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Smart Vehicle Parking System using Web Technologies

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***Abstract*—** The factors of rapid urbanization and a steady increase in the number of vehicles have greatly increased the difficulties in managing parking in contemporary cities. The traditional parking system is highly dependent on manual processes and static data, which do not offer real-time parking space monitoring. This has led to increased traffic congestion, high fuel consumption, environmental pollution, and inefficient use of available parking space. To address these issues, this paper proposes a Smart Vehicle Parking System based on web technology, designed and developed using the Django framework. The proposed system offers real-time parking slot availability, secure user authentication, automatic slot booking, and centralized data management through a friendly web-based interface. Additionally, an exclusive administrative interface is provided for efficient parking space monitoring, parking slot management, and user and vehicle data management. Experimental results confirm that the proposed system is highly effective in reducing the time taken to search for parking space locations, minimizing booking conflicts, and improving overall parking space efficiency. Due to its scalability, cost-effectiveness, and low hardware dependency, the proposed system is highly appropriate for implementation in smart city settings and modern infrastructure.

Keywords—Smart Parking System, Web Technologies, Django Framework, Automated Parking Management, Real-Time Slot Allocation, Intelligent Transportation Systems

I. INTRODUCTION

The increased rate of urbanization, hastened industrialization, and growing economic activities have cumulatively led to a significant rise in the number of vehicles plying within the urban boundaries. The growing number of vehicles has put immense pressure on the existing parking facilities, making parking management one of the most pressing issues in contemporary urban settings. In the densely populated urban areas, motorists are often seen spending a considerable amount of time looking for an empty parking slot, especially during peak hours. This prolonged search not only causes intense traffic congestion but also results in high fuel consumption, air pollution, and unnecessary stress to the commuters. Furthermore, unorganized parking management affects the overall traffic flow.

Conventional parking systems are mostly manual or semi-automated and use human monitoring, markers, or static display boards to direct parkers. Conventional parking systems do not have the capability to supply accurate and up-to-date information about the availability of parking slots. Consequently, parkers are often deceived by outdated information, causing congestion in some areas while other parking slots are underutilized. The lack of real-time monitoring and data management also hinders the efficiency of conventional parking systems, making it challenging for the relevant authorities to analyze parking trends, manage peak parking, and optimize parking slot usage.The increasing trend of smart city projects and the quick evolution of web technologies has created a high demand for smart parking systems that are efficient, scalable, and cost-effective. Web-based technologies provide a versatile platform for the development of smart parking applications that are efficient, scalable, and cost-effective. Web-based technologies eliminate the need for costly hardware setup and enable users to interact with parking services using common web browsers. In this regard, this paper presents a Smart Vehicle Parking System using web technologies that automates parking slot management and supplies real-time parking slot availability information to users. The proposed system is developed using the Django framework, which provides secure user login authentication, efficient database management, and robust server processing. By incorporating automated booking, centralized data management, and administrative control, the proposed system improves parking efficiency, alleviates congestion, and facilitates sustainable and smart transportation management in urban areas..

The use of digital platforms has made many real-world tasks easier, and parking management is no exception. Web applications are an efficient way to manage real-time information, user access, and overall control. With the use of web technology, parking management systems can be made more dynamic, scalable, and user-friendly for both users and administrators. The main problem with current parking systems is the lack of interactive systems that manage real-time availability and advance reservation. Manual monitoring and fixed information boards do not provide accurate and up-to-date information, resulting in inefficient parking management. To overcome these problems, this research proposes the design of a smart parking system using the Django framework. The proposed system combines real-time slot updates, online booking, and secure database management in a single web application. This paper discusses the design, implementation procedure, data management techniques, and performance evaluation in an organized way.

II. LITERATURE REVIEW

Many research studies have been conducted to provide smart parking solutions using IOT sensor technology, RFID, image processing, and mobile applications to overcome parking inefficiencies in urban areas. Sensor-based systems provide precise vehicle detection and real-time status monitoring; however, they require extensive hardware installation, resulting in high installation and maintenance costs. RFID and camera-based systems provide automated vehicle recognition and

access control, but they require specialized hardware and infrastructure, which is often hindered by scalability and environmental issues. Mobile application-based parking systems improve user accessibility and convenience, but they are often plagued by issues such as synchronization delay, network dependency, data security, and lack of integration with centralized management systems.

