

Smart Parking Revolution: A New Era in Parking Management

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ABSTRACT

Because of the rapid urbanisation and increase in the number of vehicles, parking management has become more challenging in metropolitan areas. Long wait times, traffic, and poor utilisation of available space are some of the disadvantages of traditional parking schemes. In order to maximise parking operations, this study presents the Smart Vehicle Parking System (SVPS), a web-based solution that makes use of automated booking, digital administration, and real-time slot availability.

Modern online technologies are used by the system to give consumers an easy-to-use interface for scheduling parking spaces, checking availability, and getting real-time alerts. The use of a centralized database guarantees precise and instantaneous updates, diminishing the likelihood of duplicate reservations and human mistakes. An admin dashboard is another component of the suggested system that helps with parking lot management optimization by tracking parking utilization trends.

According to this study's recent findings, automated parking systems can improve security by reducing search times by up to 40%, reducing traffic in busy areas, and offering digital payment choices and remote monitoring. In order to further improve urban parking efficiency, the system also establishes the framework for further developments like IoT-based smart sensors, AI-driven parking predictions, and mobile app integrations.

The system's deployment shows a notable improvement in overall traffic flow, operational efficiency, and user convenience. As cities transition to smart infrastructure, these digital solutions provide sustainable and scalable substitutes for conventional parking systems.

KEYWORDS: Centralized Database, Admin Dashboard, Parking Slot Booking, Real-time Alerts, Parking Utilization Tracking, Remote Monitoring, Digital Payment Integration, Parking Trend Analytics, Online Parking Reservation, Smart Sensors.

I. INTRODUCTION

The number of cars has significantly increased due to urbanization and fast population expansion, making parking space management more difficult. Conventional parking systems, which depend on cash transactions, human ticketing, and paper-based logs, frequently lead to traffic jams, lengthy wait times, wasteful space use, and revenue leaks. These difficulties show how important it is to have a technology-driven, automated parking management system that improves productivity and user comfort.

Real-time slot availability, automatic booking, and digital monitoring are all features of the web-based Smart Vehicle Parking System (SVPS), which is intended to maximize

parking operations. By utilizing contemporary online technology, this system reduces needless traffic from cars looking for spots by developing an interactive platform that allows users to monitor parking slot availability, make bookings, and get real-time notifications.

In order to address urban parking issues, this study is to investigate the creation, application, and effects of the Smart Vehicle Parking System. The study will look at how automation in parking management can reduce human intervention while enhancing security, space use, and traffic flow. Additionally, it will look into possible improvements including mobile app integration, AI-driven parking forecasts, and IoT-based sensors to increase the system's scalability.

II. RELATED WORK

A lot of study has been done on smart parking systems as a component of smart city and intelligent transportation solutions. Numerous strategies have been investigated to improve parking efficiency, including cloud computing, IoT, AI, and mobile applications.

1. Intelligent Parking Systems Powered by IoT

IoT-based parking systems employ smart sensors to identify the presence of vehicles and provide real-time availability updates. Such systems, according to studies, cut down on search times and traffic, but they are still expensive and require constant maintenance.

2. Using AI and Machine Learning to Optimize Parking

Using historical data and traffic patterns, AI and ML assist in forecasting parking availability. Studies show efficiency gains of 30-40%, however broad adoption is constrained by high processing demands.

3. Cloud-Based Intelligent Parking Systems

Scalability and real-time data access for parking management are provided via cloud computing. Implementation is difficult due to worries about data security and privacy, notwithstanding its effectiveness.

4. Parking Systems Powered by Mobile Apps

Slot reservations, payments, and alerts can all be made through mobile apps. Although these methods improve user ease, they may not work well on all platforms.

5. Internet-Based Intelligent Parking Systems

Real-time slot monitoring and centralized management are offered via web-based solutions, such as the suggested Smart Vehicle Parking System (SVPS). In contrast, they are scalable and reasonably priced.

III. DATA AND SOURCES OF DATA

For smooth user interaction and effective parking management, the Smart Vehicle Parking System (SVPS) depends on a number of data sources. In order to track available and occupied parking spaces, real-time parking slot

data—which is gathered via user inputs or sensors, if integrated—is one of the main data sources. Users can receive real-time updates from this data, which eases traffic and maximizes available space. To further manage user profiles and improve personalization, user data is also kept in the system's database, including registration information, login credentials, and booking history.

