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PARKEASE: SMART PARKING SYSTEM

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Abstract :- Smart parking technology has rapidly advanced in recent years, focusing on enhancing space utilization, user convenience, and real-time data processing. This research paper presents the development of a Smart Parking System that efficiently monitors and manages vehicle parking in urban environments. The system leverages a combination of IoT sensors, real-time video surveillance, and machine learning algorithms to detect available parking slots, guide drivers, and prevent unauthorized usage. It is designed to function seamlessly in both large-scale infrastructures such as malls and airports, and resource-constrained areas like small residential complexes. The system supports mobile integration, allowing users to reserve spots remotely, receive live updates, and make digital payments. By continuously learning from traffic and parking patterns, the system adapts to changing conditions, making it a scalable, efficient, and sustainable solution for modern smart cities.

Keywords: Smart Parking, IoT, Real-time Monitoring, Machine Learning, Efficiency, Automation, Vehicle Detection, Slot Management, Image Processing, Urban Mobility, Development

I. INTRODUCTION

In recent years, the integration of IoT and automation in transportation systems has seen rapid advancement, enabling the development of intelligent infrastructure for urban environments (Kumar et al., 2020 [1]). One such emerging solution is the smart parking system, which addresses the increasing challenges of space scarcity and traffic congestion (Singh & Patel, 2021 [2]). These systems use real-time monitoring, sensors, and machine learning to optimize parking space usage and guide vehicles efficiently.

Smart parking leverages image processing and sensor technologies to detect vacant slots and manage vehicle flow (Roy & Mehta, 2019 [3]). Traditional parking systems often result in time wastage, traffic build up, and fuel consumption due to manual effort and lack of coordination (Verma et al., 2022 [4]). By automating this process, smart systems can reduce human intervention, streamline operations, and improve overall efficiency.

An increasing number of studies support the use of smart parking for improving urban mobility and enhancing user convenience (Joshi et al., 2021 [5]). This system can be especially beneficial in public spaces, malls, campuses, and city centres, offering a reliable solution for modern parking management (Yadav & Choudhary, 2020[6]).

II. METHODOLGY

A. Existing System

Current smart parking systems adopt a hybrid approach that integrates IoT-based hardware, sensor networks, and intelligent software to automate parking management and enhance space utilization. Typically, these systems deploy ultrasonic or infrared sensors at each parking slot to detect vehicle presence. These sensors continuously send data to a central control unit, which updates the occupancy status of the parking area in real-time. Some advanced implementations also include cameras equipped with license plate recognition to monitor vehicle entries and exits (Rao et al., 2021 [1]).

The hardware setup often includes microcontrollers (like Arduino or Raspberry Pi), sensors, and display units for guiding users. Sensors installed in each slot detect whether the space is vacant or occupied, while microcontrollers

collect and transmit this data to a central server or cloud platform. In some designs, visual indicators like LED lights signal slot availability, enhancing visibility for incoming drivers.

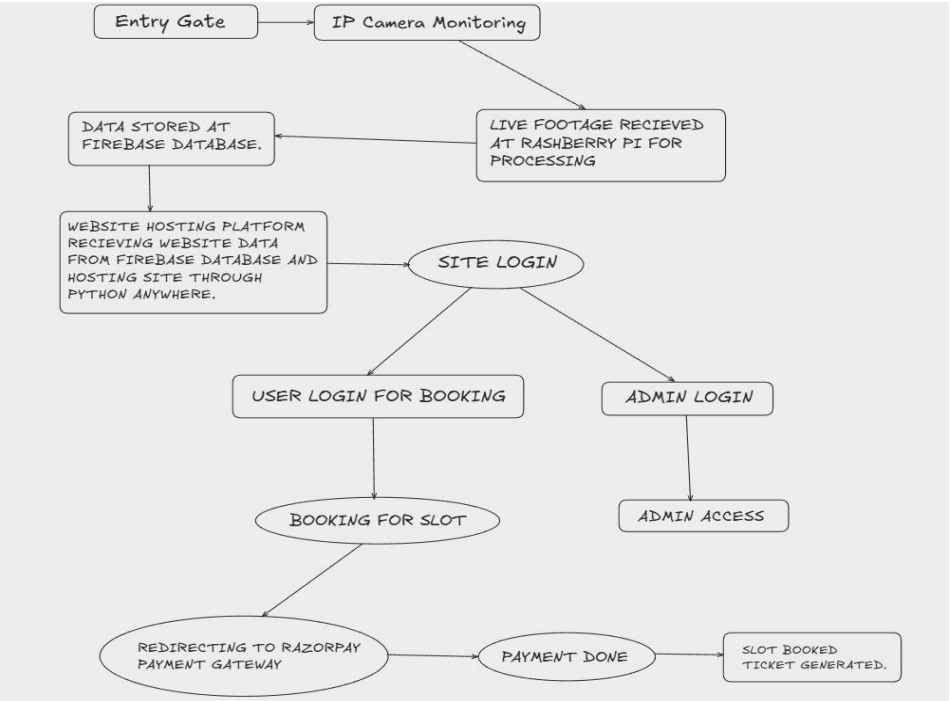
On the software side, the system uses real-time data analytics and machine learning algorithms to manage slot allocation and traffic flow. It includes modules for vehicle detection, user authentication, and dynamic route guidance, all of which are accessible through a web or mobile application. Image processing techniques may also be employed for recognizing vehicle plates and preventing unauthorized parking.
These systems typically feature a user-friendly dashboard for administrators to monitor overall parking utilization, generate reports, and track usage patterns over time. Integration with mobile apps allows users to check real-time availability, reserve parking spots in advance, and make contactless payments, improving convenience and efficiency.
Overall, existing smart parking systems combine reliable hardware with intelligent software to address common urban parking challenges. They aim to reduce search time, lower fuel consumption, and optimize parking space usage, making them highly applicable in malls, offices, airports, and smart cities.