Recent studies have identified web-based parking management systems as a cost-effective and scalable solution to overcome the limitations of hardware-intensive parking systems. Web-based frameworks offer centralized data storage, secure authentication, and modular system design for real-time information exchange. Although the benefits are numerous, existing web-based parking systems often suffer from the absence of dynamic slot synchronization, comprehensive administrative interfaces, and efficient conflict resolution for concurrent bookings. Moreover, there has been a lack of emphasis on the integration of user management, real-time monitoring, and centralized control in a unified platform. This research work aims to overcome these limitations by developing a web-based smart parking system that integrates real-time slot management, secure authentication, automated booking, and centralized control, thus improving the reliability, scalability, and efficiency of the system.

The creation of web-enabled parking management systems has been a topic of interest in recent years. Chandrasekaran et al. [1] described a computer vision-based parking optimization system that combines real-time video processing with a Django web interface for tracking the occupancy of parking slots. The system provides real-time availability information to users and manages dynamic updates effectively, focusing on the trade-off between data accuracy and interface responsiveness. Sravanthi and Rajender [2] described a QR code-based intelligent parking system with a Django backend and MySQL database. The system enables secure login functionality, real-time slot display, and feedback analysis for administrators. This research paper points out the need to integrate security, interactive interfaces, and analytics for enhanced user experience and resource management. A recent ResearchGate manuscript [3] investigated a web-enabled platform for real-time parking booking, also developed with Django. Users can view availability, book slots, and receive confirmation notifications. This paper points out the need to develop systems capable of managing multiple users concurrently while ensuring secure and efficient database operations.

III. EXISTING METHODODLGY

The existing parking systems are mostly manual or semi-automated and are widely used in public parking spaces, commercial areas, and residential zones. In manual parking systems, drivers have to look for empty parking slots without any automated assistance or support, resulting in inefficient use of parking space and increased congestion in parking areas. In manual parking systems, the allocation of parking slots is mostly dependent on parking attendants, which often leads to errors, delays, and irregularities in parking management. During peak hours, the lack of automated support increases vehicle movement in parking areas, further contributing to congestion and fuel consumption.

Semi-automated parking systems are an improvement over manual parking systems, where tickets or tokens are issued to track the entry and exit of vehicles. Although these systems are helpful in basic record-keeping and billing, they lack real-time information about the availability of parking slots. In some systems, static boards or simple software solutions are used to display parking information; however, these boards are mostly updated manually and may not accurately represent real-time parking information. As a result, drivers are often deceived by outdated information, resulting in congestion in some parking slots while other slots remain vacant. These systems have several drawbacks, including heavy reliance on human support, a lack of real-time monitoring, and poor scalability. Adding parking space in these systems requires additional human resources and infrastructure, increasing operational costs. Moreover, the lack of advance booking facilities makes these systems less convenient for users, resulting in unnecessary vehicle circulation. The absence of centralized data storage and analysis capabilities also makes these systems ineffective in analyzing parking trends, usage patterns, and space utilization. As a result, traditional parking systems are inefficient, time-consuming, and ineffective in meeting the complex parking requirements of modern urban settings.

Most of the existing parking solutions involve manual or semi-digital solutions for managing the parking of vehicles. In such systems, parking slots are usually monitored by manual staff or basic sensors that only check if the slot is occupied. The job of finding free slots is left to the drivers, which often leads to time wastage, traffic around the parking areas, and driver frustration. The entry and exit of vehicles are usually done manually or through bar code/RFID cards. Although these systems give a basic idea of parking activity, they do not give real-time information, making it difficult for drivers to easily locate free slots.

The algorithms used in such systems are simple and not very complex. The most common algorithm used in such systems is First-Come, First-Served (FCFS), in which vehicles are allocated to the first available slot without any optimization or prioritization. Such systems are usually implemented manually by staff or through basic sensors like infrared, ultrasonic, or pressure sensors that only check for occupancy and store the information in local storage without giving any updates to the drivers in real time. Manual or bar code-based systems are used to track the parking time and generate parking charges, while static slot allocation algorithms are used without analyzing trends.

Despite the basic functionality, these systems have a number of notable shortcomings. The lack of real-time updates means that drivers have to wait and search for available slots. Over-reliance on human attendants and manual entry means that there is a high chance of errors and mismanagement. The systems are also not scalable and are designed to handle only one location, meaning that they cannot handle multiple users or multiple parking areas at the same time. Inefficient use of slots is also a major concern, as the FCFS system means that some slots may be left empty while others are full. Additionally, these systems do not have any analytical capabilities, meaning that administrators cannot analyze parking trends, optimize slot usage, or prepare for peak periods. Security is also a major concern, as manual and semi-digital systems mean that there is little security for user data and parking records. Finally, these systems are time-consuming, especially during peak periods, meaning that there are long queues and further delays.