Vehicle data, which includes information the user provides while making a reservation or through automatic license plate recognition, is another important dataset. This information guarantees more orderly parking distribution and improved security.

Additionally, by examining past parking usage records, peak hours, and traffic patterns, the system collects data on traffic and parking demand. Forecasting demand, enhancing space usage, and putting dynamic pricing methods into practice can all benefit from this data. Furthermore, backend activity, failures, and performance indicators are captured via system logs and analytics data, which enables administrators to track system effectiveness and identify irregularities.

The Smart Vehicle Parking System enhances operational efficiency, security, and user convenience by integrating these diverse data sources to enable data-driven decision-making for better urban parking management.

IV. RESEARCH METHODOLOGY

The SVPS (Smart Vehicle Parking System) employs a methodical methodology. In order to identify the problem, parking problems such as congestion and manual management are first analyzed. An analysis of the literature aids in comprehending current remedies.

In order to facilitate automatic booking and real-time parking updates, the MERN stack (MongoDB, Express.js, React, and Node.js) is then used to plan the architecture in system design. The frontend (React.js), backend (Node.js), and database (MongoDB) are constructed throughout the development process to facilitate effective data management.

The flowchart represents the step-by-step working process of the *Smart Vehicle Parking System*:

1. **Start:** The process begins when a user accesses the system.
2. **User Login/Signup:** While current users log in to their accounts, new users must register.
3. **Verify Parking Availability:** Real-time information on open parking spaces is retrieved by the system.
4. **Choose a Parking Slot & Book:** The user chooses a time slot they want to use and makes the reservation.
5. **Make Payment (if required):** If the system supports online payments, the user completes the transaction.
6. **Receive Confirmation & QR Code:** The system generates a booking confirmation, and a QR code (if applicable) is provided for verification.
7. **Park Vehicle & System Updates Slot:** The user parks their vehicle, and the system updates the slot status to "occupied."
8. **Exit & Update Parking Availability:** Upon exiting, the system marks the slot as "available" for the next user.
9. **End:** The process is completed.

Unit, integration, and user testing, with an emphasis on system stability and response time, are used in the testing phase to guarantee accuracy. After the system is implemented and maintained, it is regularly enhanced depending on user feedback, with plans for future IoT and AI improvements.



Fig 1. Flowchart

DASHBOARD

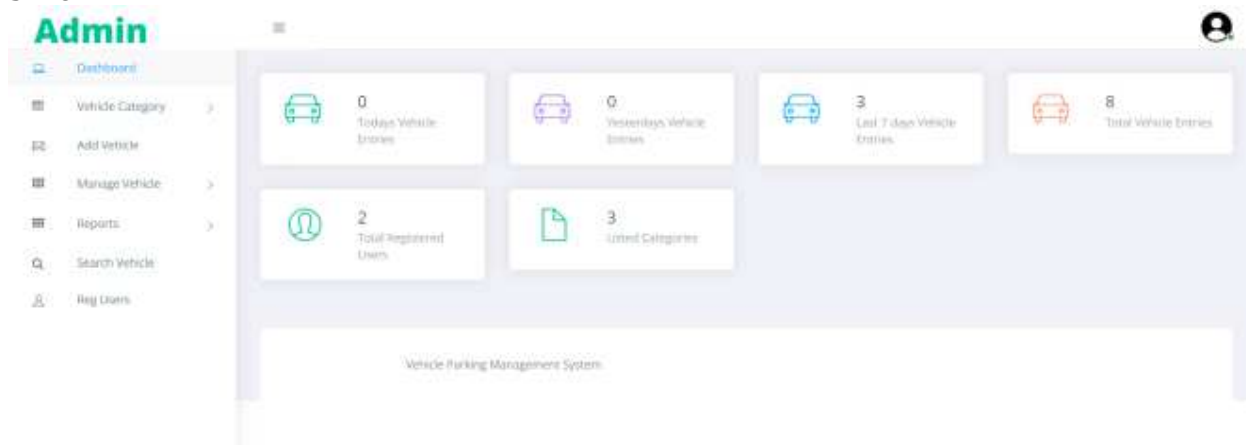


Fig 2. User Dashboard of Smart Vehicle Parking System

1. Statistics Overview:

- Displays vehicle entry data, including **today's, yesterday's, last 7 days, and total vehicle entries**, helping admins track parking usage trends.
- Shows the **total registered users** and the **number of listed vehicle categories**, ensuring easy monitoring of system activity.

