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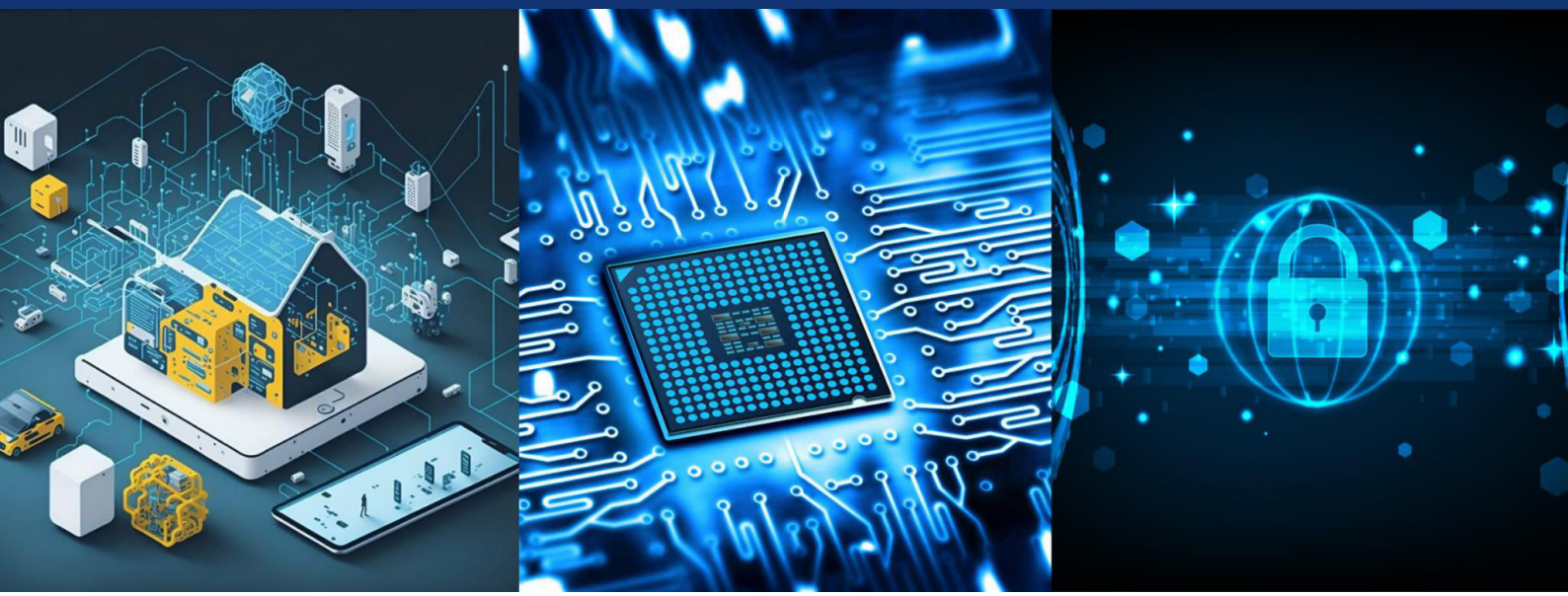