B. Proposed System

The proposed smart parking system enhances conventional parking methods by incorporating advanced IoT sensors, real-time monitoring, and intelligent automation to improve efficiency, accuracy, and user experience.
Upon arrival, vehicles are detected by infrared or ultrasonic sensors installed at each parking slot. These sensors transmit real-time data to a centralized server, which updates the parking status and displays available spots on digital boards or mobile applications. In some cases, cameras with automatic license plate recognition (ALPR) are used for vehicle identification and security logging.
The system applies machine learning algorithms to analyze traffic flow and parking usage patterns, enabling dynamic space management and predictive analytics. This adaptive approach helps reduce congestion and ensures optimal allocation of available parking slots. Users can access a mobile or web-based platform to check real-time availability, reserve slots in advance, and make secure digital payments.
Administrators benefit from a centralized dashboard for monitoring parking activity, managing slot availability, and generating usage and revenue reports. Notifications can be configured to alert for violations, overstays, or unauthorized access, enhancing overall security and operational control.
To ensure data privacy and system security, the architecture includes encrypted communication protocols, access control mechanisms, and secure cloud storage. License plate data and user credentials are stored with restricted access, complying with data protection standards.
Designed with scalability in mind, the system is suitable for a range of environments—from small campuses to large commercial facilities—and can be customized to integrate with existing smart city infrastructure or building management systems, making it a comprehensive and adaptable solution.

C. Data Flow Diagram of Smart Parking System

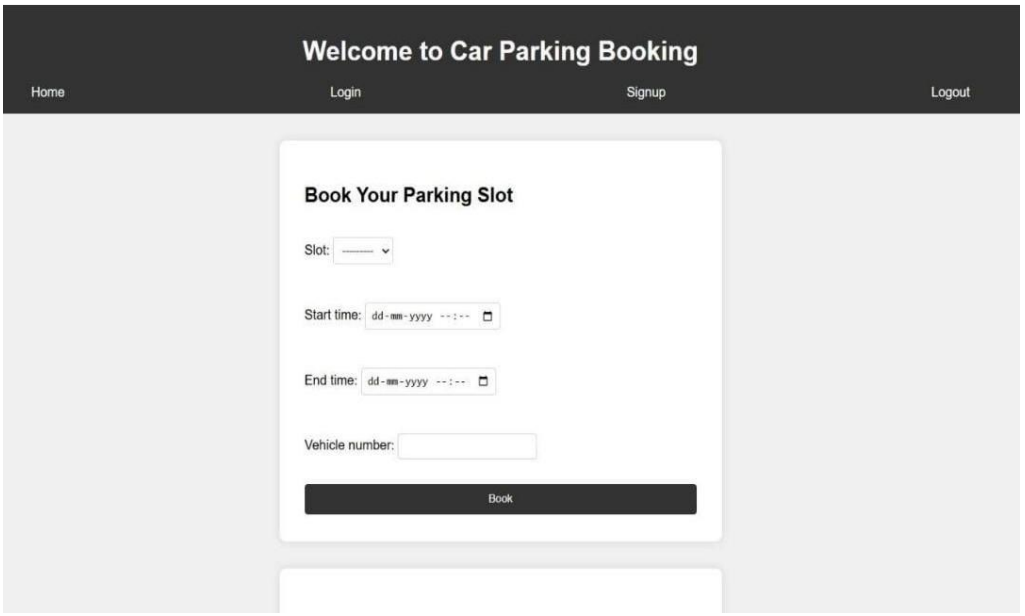
The proposed smart parking system is designed to deliver real-time parking slot monitoring, secure booking, and automated payment processing. The data flow is driven by IoT devices and cloud-based services, with integration between sensors, cameras, Firebase, and a website hosting platform.
The process starts at the Entry Gate, where an IP Camera captures live footage of incoming vehicles. This footage is sent to the Raspberry Pi for local processing, including number plate recognition and real-time monitoring. The data, including slot availability and user activity, is stored and updated on Firebase, acting as the system's central database.
A website hosted using PythonAnywhere pulls data from Firebase and serves it to users in real-time. The platform features two types of login portals: User Login for booking and Admin Login for management purposes.