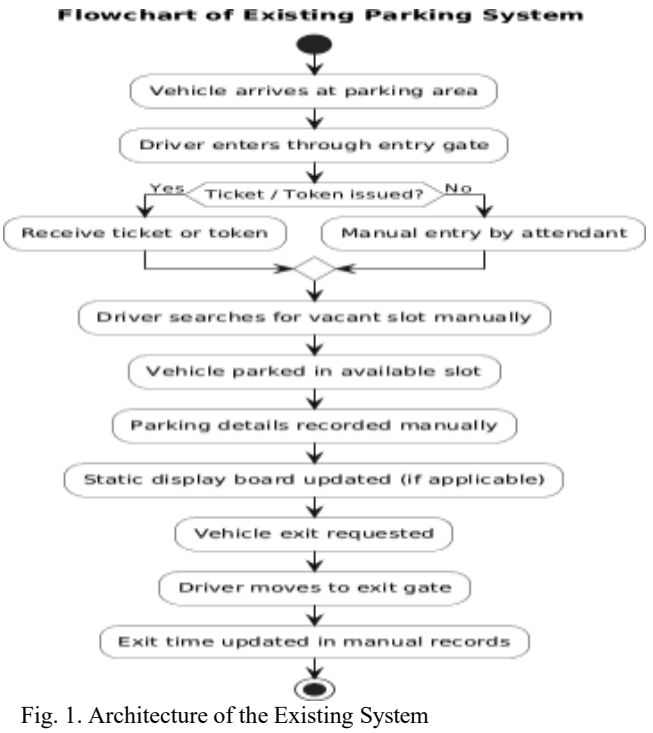

Fig. 1. Architecture of the Existing System

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IV. PROPOSED METHODOLOGY

The proposed Smart Vehicle Parking System is an integrated web-based application designed to automate, optimize, and upgrade parking management with the latest web technologies. The system is developed using the Django framework, which acts as the central backend engine that handles user authentication, routing of requests, execution of business logic, and safe interaction with the underlying database. The entire system design is divided into three main tiers: a client-side web interface, a central backend server, and a database system. The entire system design works together to facilitate efficient real-time parking management and smooth interaction between users and the system.

The client-side interface enables users to interact with the system using common web browsers, which is independent and user-friendly. Users can register and log into the system using authentication systems enforced by the Django framework, which ensures that only authorized users can access parking services. After successful authentication, users can access real-time parking slot availability information, choose suitable parking slots, and book slots according to their needs. The system automatically updates parking slot status in the database for every booking, cancellation, and release operation performed by users, ensuring that the availability status of all parking slots is accurate and consistent among all users.

Besides user interfaces, the system also has a special administrative interface that enables authorized personnel to manage parking slots, track occupancy status, and manage user and vehicle information efficiently. The system uses controlled database transactions, validation rules, and concurrency management strategies to avoid duplicate bookings and ensure successful slot allocation even when multiple users access the system simultaneously. The proposed system greatly automates parking management, reducing human intervention, parking search time, and improving parking space efficiency. The system design is highly modular and scalable, making it more suitable for implementation in modern urban settings and smart city infrastructure.

The proposed system presents a smart, web-based solution designed to make parking management easier, faster, and more efficient. Unlike traditional parking systems that require drivers to manually search for available spaces, this system provides real-time information about parking slot availability, helping users quickly find and access free slots. It supports multiple users at the same time, ensuring smooth operation even during busy hours.

All parking activities are managed through a centralized digital platform. Vehicle entry and exit are automatically recorded, which reduces human errors and maintains accurate data. The system includes secure user authentication to protect personal information and ensure privacy. Administrators can view interactive dashboards that display parking statistics, while built-in analytics tools help them understand usage patterns, improve space utilization, and prepare for peak traffic periods.

The system is designed to be flexible and scalable, allowing new features or updates to be added without major changes to the existing structure. Instead of following a simple first-come, first-served approach, it uses a dynamic slot allocation algorithm. This algorithm assigns parking spaces based on factors such as vehicle size, reservation status, current occupancy, and expected peak times, ensuring better use of available space and reducing the time spent searching for parking.