# International Journal of Innovative Research in Computer and Communication Engineering

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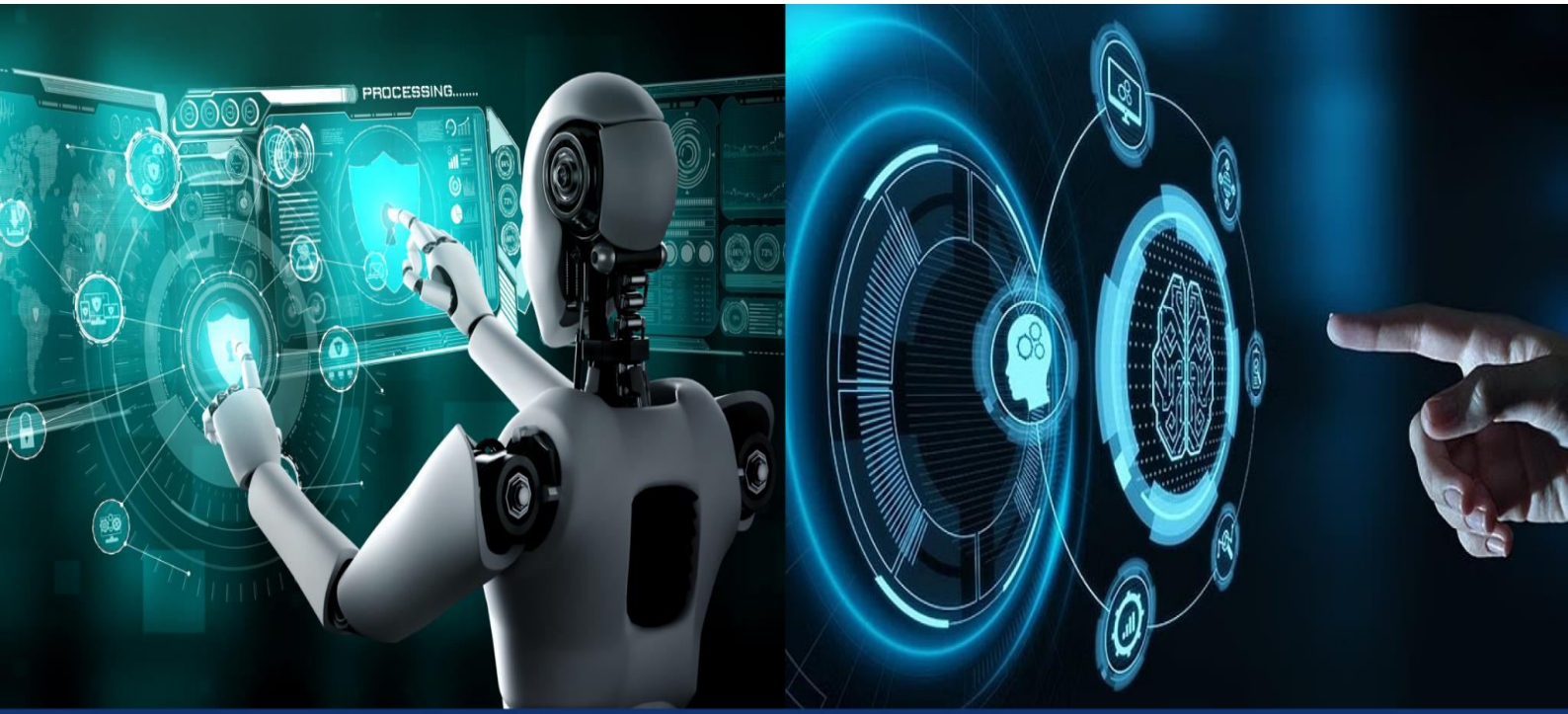


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# Smart Parking System with IoT Integration

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**ABSTRACT:** Smart parking systems are essential for modern urban infrastructure, addressing challenges related to security, safety, and operational efficiency. This paper presents an IoT-integrated smart parking system that implements facial recognition for secure user authentication and a fire detection mechanism for enhanced safety. The system employs IoT-enabled devices for real-time data exchange and monitoring, enabling efficient parking management. Facial recognition ensures controlled access by verifying authorized users, while fire detection utilizes sensors and image processing to promptly identify potential hazards and issue alerts. Experimental results validate the system's effectiveness in user authentication, hazard detection, and timely response, making it a robust solution for urban environments.

**KEYWORDS:** Smart parking system, Internet of Things (IoT), facial recognition, fire detection, web-based platform, real-time monitoring, pre-booking, on-spot booking, parking management, security, safety, institutional environments

## I. INTRODUCTION

The increasing number of vehicles in urban and institutional environments has made efficient parking management a pressing challenge. Traditional parking systems often suffer from issues such as unauthorized access, inefficient slot allocation, and inadequate safety measures. Smart parking systems, driven by advancements in Internet of Things (IoT) technology, offer innovative solutions that enhance security, safety, and operational efficiency. This paper introduces a web-based smart parking system designed specifically for institutional settings, catering to the needs of both students and lecturers.

The proposed system integrates IoT-enabled devices, facial recognition technology, and fire detection capabilities into a centralized web-based platform. The system's dual booking functionality allows lecturers to pre-book parking slots to ensure guaranteed availability, while students are provided the convenience of on-spot booking based on real-time availability. The web-based interface ensures that users can easily access the system from any device, while IoT integration facilitates seamless communication and monitoring of parking spaces.

Key features of the proposed system include:

- Web-Based Platform: Accessible to users anytime and anywhere for efficient parking management.
- Dual Booking Modes:

Lecturers can pre-book parking slots in advance.

