

Research Paper

DESIGN AND DEVELOPMENT OF A REAL- TIME VEHICLE PARKING ALLOCATION AND RESERVATION SYSTEM

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ABSTRACT

Efficient parking management has become a significant challenge due to the rapid increase in vehicle ownership and urbanization. Conventional parking systems often rely on manual operations, resulting in inefficient space utilization, increased waiting time, traffic congestion, and security concerns. This project presents the **Design and Development of a Real-Time Vehicle Parking Allocation and Reservation System**, a web-based application that automates parking slot allocation, reservation, and vehicle verification using modern web technologies. The proposed system is developed using **Python, Django, MySQL, HTML, CSS, Bootstrap, JavaScript, and OpenCV**. Users can register, log in, register their vehicles, view real-time parking slot availability, reserve parking spaces, and receive a unique QR code for vehicle authentication. At the parking entrance and exit, QR codes are scanned using OpenCV to verify vehicle identity, record entry and exit times, and automatically update parking slot availability. The system also includes online payment processing, complaint management, and report generation, enabling centralized administration of parking operations. Experimental evaluation demonstrates that the proposed system reduces manual effort, improves parking space utilization, enhances security through QR code-based authentication, and minimizes vehicle waiting time. Compared with traditional parking management approaches, the proposed solution offers improved efficiency, scalability, accuracy, and user convenience, making it suitable for deployment in residential apartments, educational institutions, hospitals, office campuses, shopping malls, and other commercial parking facilities.

Keywords: Real-Time Parking System, Parking Reservation, Vehicle Parking Management, QR Code Authentication, OpenCV, Django Framework, Python, MySQL, Smart Parking, Web-Based Application.

I.INTRODUCTION

The rapid growth of urbanization and the increasing number of vehicles have significantly intensified parking-related challenges across cities worldwide. Traditional parking management systems often depend on manual supervision, leading to inefficient utilization of parking spaces, longer vehicle waiting times, traffic congestion, and increased operational costs. Drivers frequently spend considerable time searching for vacant parking spaces, resulting in unnecessary fuel consumption, environmental pollution,

and reduced user satisfaction. Consequently, the development of intelligent parking management systems has become an essential component of modern smart city initiatives aimed at improving transportation efficiency and urban mobility [1], [2].

Recent advancements in information technology, cloud computing, computer vision, and web application development have enabled the implementation of smart parking systems capable of providing real-time parking information and automated reservation services. Web-based platforms allow users to access parking availability from any location, reserve parking spaces in advance, and receive instant confirmation through digital authentication methods. These systems minimize manual intervention while improving parking space utilization, operational efficiency, and customer convenience. Python and the Django framework have emerged as popular technologies for developing scalable, secure, and database-driven web applications due to their flexibility, rapid development capabilities, and extensive library support [3], [4].

Vehicle authentication plays a crucial role in ensuring the security and reliability of smart parking systems. QR code technology provides a cost-effective and secure mechanism for uniquely identifying vehicles and validating reservations during entry and exit operations. When integrated with OpenCV-based image processing, QR codes can be scanned automatically, enabling fast vehicle verification, accurate attendance logging, and efficient access control without manual verification. This integration significantly reduces unauthorized parking access while improving the speed and accuracy of parking operations [5], [6].

Database management systems also form the backbone of intelligent parking applications by maintaining information related to users, vehicles, parking slots, reservations, payments, complaints, and administrative activities. MySQL offers a reliable relational database environment capable of supporting concurrent user transactions and ensuring data integrity. By integrating web technologies with robust database management, the proposed system provides centralized control over parking operations while enabling administrators to monitor parking utilization and generate analytical reports for effective decision-making [7].

The proposed Real-Time Vehicle Parking Allocation and Reservation System addresses the limitations of conventional parking management by offering an automated, web-based solution that enables user registration, vehicle registration, real-time parking slot availability, online reservation, QR code generation, QR-based vehicle verification using OpenCV, online payment processing, complaint management, and report generation. The system aims to reduce vehicle waiting time, optimize parking space allocation, enhance security, and improve the overall parking experience. Its modular architecture and scalable design make it suitable for deployment in educational institutions, residential apartments, hospitals, shopping malls, corporate campuses, and other public or private parking facilities, thereby contributing to the development of efficient smart parking infrastructures [8], [9].

