to modern parking challenges. By integrating QR code technology with automated parking management, the system reduces manual work, minimizes waiting time, enhances security, and optimizes parking space utilization. The proposed system supports real-time monitoring, automated fee calculation, and digital payment processing. Its low implementation cost and ease of use make it suitable for shopping malls, airports, educational institutions, hospitals, and smart city projects. Overall, the system contributes to efficient transportation management and improved user satisfaction.

The QR Code Based Smart Vehicle Parking Management System provides an efficient, secure, and user-friendly solution for modern parking management. By automating vehicle identification, parking slot allocation, fee calculation, and record management, the system reduces manual work and improves overall operational efficiency. QR code technology offers a cost-effective alternative to traditional parking management methods while maintaining high security and reliability. The proposed system supports smart city initiatives and contributes to better traffic management, reduced congestion, and enhanced user satisfaction.

The QR Code Based Smart Vehicle Parking Management System is an efficient and cost-effective solution for modern parking challenges. By integrating QR code technology with automated parking operations, the system reduces manual effort, minimizes waiting time, enhances security, and optimizes parking space utilization. The system provides accurate record management, automated fee calculation, and digital payment support. It can be implemented in shopping malls, hospitals, airports, educational institutions, and commercial complexes. Overall, the proposed system contributes to improved transportation management and supports the vision of smart cities.

The QR Code Based Smart Vehicle Parking Management System provides an efficient, secure, and cost-effective solution for modern parking challenges. The system automates vehicle entry, exit, parking allocation, and payment processing. Experimental results demonstrate improved efficiency, reduced waiting time, and enhanced user experience compared to traditional parking systems.

Future Scope

The QR Code Based Smart Vehicle Parking Management System can be enhanced further by integrating advanced technologies and smart features.

Some future developments are:

1. IoT-Based Parking Slot Detection

The system can be integrated with IoT sensors to detect the availability of parking spaces in real time. Users can view vacant slots instantly through a mobile application or display board.

2. Mobile Application Integration

A dedicated mobile application can allow users to register vehicles, reserve parking spaces, view parking availability, make payments, and receive notifications.

3. Automatic Number Plate Recognition (ANPR)

The system can be combined with ANPR technology to automatically identify vehicles using cameras, reducing the need for QR code scanning.

4. Artificial Intelligence and Machine Learning

AI algorithms can predict parking demand, optimize space allocation, and analyze parking usage patterns for better management.

5. Smart Navigation Assistance

The system can provide GPS-based navigation to guide drivers directly to available parking spaces, reducing search time and traffic congestion.

6. Cloud-Based Data Management

Cloud integration can enable centralized storage of parking records, allowing access from multiple locations and improving scalability.

7. Online Reservation System

Users can reserve parking spaces in advance, ensuring availability before reaching the parking facility.

8. Dynamic Parking Fee System

Parking charges can be adjusted automatically based on demand, peak hours, or special events to optimize parking utilization and revenue generation.

7. ACKNOWLEDGMENTS

We extend our heartfelt thanks to our Principal and Head of Department, Dr. Anil Chitade, for their insightful suggestions and constant motivation.

We would also like to express our appreciation to the faculty and staff of the CSE - Data Science for creating an inspiring academic environment.

8. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research paper. The research was conducted independently without any financial, institutional, or personal influence that could affect the outcomes of the study.

9. RESEARCH INTEGRITY STATEMENT

The authors declare that the manuscript is original, complies with the journal's plagiarism and AI usage requirements, has not been published or submitted elsewhere, and that all applicable ethical guidelines have been followed in conducting.

reporting, and publishing the research.

10. REFERENCES

- [1] Sharma, R., Gupta, A., & Singh, P. (2020). IoT-Based Smart Parking System. *International Journal of Computer Applications*, 176(15), 12–18.
- [2] Patel, M., & Kumar, S. (2021). Cloud-Based Vehicle Parking Management System. *International Journal of Engineering Research and Technology*, 10(4), 245–251.
- [3] Singh, A., Verma, R., & Sharma, D. (2022). RFID-Based Smart Parking System for Urban Areas. *International Journal of Advanced Research in Computer Science*, 13(2), 88–95.
- [4] Verma, K., & Gupta, N. (2023). QR Code Enabled Smart Parking Management System. *Journal of Smart Computing and Applications*, 8(1), 45–53.
- [5] Rajput, S., & Mishra, P. (2024). Smart City Parking Solutions Using QR Technology. *International Journal of Innovative Technology and Research*, 12(1), 101–109.
- [6] Kumar, V., & Sharma, R. (2024). Automated Vehicle Parking Management Using QR Codes and IoT. *International Journal of Emerging Technologies*, 15(3), 67–75.
- [7] K. P. Bhuvaneshwari and S. Priya, "Smart Parking Management System Using QR Code Technology," *International Journal of Engineering Research and Technology*.
- [8] Rajesh Kumar et al., "Smart Parking System for Urban Areas Using QR Codes and Cloud Computing," *IEEE Conference Proceedings*.
- [9] M. Ali and A. Khan, "Automated Vehicle Parking Management System," *International Journal of Computer Applications*.
- [10] ISO/IEC 18004: Information Technology – QR Code Bar Code Symbology Specification.
- [11] Python Software Foundation Documentation.
- [12] Smart City Mission Guidelines, Government of India.
- [13] Research papers on IoT-Based Smart Parking Systems and Intelligent Transportation.
- [14] Bhuvaneshwari, K.P., and Priya, S., "Smart Parking Management System Using QR Code Technology," *International Journal of Engineering Research and Technology*.

11. ABOUT THE AUTHOR(S)

Harshita Telang is pursuing a Bachelor of Technology in Computer Science and Engineering (Data Science) at Rajiv Gandhi College of Engineering and Research Technology (RCERT), Chandrapur. Her research interests include Java, Python, Artificial Intelligence, Machine Learning, Web Development, Generative AI, and Data Analytics.

Sneha Dambhare is a Bachelor of Technology student in Computer Science and Engineering (Data Science) at RCERT, Chandrapur. Her areas of interest include Python, Artificial Intelligence, Machine Learning, Web Development, Generative AI, and Data Analytics.

Prof. Bhagyashree Karmarkar is an Assistant Professor in the Department of CSE–Data Science at RCERT, Chandrapur. Her research focuses on Data Analytics, Artificial Intelligence, Machine Learning, and emerging computational technologies.