Students can book parking slots on the spot in real time.

- Facial Recognition Technology: Ensures secure access by verifying the identity of users, limiting entry to authorized personnel only.
- Fire Detection System: Utilizes sensors and image processing to detect fire hazards and promptly trigger alerts, ensuring safety.

By combining these features, the system not only streamlines the parking process but also addresses critical safety and security concerns. The integration of facial recognition improves access control, while the fire detection mechanism enhances safety within the parking area. Additionally, the centralized web platform simplifies management and provides real-time updates to users.

Experimental results demonstrate its effectiveness in ensuring operational efficiency, secure access control, and real-time hazard detection. These findings establish the system's potential for application in modern institutions and urban infrastructures.

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## II. LITERATURE SURVEY

The rapid advancement of IoT and AI technologies has spurred the development of smart parking systems to address parking inefficiencies, security concerns, and safety hazards. Existing IoT-based solutions primarily focus on real-time slot management and monitoring. For instance, Kumar and Singh [1] designed an IoT-enabled parking system that used sensors to monitor slot availability in urban areas. While their approach improved space utilization, it lacked sufficient access control mechanisms to deter unauthorized usage. Similarly, Ahmed and Khan [2] introduced a cloud-based parking reservation system, enabling users to book slots remotely. However, this system failed to address critical safety aspects, such as fire detection, and lacked user authentication for real-time validation.

To improve security, facial recognition technology has been explored in parking systems. Lee et al. [3] implemented a facial recognition-based solution to restrict access, ensuring only authorized users could enter parking facilities. Although effective in controlling access, their system did not incorporate IoT-enabled real-time slot allocation or monitoring. Sharma and Patel [4] expanded on this concept by using biometric authentication for parking management. However, their solution was limited in scalability, making it unsuitable for larger institutional or urban deployments.

Fire detection systems have also been studied in the context of parking safety. Chen et al. [5] employed IoT sensors and thermal imaging to detect fire hazards in public spaces. While their system proved effective in identifying incidents, it was not integrated into comprehensive parking management platforms. Zhang Q., Liu J., and Huang F. [6] proposed an AI-driven parking optimization system leveraging machine learning algorithms to predict parking demand patterns. By analysing historical and real-time data, their system dynamically allocates parking spaces, reducing congestion and improving space utilization. The authors emphasize the transformative potential of predictive analytics in revolutionizing traditional parking systems.

Ahmed M., Khan A., and Singh P. [7] presented a safety-oriented parking system integrating fire detection sensors and theft prevention mechanisms. Their work highlights how these features safeguard users and vehicles, reducing risks and enhancing trust in smart parking infrastructure. The importance of real-time alerts in emergency scenarios is a critical aspect of their study, emphasizing system reliability.
Smith J., Brown K., and Taylor M. [8] introduced an IoT-enabled parking system using IR sensors for real-time space detection. Their study integrates cloud-based platforms for centralized monitoring and remote management. They underscore the advantages of IoT and cloud technologies in achieving scalable and efficient parking solutions, particularly in urban and campus settings.

Ramirez L., Torres M., and Martinez J. [9] explored sustainable parking infrastructure by incorporating electric vehicle (EV) charging stations and solar power systems. Their research focuses on eco-friendly transportation and reducing the carbon footprint of parking facilities. The authors highlight the alignment of such integrations with sustainability goals and the enhanced appeal of modern parking solutions. Johnson R. and Clark T. [10] discussed dynamic pricing strategies in smart parking systems. Their research explores the use of real-time demand data to adjust pricing dynamically, promoting efficient space utilization and incentivizing off-peak parking. This innovative approach also enhances revenue generation for operators.

These studies highlight the potential of IoT, facial recognition, and fire detection technologies, but also reveal limitations in their standalone applications. The proposed system addresses these gaps by integrating IoT-enabled real-time monitoring, facial recognition for secure access, and fire detection for hazard prevention into a unified web-based platform. It introduces dual booking modes for lecturers and students, offering pre-booking and on-spot booking functionalities, making it a versatile and scalable solution for institutional environments.

## III. RELATED WORKS

The advancement of IoT and AI technologies has significantly contributed to developing smart parking systems, addressing parking inefficiencies, security concerns, and safety issues. Various studies have made noteworthy contributions to this domain, each showcasing distinct strengths while identifying limitations that underline the need for comprehensive integration.