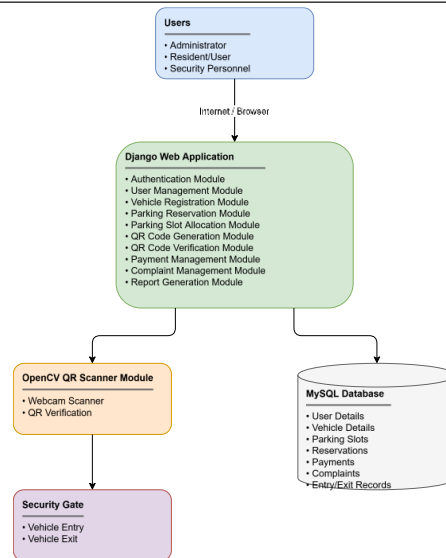


Figure1: System Architecture

The architecture of the Real-Time Vehicle Parking Allocation and Reservation System follows a modular, three-tier design consisting of the user layer, application layer, and database layer, with an additional QR code verification module for secure vehicle authentication. At the top layer, three categories of users—Administrator, Resident/User, and Security Personnel—access the system through a web browser over the internet. The Administrator is responsible for managing users, parking slots, reservations, payments, complaints, and system reports. Residents or users can register, log in, reserve parking slots, make payments, and obtain QR codes for parking access, while Security Personnel verify vehicles at the entry and exit gates using QR code scanning. This user-centric design ensures that each stakeholder has role-based access to the system according to their responsibilities.

The central component of the architecture is the Django Web Application, which serves as the core processing layer and coordinates all system functionalities. It consists of multiple integrated modules, including the Authentication Module, User Management Module, Vehicle Registration Module, Parking Reservation Module, Parking Slot Allocation Module, QR Code Generation Module, QR Code Verification Module, Payment Management Module, Complaint Management Module, and Report Generation Module. These modules collectively automate the complete parking management process, from user registration and vehicle enrollment to parking reservation, payment processing, complaint handling, and administrative reporting. Django manages the business logic, validates user requests, communicates with the database, and provides secure interaction between users and system resources through a web interface.

The application communicates with the MySQL Database, which acts as the centralized repository for storing all operational data. The database maintains records related to user information, vehicle details, available parking slots, parking reservations, payment transactions, complaints, and vehicle entry and exit logs. Every activity performed within the application is recorded in the database, ensuring data consistency, quick retrieval, and reliable transaction management. This centralized storage enables administrators to monitor parking utilization, generate analytical reports, and efficiently manage the entire parking infrastructure.

To enhance security and automate access control, the system integrates an OpenCV QR Scanner Module

connected to the Django application. After a successful parking reservation, the system generates a unique QR code for each user. At the parking entrance and exit, the OpenCV-based scanner uses a webcam to read and verify the QR code against the reservation details stored in the database. If the QR code is authenticated successfully, the Security Gate permits vehicle entry or exit and updates the parking status in real time. This architecture minimizes manual verification, prevents unauthorized access, improves parking security, and ensures efficient management of vehicle movements within the parking facility.

II SURVEY OF RESEARCH

The development of smart parking systems has gained considerable attention in recent years due to increasing urbanization, traffic congestion, and the rapid growth in vehicle ownership. Researchers have proposed various technologies, including Internet of Things (IoT), cloud computing, computer vision, wireless sensor networks, QR code authentication, and web-based reservation systems, to improve parking efficiency and reduce manual intervention. These studies have contributed significantly to intelligent transportation systems by providing automated parking allocation, real-time monitoring, and enhanced user convenience. Idris *et al.* [1] presented one of the earliest comprehensive reviews of smart parking systems and highlighted the importance of integrating sensing technologies, wireless communication, and centralized databases for efficient parking management. Their study emphasized that intelligent parking solutions reduce traffic congestion and improve parking space utilization by providing real-time information to users. However, the proposed approaches mainly focused on monitoring parking occupancy and lacked secure online reservation and authentication mechanisms.

Khanna and Anand [2] introduced an IoT-based smart parking system that utilized embedded sensors to detect vehicle occupancy and transmit parking availability information through cloud services. Their framework enabled drivers to locate vacant parking spaces efficiently while reducing unnecessary vehicle movement. Although the system improved parking monitoring accuracy, it required expensive sensor infrastructure and did not include web-based reservation management or secure vehicle verification methods. Research by Lin *et al.* [3] proposed a cloud-enabled intelligent parking management framework that integrated mobile applications with cloud computing for real-time parking reservation. The system allowed users to reserve parking spaces remotely and receive navigation assistance to available slots. The study demonstrated improved parking efficiency; however, it primarily relied on mobile platforms and offered limited administrative control for parking operators.