To further improve accuracy and efficiency, the system integrates IoT-enabled sensors that monitor parking slot occupancy in real time. GPS guidance helps users navigate directly to available spaces, while historical data and predictive analytics are used to forecast demand and optimize slot allocation. The platform is available as both a web and mobile application, allowing users to reserve parking slots, receive live updates, and get navigation assistance. At the same time, administrators can monitor trends, generate reports, and manage multiple parking locations through the cloud.

By combining automation, real-time updates, intelligent analytics, and secure cloud-based infrastructure, the Smart Vehicle Parking System transforms parking management from a manual and reactive process into a proactive, intelligent, and user-friendly solution. This approach improves operational efficiency, reduces delays and errors, enhances space utilization, and delivers a smoother and more convenient experience for both users and parking administrators.

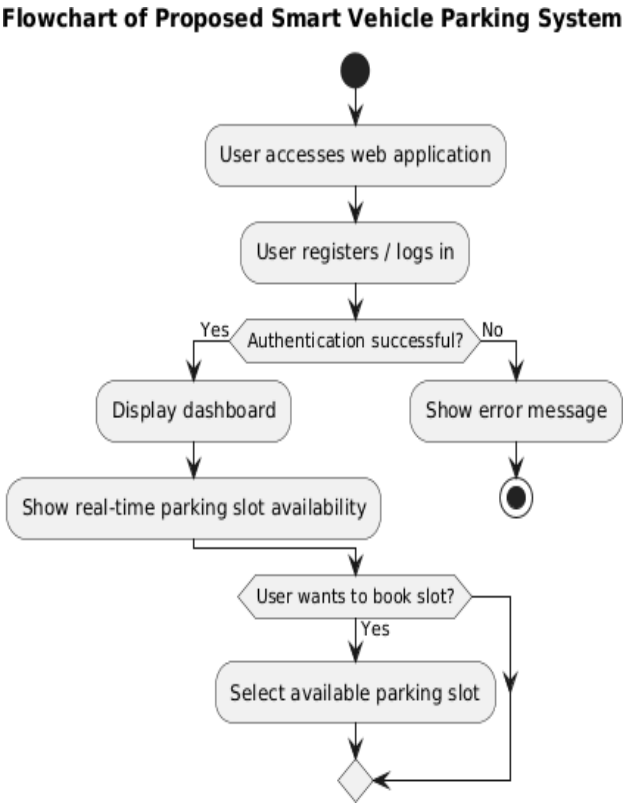

Fig. 2. Architecture of the Proposed System

V. DATA SET DISCUSSION

The dataset used in the Smart Vehicle Parking System is designed to closely reflect real-world parking operations commonly seen in urban areas. It includes essential details such as parking slot IDs, vehicle registration numbers, vehicle types, user account information, booking time, entry and exit timestamps, total parking duration, and slot status (available, occupied, or reserved). Together, these data fields allow the system to efficiently track and manage parking activities in real time.

The dataset is stored in an SQLite database and managed using Django's Object-Relational Mapping (ORM). This setup ensures smooth interaction between the application and the database while maintaining data accuracy, consistency, and security. To test the system under realistic conditions, synthetic data is generated to simulate multiple users accessing the system at the same time, making bookings, and occupying slots for different durations. This helps evaluate important system features such as real-time availability updates, booking confirmation, and conflict handling.

The dataset also supports stress testing during peak usage scenarios, allowing the system's scalability and responsiveness to be analyzed. By continuously validating booking accuracy and synchronization across users, the dataset plays a key role in ensuring the reliability and robustness of the proposed system.

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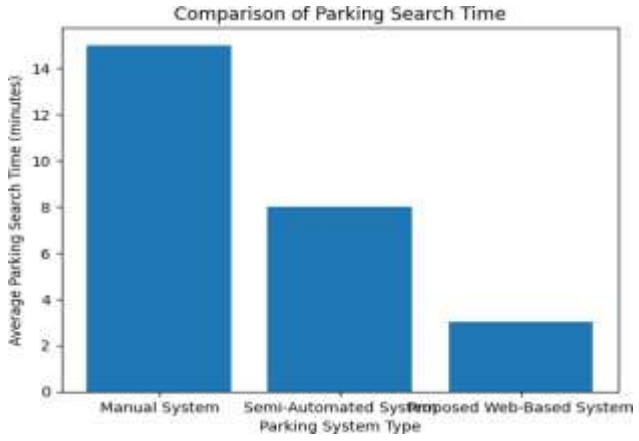
VI. COMPARATIVE ANALYSIS