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Kumar and Singh [1] proposed an IoT-based parking system utilizing sensors to monitor slot availability in urban areas. Their solution enhanced space utilization but lacked access control mechanisms to prevent unauthorized use. Similarly, Ahmed and Khan [2] introduced a cloud-based reservation system for remote slot booking. However, their approach failed to incorporate crucial safety features, such as fire detection, and lacked user authentication for real-time validation. Security-focused approaches have also been explored. Lee et al. [3] implemented a facial recognition system to restrict parking access to authorized individuals. While this method strengthened access control, it lacked integration with IoT-based real-time slot monitoring. Sharma and Patel [4] advanced the concept with biometric authentication for parking management. However, their system faced scalability challenges, limiting its application to larger-scale environments.

Safety features have been a focal point in several studies. Chen et al. [5] utilized IoT sensors and thermal imaging to identify fire hazards. Although effective in detecting incidents, their system was not integrated into a complete parking management platform. Ahmed, Khan, and Singh [7] proposed a safety-enhanced parking solution incorporating fire detection and theft prevention systems. Their work emphasized real-time alerts as a key component for ensuring user safety and system reliability.

Optimization and sustainability are other areas of interest. Zhang, Liu, and Huang [6] introduced an AI-based parking optimization system using machine learning algorithms to predict parking demand. Their solution dynamically allocated spaces, improving efficiency and reducing congestion. Ramirez, Torres, and Martinez [9] focused on eco-friendly infrastructure, incorporating EV charging stations and solar energy to support sustainable transportation and lower carbon emissions.

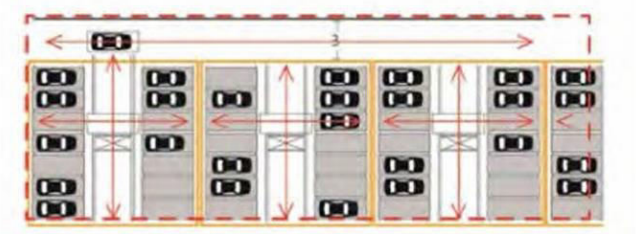
Smith, Brown, and Taylor [8] integrated IoT-based real-time slot detection with cloud platforms for centralized management. This approach demonstrated scalability and efficiency, particularly in urban and campus environments. Johnson and Clark [10] explored dynamic pricing strategies, adjusting prices based on demand to encourage off-peak usage and optimize space utilization.

Despite these advancements, many existing systems lack comprehensive integration of IoT, facial recognition, and fire detection into a single platform. The proposed system addresses these limitations by uniting these technologies in a web-based platform that offers real-time monitoring, secure access through facial recognition, and hazard prevention measures. With dual booking modes tailored for lecturers and students, this solution is adaptable and scalable, making it ideal for institutional parking environments.

## IV. PROPOSED SYSTEM ARCHITECTURE

A. System Overview

The Smart Parking System with IoT Integration addresses the inefficiencies of traditional parking systems through automation, real-time data, and advanced safety features. The system utilizes IoT-based components, including sensors, microcontrollers, and cloud infrastructure, to enhance parking management. Key functionalities include automated vehicle entry and exit, fire detection, face authentication, and integrated EV charging stations.



B. System Architecture

The architecture integrates hardware and software components for seamless operation:

**Hardware**: IR sensors for parking slot detection, fire sensors for safety, NodeMCU for Wi-Fi connectivity, and microcontrollers like ESP32 for processing data.

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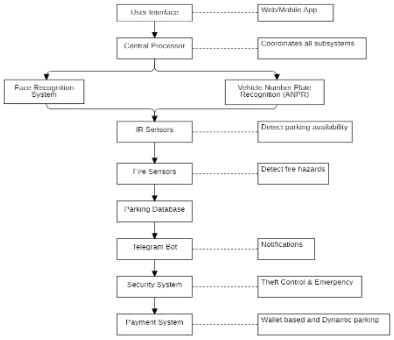
**Software**: Python with OpenCV for image processing and facial recognition, and cloud-based storage for managing parking data.Data is collected via sensors, processed through a central microcontroller, and transmitted to cloud servers. The cloud enables remote monitoring and real-time updates accessible through a web-based user interface.
**Automated Parking Management:** Real-time detection and allocation of parking spaces using sensors and algorithms.
**Safety Systems:** Integration of fire detection sensors to ensure user safety and trigger timely alerts.
**Security Features:** Face authentication for vehicle owners, ensuring authorized access.
**EV Charging Integration:** Dedicated charging stations support sustainable transportation.
**User Interaction:** Mobile and web-based applications for booking, payments, and parking updates.