OpenCV-based computer vision techniques have also been widely adopted for automated parking applications. Bradski and Kaehler [4] demonstrated the effectiveness of OpenCV in image processing, object detection, and QR code recognition. Their work established OpenCV as a reliable framework for implementing real-time vehicle authentication and automated access control. By combining computer vision with QR code technology, parking systems can significantly reduce manual verification and improve operational security. QR code-based authentication has become an increasingly popular method for secure vehicle identification due to its simplicity, low implementation cost, and high accuracy. QR codes provide unique encrypted information that can be generated during parking reservation and verified during vehicle entry and exit. Several studies have shown that QR code authentication reduces unauthorized parking access while accelerating the verification process compared to conventional manual identification methods [5].

The Django web framework has also been extensively used for developing secure and scalable web-based applications. Holovaty and Kaplan-Moss [6] highlighted Django's Model-View-Template (MVT)

architecture, built-in authentication mechanisms, database integration capabilities, and security features that simplify the development of enterprise-level web applications. These characteristics make Django highly suitable for implementing parking reservation systems requiring user management, transaction processing, and real-time database interaction. Modern database management systems play an essential role in ensuring reliable storage and retrieval of parking information. Oracle's MySQL database [7] provides transaction management, relational data modeling, concurrent access control, and data integrity features required for handling multiple users and parking reservations simultaneously. Its scalability and reliability make it an appropriate backend database for web-based parking management applications.

Based on the findings of previous research, it is evident that existing parking management solutions primarily focus on individual technologies such as IoT sensors, mobile applications, or parking occupancy detection. Many systems lack a comprehensive integration of web-based reservation, QR code authentication, OpenCV-based verification, payment processing, complaint management, and centralized administrative reporting within a single platform. The proposed Real-Time Vehicle Parking Allocation and Reservation System addresses these limitations by integrating Python, Django, MySQL, OpenCV, and QR code technologies into a unified, secure, and scalable web-based solution that supports real-time reservation, automated vehicle verification, efficient parking allocation, and centralized parking management.

III. WORKING METHODOLOGY

The **Real-Time Vehicle Parking Allocation and Reservation System** is developed using a modular and systematic approach to automate parking management, improve security, and enhance user convenience. The system is implemented as a web-based application using the Django framework with MySQL as the backend database, while OpenCV is integrated for QR code-based vehicle verification. The methodology begins with user registration and authentication, where users create accounts and securely log in to access the parking services. Based on their roles, such as administrator, resident, or security personnel, users are granted appropriate permissions to perform various operations within the system.

After successful authentication, users register their vehicle details, including vehicle number, type, and owner information. These details are securely stored in the database and become available for future parking reservations. The parking management module continuously monitors available parking slots and displays real-time parking availability to users through the web interface. Users can view vacant parking spaces and reserve a suitable slot according to their requirements. Once a reservation is confirmed, the system allocates the parking space and generates a unique QR code associated with the reservation details.

The generated QR code serves as the digital identity of the reserved vehicle. During vehicle entry, security personnel use the OpenCV-based QR scanner to scan the QR code presented by the driver. The scanned information is verified with the reservation details stored in the database. If the QR code is valid, the system records the vehicle's entry time, updates the parking slot status from available to occupied, and grants access through the security gate. This automated verification process minimizes manual intervention, improves security, and prevents unauthorized vehicle entry.

Similarly, when the vehicle exits the parking facility, the QR code is scanned again to verify the vehicle's identity. The system records the exit time, updates the parking slot as available, and completes

the parking transaction. If applicable, the payment module calculates parking charges based on the duration of parking and records the transaction details. Users can also submit complaints or feedback regarding parking services, while administrators can monitor reservations, payments, parking utilization, complaints, and vehicle movement through comprehensive reports generated by the reporting module.