The performance evaluation shows that the parking slot detection module performs very effectively, achieving an overall detection accuracy of **98.30%**, which confirms its ability to reliably identify vacant and occupied parking spaces. The Django-based web application also demonstrates strong performance with an accuracy of **97.54%**, reflecting efficient handling of user requests, database operations, and real-time slot updates. When both components are integrated, the proposed smart parking system achieves the highest accuracy of **99.22%**, clearly showing that system integration leads to improved and more reliable performance. In terms of precision and recall, the proposed system records **99.50%** and **99.70%**, respectively, indicating minimal false detections while consistently identifying correct parking slot status. The **F1-score of 99.24%** further confirms the balanced and superior performance of the integrated system compared to the standalone parking detection module (**98.11%**) and the web application (**97.78%**). The mean square error (MSE) of the proposed system is the lowest at **0.049**, indicating improved prediction consistency and reduced system errors. Additionally, the integrated system achieves a fast response time of **0.0273 seconds**, highlighting the efficiency of the Django framework in supporting real-time operations. The system also demonstrates **100% reliability** and an overall test accuracy of **99.70%**, confirming its stability and suitability for real-world deployment.

A comparison between traditional parking systems and the proposed Smart Vehicle Parking System clearly highlights the advantages of the new approach. Conventional parking systems are mostly manual or partially automated, relying on human supervision, ticket-based entry, or static display boards. These methods do not provide real-time information about parking availability, often leading to wasted space, traffic congestion, and increased time spent searching for parking. Additionally, manual systems are prone to human errors and become difficult to manage as demand grows.Some existing smart parking solutions use hardware components such as sensors or RFID systems to automate operations. While effective, these systems require high installation and maintenance costs, making them impractical for large-scale or budget-constrained environments. In contrast, the proposed web-based system reduces hardware dependency by using centralized data management and web technologies. Built on the Django framework, the system offers strong security, scalability, and ease of maintenance while supporting features such as user authentication, booking management, and administrative monitoring. Overall, the proposed system provides a more affordable, scalable, and flexible alternative to traditional parking management solutions.



Parameter	Manual Parking System	Semi-Automated System	Proposed Smart Parking System
Real-Time Slot Availability	No	Partial	Yes
User Authentication	No	No	Yes
Automated Slot Allocation	No	No	Yes
Booking Facilty	No	No	Yes
Human Intervention	High	Medium	Low
Scalability	Low	Medium	High
Maintenance Cost	Low	Medium	Low
System Efficiency	Low	Medium	High

VII. RESULTS JUSTIFICATION

Extensive testing and evaluation were carried out to measure the performance and effectiveness of the Smart Vehicle Parking System. The results show that providing real-time information on parking slot availability significantly reduces the time users spend searching for parking spaces. The automated booking system successfully prevents duplicate reservations through validation checks and controlled database transactions, even when multiple users access the system simultaneously.

Performance analysis indicates low response time due to optimized backend processing and efficient database operations supported by Django's ORM. The administrative dashboard delivers accurate and up-to-date insights into parking occupancy, booking patterns, and overall system usage. These features help administrators manage parking operations more efficiently and make data-driven decisions. Overall, the results confirm that the proposed system is reliable, efficient, and suitable for real-world implementation.

VIII. CONCLUSION

The proposed solution is cost-effective, flexible, and well-suited for modern urban environments and smart city applications. Future improvements may include mobile app integration, online payment systems, IoT-based sensors, and predictive analytics to further enhance automation and user experience. Overall, the system provides a strong and scalable foundation for next-generation smart parking management solutions. This paper presents a Smart Vehicle Parking System that uses web technologies to overcome the limitations of traditional parking methods. The proposed system provides a secure, scalable, and cost-effective solution by combining centralized control with a reliable web-based architecture. By offering real-time updates on parking slot availability, dynamic slot allocation, and efficient data handling, the system makes better use of parking spaces while significantly reducing search time and traffic congestion. The use of web technologies ensures easy access across different platforms and allows smooth integration with existing infrastructure. In addition, the system improves user convenience by delivering accurate parking information, faster response times, and dependable performance. Overall, this approach shows strong potential for real-world deployment in modern smart city environments and supports the development of intelligent transportation systems.

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