C. Workflow
Users access the system via a mobile app or web portal to check parking availability.On arrival, vehicles are authenticated using Automatic Number Plate Recognition (ANPR) and/or face recognition.IR sensors detect available parking slots, guiding users to the appropriate space.Fire sensors monitor safety hazards, notifying users and administrators during emergencies.The system supports cashless payments and real-time notifications.

D. Working
The Smart Parking System with IoT Integration comprises several modules, each contributing to the overall functionality and efficiency of the system. Below is a detailed description of the working of its core modules:
1. Faculty parking:
Faculty parking is managed through a dedicated slot allocation system, where faculty members are assigned permanent parking spaces for their exclusive use. A prepaid wallet system is implemented, allowing faculty to pay a fixed monthly fee for parking access. To ensure only authorized vehicles enter and exit the parking area, entry and exit are validated using advanced technologies such as face recognition or license plate recognition. Faculty members can also monitor their wallet balance and parking status in real-time through an integrated web or mobile application, providing convenience and transparency.

2. Student parking:
Student parking operates on a dynamic slot allocation system, where students do not have reserved parking spaces but can access available slots through on-the-spot registration. Upon arrival, students use the system's interface to register their vehicle and secure a parking slot based on real-time availability. Students are charged on a per-use basis, with payments processed through digital wallets or other online payment methods. To ensure secure access, entry and exit for students are authenticated using license plate recognition, similar to the process used for faculty parking.

3. Image Capture and Processing Module:
The Image Capture and Processing Module is integral to the number plate detection system, handling preprocessing, region identification, and character isolation. Initially, image gaps are filled to enhance the visibility of the number plate region, and dimensions are determined for standardized processing. White pixel counts in predefined matrices are analyzed, applying adaptive thresholds to refine the plate area in both horizontal and vertical directions. Potential regions are identified, and the most suitable area is selected using logical criteria, followed by a logical AND operation with the binary image for further refinement. The identified region is cropped, noise-filtered, and segmented to isolate individual

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characters. Character recognition employs template matching, where segmented characters are resized and compared to pre-stored templates to identify the best match. The recognized characters are sequentially saved in a text file for subsequent use. This module efficiently integrates preprocessing, segmentation, and recognition techniques for accurate number plate detection and identification.

4. Parking Slot Detection Module:
To identify vacant parking slots and guide users to the nearest available spot.IR Sensors installed at each parking slot continuously monitor occupancy status.If a slot is occupied, the sensor sends a signal indicating unavailability.The microcontroller collects sensor data and updates the parking availability in real-time on a web-based application.Users receive notifications about available slots and are guided to the appropriate location.

5. Fire Detection Module:
To enhance safety by identifying and addressing fire hazards.Fire sensors monitor the parking area for smoke and heat.When a fire is detected, the system triggers alarms and sends notifications to users and administrators.

6. EV Charging Integration Module:
To provide electric vehicle (EV) charging facilities within the parking system.Dedicated charging stations are integrated into select parking slots.When a user parks an EV in these slots, charging begins automatically after authentication.

7. Payment and Booking Module:
To simplify the booking and payment process for users.Users access a mobile app or web portal to book a parking slot in advance.Payment can be made.Once the payment is processed, the booking details are updated in the database, and a confirmation is sent to the user.On completion of the parking session, the system calculates the total charges and deducts the amount from the user's account.

## V. DESIGN METHODOLOGY

A. Frontend functionality
The frontend of the Smart Parking System with IoT Integration provides a seamless, user-friendly interface designed to enhance user convenience and system accessibility. It facilitates essential functionalities such as user authentication, real-time parking availability updates, slot booking, payment processing, and emergency notifications. Users can log in or register through the web or mobile application, with added security via face authentication. The system allows users to view live parking slot availability and reserve slots in advance, with navigation instructions provided to guide them to their allocated spaces. Payment processing is streamlined. In case of emergencies, such as fire detection, real-time alerts are displayed. A user dashboard offers a snapshot of activities, including parking status, booking history, payments details.