Data Flow Steps:

1. **Vehicle arrives at entry gate**
   → IP Camera records video and sends footage to Raspberry Pi.
2. **Raspberry Pi processes the video feed**
   → Recognizes license plate or vehicle presence.
   → Sends data to Firebase Database**.**
3. **Firebase stores real-time data**
   → Slot availability, user entries, and live status are updated**.**
4. **Website hosted via PythonAnywhere**
   → Fetches data from Firebase.
   → Displays available slots and login options.
5. **User Login / Admin Login**
   → Authenticates users and provides access to respective dashboards**.**
6. **Slot Booking (User)**
   → User selects available slot.
   → Redirected to Razorpay payment gateway.
7. **Payment Completed**
   → Confirmation sent back to Firebase.
   → Slot marked as booked.
   → Ticket generated and displayed/downloaded.

8. **Admin Panel Access**
   → View all bookings, transactions, and slot status.
   → Add/remove slots and manage system.



III. EXPERIMENTAL ANALYSIS AND RESULTS.

System Prerequisites

Parking Slot Database Creation: The first step involves creating a database of available parking slots, including slot IDs, status (occupied/vacant), and user booking information.

User Database: Store registered users' details, including login credentials and booking history.

Training and Vehicle Detection (YOLO Model)

Utilize a pre-trained YOLO model fine-tuned on vehicle datasets (e.g., cars, bikes, trucks).

The Raspberry Pi or edge device captures live video from IP cameras installed at parking entry and exit points.

The YOLO algorithm detects and classifies vehicles in each frame in real-time.

Bounding boxes are drawn around detected vehicles, and their positions are tracked to monitor parking slot occupancy.

Image and Video Processing
Capture video stream at the entry gate using IP cameras connected to the Raspberry Pi.
Frames are processed by the YOLO algorithm on the edge device to detect vehicles quickly and efficiently.
Vehicle presence updates the status of parking slots dynamically, marking slots as occupied or vacant accordingly.
To improve accuracy, background subtraction and motion detection techniques filter out irrelevant frames and reduce false positives.

Data Synchronization and Storage
Detected vehicle and parking slot data are transmitted to a Firebase real-time database.
The database stores all relevant information: slot availability, booking status, user info, timestamps, and payment confirmations.

Web Interface and User Management
The system hosts a user-friendly website on PythonAnywhere which interfaces with Firebase to:
Display live parking slot availability to users.
Provide User Login for booking parking slots.
Provide Admin Login for managing slots and monitoring system status.

Booking and Payment Processing
Users select parking slots via the website and proceed to payment through the integrated Razorpay gateway.
Upon successful payment, the system updates Firebase to mark the slot as booked and generates a digital parking ticket for the user.

Real-Time Monitoring and Alerts
Admin dashboard shows real-time parking lot occupancy and booking logs.
Notifications are sent for unauthorized vehicles or overstay incidents using Firebase Cloud Messaging (FCM).

Scalability and Maintenance
The modular design supports multiple parking areas with centralized control.
Easy addition of new cameras and parking zones without major reconfiguration.
Regular model updates improve vehicle detection accuracy as new data becomes available.

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IV. FUTURE SCOPE

The proposed parking system has demonstrated promising results in automating and securing parking environments. To further enhance its effectiveness and usability, the following improvements are suggested:

- Multi-Camera Tracking: Deploying multiple cameras for full 360-degree surveillance of the parking area to monitor vehicle movement in real time.
- Night Vision Support: Use of IR cameras or low-light enhancement for 24/7 parking lot security.
- License Plate Recognition (LPR): Integration of OCR for license plate reading to add an extra verification layer.
- Mobile App Integration: A companion app can allow users to book, pay, and get navigation to their slot.
- Smart Notifications: Real-time SMS/email alerts to users regarding booking confirmation, slot availability, or expired parking times.
- Dynamic Pricing Model: Implement flexible pricing based on peak and off-peak hours.
- Green Slot Indication: Integration of LED indicators at each slot for visual availability cues.

V. CONCLUSION.

The smart parking system provides a modern and secure way to manage vehicle entry and slot booking through automation, YOLO object detection, and facial recognition. This not only improves the user experience but also minimizes manual errors, prevents unauthorized access, and optimizes parking space usage. With cloud-based monitoring and payment integration, the system presents a scalable solution for both small and large infrastructures, such as malls, universities, and corporate campuses.

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