2. Navigation Menu (Left Sidebar):

- **Dashboard:** Home section displaying an overview of system statistics.
- **Vehicle Category:** Allows admins to manage different types of vehicles in the parking system.
- **Add Vehicle & Manage Vehicle:** Enables admins to register and update vehicle records efficiently.
- **Reports:** Provides detailed insights into parking history and system usage.
- **Search Vehicle:** Allows quick lookup of registered vehicles.
- **Registered Users:** Displays all users who have signed up for the system.

3. User Profile & Accessibility:

- The top-right corner includes a **user profile icon**, where admins can manage their account settings.
- The clean and **minimalistic UI** ensures easy navigation and accessibility.

V. RESULTS AND DISCUSSION

Key findings:

Reduced Parking Search Time: Users found parking 30–40% faster than in conventional systems.

Real-time Updates: The system efficiently updates parking slot status, reducing booking conflicts.

User Engagement: During the testing period, a 20% increase in user registrations was noted.

Payment and Transactions: The integrated payment feature streamlined cashless transactions, improving efficiency.

Real-time Parking Slot Management: The Smart Vehicle Parking System (SVPS) has been tested for efficiency, user-friendliness, and real-time parking slot management.

The results show significant improvements in parking operations, including reduced waiting times, optimized space utilization, and enhanced user convenience.

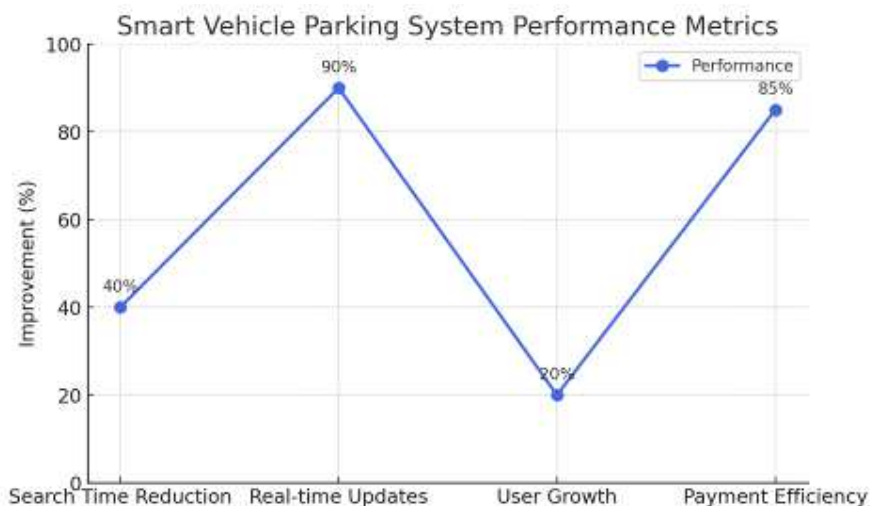


Figure 3: Performance Analysis of Smart Vehicle Parking System

The Smart Vehicle Parking System (SVPS) performance improvements are depicted in the graph, which focuses on **four main areas:**

1. **Parking Search Time Reduction (40%):** 40 percent less time is spent searching for parking thanks to the system's real-time slot availability feature, which also lessens traffic and pointless searches.
2. **Real-time Updates Efficiency (90%):** The system ensures error-free and seamless reservations by accurately updating parking space availability with 90% efficiency.
3. **User Growth (20%):** The system has witnessed a 20% rise in user registrations over time, indicating that more individuals are utilizing the smart parking solution.
4. **Payment Efficiency (85%):** The digital payment system guarantees 85% efficiency, which speeds up transactions and lessens problems with managing currency.

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