B. Backend functionality:
The backend of the Smart Parking System with IoT Integration is responsible for managing the system's core functionality, including data processing, communication with hardware, and integration with the frontend. It processes inputs from sensors, such as parking slot status and fire alerts, in real-time and ensures this data is accurately reflected in the system. The backend handles user authentication, authorizing access through secure methods, and manages bookings, payments, and notifications. It maintains a centralized database for storing user details, booking records, payment transactions, and system logs, ensuring data consistency and efficient retrieval. APIs facilitate seamless communication between the frontend and backend, enabling real-time updates on parking availability, slot reservations, and payment confirmations. The backend also supports safety mechanisms, triggering alerts and notifications in emergencies, such as fire hazards, while updating the system status dynamically. To ensure reliability, the backend incorporates fault-tolerant mechanisms and supports scalability to accommodate increasing users and parking spaces, making it a robust solution for efficient parking management.

C. Implementation
The implementation of the Smart Parking System with IoT Integration involves integrating hardware components, backend processing, and a user-friendly frontend interface to create a seamless and efficient parking solution. The system

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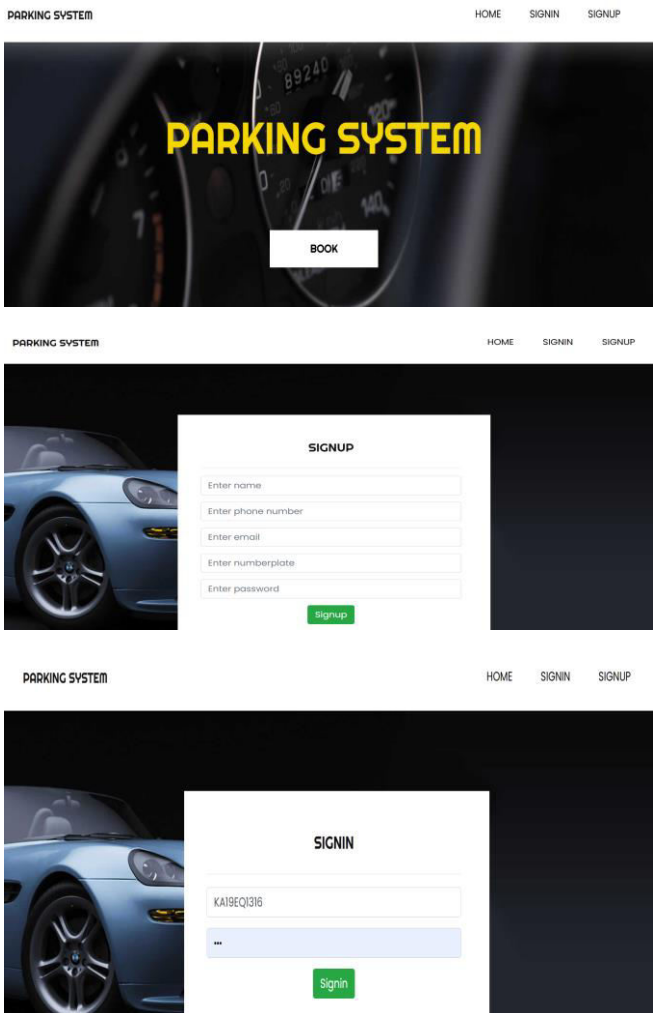
incorporates distinct slots for students and faculty, catering to their unique parking needs. Faculty members are allocated permanent parking slots with a prepaid wallet system, allowing for monthly payments and hassle-free access. Students, on the other hand, utilize on-the-spot registration for dynamic slot allocation. The hardware setup includes IR sensors for detecting parking slot availability, fire sensors for safety monitoring, and cameras for license plate and face recognition. These components communicate with the backend system, which processes real-time data, updates the centralized database, and ensures secure user authentication and slot management. The backend integrates with a cloud platform, enabling remote monitoring, scalability, and efficient data storage. A user-friendly frontend interface provides access to functionalities such as slot booking, real-time parking updates, payment processing, and safety alerts via web and mobile applications. Advanced algorithms manage parking slot allocation, vehicle authentication, and emergency responses, ensuring operational efficiency and user safety. Comprehensive testing phases validate the system's performance, security, and reliability, delivering a robust, scalable solution tailored to modern urban parking demands.

D. Development

1. Faculty login page

The Faculty Login page provides authorized faculty members secure access to manage parking space allocations and monitor real-time occupancy data.