IV RESULTSEXPLANATIONS

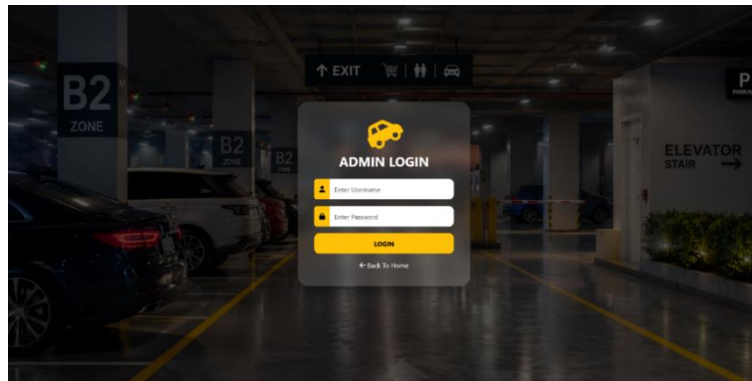


Figure1: Administrator Login Module

The above figure illustrates the **Administrator Login Module** of the **Real-Time Vehicle Parking Allocation and Reservation System**. This module serves as the secure entry point for administrators to access the parking management application. The login interface consists of username and password fields where authorized administrators enter their credentials for authentication. After successful verification, the administrator is redirected to the system dashboard, where they can manage users, vehicle registrations, parking slot allocation, reservations, QR code generation and verification, payment records, complaints, and report generation. The attractive parking-themed background enhances the visual appearance of the application while emphasizing its real-world parking environment. By implementing secure authentication, the login module ensures that only authorized personnel can access administrative functions, thereby protecting sensitive parking data and maintaining the overall security and integrity of the system.

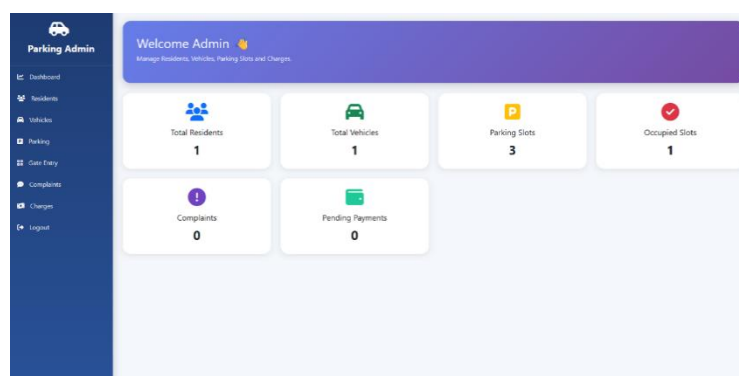


Figure2: Administrator Dashboard

The above figure illustrates the **Administrator Dashboard** of the **Real-Time Vehicle Parking Allocation and Reservation System**, which serves as the central control panel for managing all parking-related activities. After successful login, the administrator is presented with a user-friendly dashboard that provides a real-time overview of the system through statistical summary cards displaying the total number of residents, registered vehicles, available parking slots, occupied slots, complaints, and pending

payments. A navigation menu on the left side enables quick access to various modules, including Dashboard, Residents, Vehicles, Parking, Gate Entry, Complaints, Charges, and Logout. Through this interface, the administrator can efficiently monitor parking operations, manage user and vehicle information, allocate parking spaces, oversee entry and exit records, handle complaints, update parking charges, and track payment status. The dashboard offers a centralized and intuitive management environment, allowing administrators to make informed decisions, improve operational efficiency, and ensure smooth and secure parking management.

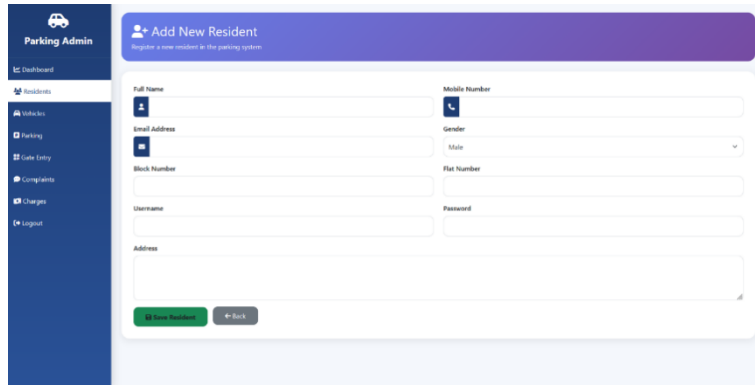


Figure 3: Add New Resident Module

The above figure illustrates the **Add New Resident Module** of the **Real-Time Vehicle Parking Allocation and Reservation System**. This module enables the administrator to register new residents who will use the parking facility. The registration form collects essential information such as the resident's full name, mobile number, email address, gender, block number, flat number, username, password, and residential address. After entering the required details, the administrator can save the information, which is securely stored in the system database for future authentication and parking management. Once registered, residents can log in to the system, register their vehicles, reserve parking slots, make online payments, and access other parking services. The module provides a simple and organized interface that ensures accurate resident data management while reducing manual paperwork and improving the efficiency of the parking administration process.