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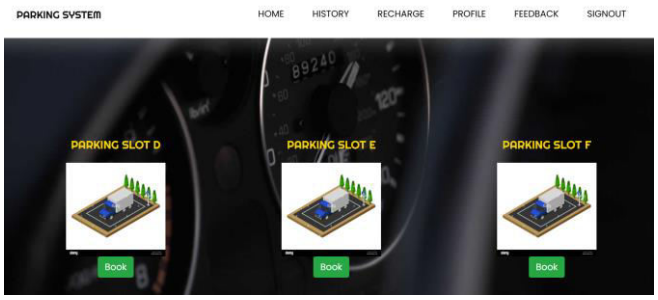


2. Student login page

The Student Login feature allows registered students to securely access the Smart Parking System. Through this interface, students can check parking availability, reserve spaces, and make payments. The login process ensures data security while providing a user-friendly experience for managing their parking needs.

3. Slot confirmation


## VI. RESULTS

The Smart Parking System with IoT integration has successfully addressed key inefficiencies and challenges commonly found in traditional parking systems within university environments. By utilizing IR sensors, the system automates the detection of available parking spaces in real-time, optimizing space utilization and reducing the reliance on manual management processes. This has resulted in significant improvements in parking efficiency, reduction in congestion, and streamlined operations across campus parking areas.

For faculty members, the system offers a permanent booking feature accessible through a dedicated website. This system includes a wallet function, allowing parking fees to be deducted either at the end of the month or directly upon vehicle exit, simplifying the payment process. In contrast, students benefit from the flexibility of on-spot booking, with payments processed each time they exit the parking facility, making the system accessible and user-friendly.

The system also enhances user communication and convenience through the integration of a Telegram bot. This bot provides real-time notifications, alerting users to slot availability, entry and exit events, and the deductions made from their accounts. These notifications ensure a seamless and transparent parking experience, fostering better engagement and visibility into parking activities.

Safety and security have been prioritized through advanced features, such as fire detection sensors. These sensors trigger immediate alerts and alarms in the event of fire hazards, allowing for timely evacuation and minimizing risks to vehicles and infrastructure. Additionally, the theft control mechanism locks exit gates if unauthorized vehicle removal is detected. Real-time notifications are sent to both authorities and users, facilitating prompt responses to security incidents. The face recognition authentication further enhances security by ensuring only authorized individuals can access or retrieve vehicles, significantly reducing the risk of theft and unauthorized access.

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In summary, the results of the Smart Parking System reflect a comprehensive and reliable solution to the long-standing parking inefficiencies faced by universities. The integration of IoT sensors, real-time notifications, fire detection and face recognition has created a secure, efficient, and scalable parking infrastructure. These features not only address current parking challenges but also position the system well for future scalability. Future enhancements, including AI-driven parking optimization, dynamic pricing strategies, and advanced analytics, will further improve parking management, making this system a sustainable and forward-thinking solution for modern campus environments.

## VII. CONCLUSION AND FUTURE SCOPE

The Smart Parking System with IoT integration offers a cutting-edge solution to the inefficiencies and challenges faced by traditional parking systems in university environments. By automating parking management with IR sensors that detect available spaces, the system optimizes space utilization and reduces reliance on manual processes, leading to improved parking efficiency and a seamless user experience. The system caters to different user groups, with faculty members benefiting from permanent booking options and flexible payment methods, while students enjoy the convenience of on-spot booking.

Safety and security are prioritized through advanced features, including fire detection sensors that trigger immediate alerts and alarms in case of fire hazards, ensuring timely evacuation and minimizing risks to vehicles and infrastructure. Additionally, the theft control mechanism locks exit gates when unauthorized vehicle removal is detected, while real-time notifications are sent to authorities and users, enabling swift responses. Face recognition authentication further enhances security by ensuring that only authorized individuals can access or retrieve vehicles, reducing the risk of theft and unauthorized access.

The future scope of the Smart Parking System includes several opportunities for further development and refinement. Key areas for enhancement involve the integration of AI-driven parking optimization, which can analyze real-time and historical data to predict parking demand and dynamically allocate spaces, reducing congestion and improving efficiency. Additionally, implementing dynamic pricing strategies based on real-time demand will optimize space utilization and generate additional revenue. These advancements will ensure the system remains scalable, secure, and sustainable, making it a versatile and forward-thinking solution for modern university campuses.

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