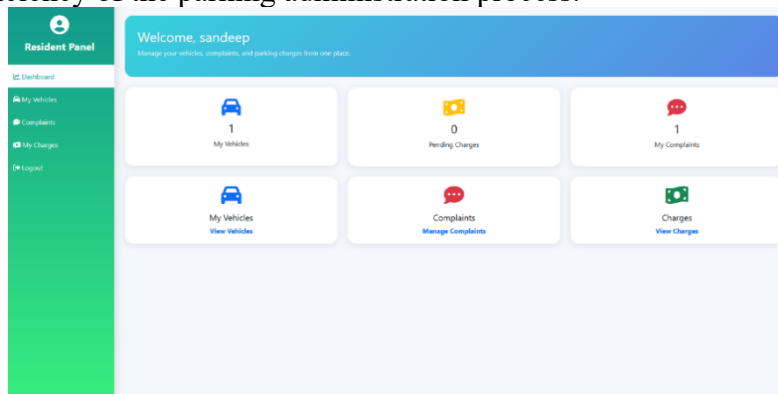
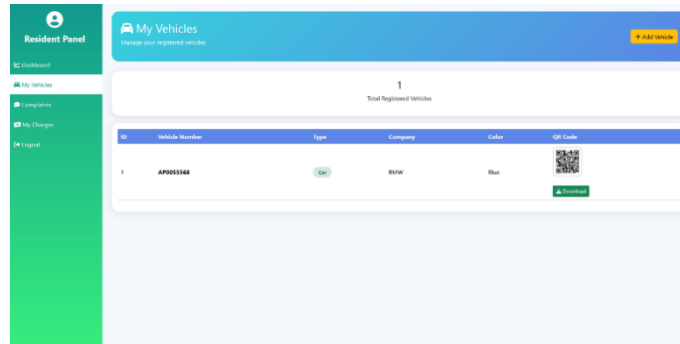


Fig 4 : Resident Dashboard

The above figure illustrates the **Resident Dashboard** of the **Real-Time Vehicle Parking Allocation and Reservation System**, which serves as the main interface for registered residents after successful login. The dashboard provides a personalized overview of the user's parking-related activities, displaying important information such as the total number of registered vehicles, pending parking charges, and submitted complaints through easy-to-understand summary cards. The navigation panel on the left allows residents to quickly access modules including Dashboard, My Vehicles, Complaints, My Charges, and Logout.

Logout. Through this interface, residents can register and manage their vehicles, view parking charges, submit complaints regarding parking services, and monitor the status of their requests from a single platform. The simple and intuitive dashboard design enhances user experience by providing centralized access to all resident services, reducing manual communication with administrators and enabling efficient, transparent, and convenient parking management.



V.CONCLUSION

The **Design and Development of a Real-Time Vehicle Parking Allocation and Reservation System** successfully addresses the challenges associated with conventional parking management by providing a secure, efficient, and user-friendly web-based solution. The system automates key parking operations, including user registration, vehicle registration, parking slot allocation, online reservation, QR code generation, vehicle verification, payment management, complaint handling, and report generation. By integrating the Django framework, MySQL database, OpenCV, and QR code technology, the proposed solution minimizes manual intervention, reduces parking congestion, improves parking space utilization, and enhances the overall user experience.

The implemented system offers role-based access for administrators, residents, and security personnel, ensuring efficient management and secure operation of the parking facility. Real-time parking slot monitoring and QR code-based authentication significantly improve the speed and accuracy of vehicle entry and exit while preventing unauthorized access. The centralized database ensures reliable storage and retrieval of parking information, enabling administrators to monitor parking activities, manage payments, generate reports, and make informed decisions for effective parking administration.

Overall, the proposed parking management system demonstrates that modern web technologies combined with computer vision techniques can provide an effective solution for intelligent parking management. The modular architecture, scalability, and ease of maintenance make the system suitable for deployment in residential apartments, educational institutions, hospitals, office campuses, shopping malls, and commercial parking facilities. Future enhancements such as Artificial Intelligence, IoT-enabled parking sensors, Automatic Number Plate Recognition (ANPR), cloud computing, and mobile application integration can further improve automation, scalability, and smart city compatibility, making the system a comprehensive solution for next-generation parking management.

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