

IOT BASED SMART CAR PARKING SYSTEM

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ABSTRACT

The rapid increase in the number of vehicles in urban areas has led to serious challenges in parking management, resulting in traffic congestion, increased fuel consumption, and environmental pollution. Traditional parking systems are inefficient as they rely on manual monitoring and do not provide real-time information about slot availability. To overcome these limitations, this project presents an Internet of Things (IoT)-based smart parking system that enables efficient and automated parking management.

The proposed system utilizes an ESP32 microcontroller as the central unit, integrated with ultrasonic sensors to detect the availability of parking slots in real time. Infrared sensors are used to identify vehicle movement at entry and exit points, while an RFID module ensures secure and authorized access to the parking area. A servo motor is employed to automate gate operations, and a 16×2 LCD display provides on-site information to users. Additionally, a GSM module is incorporated to send notifications regarding vehicle entry, exit, and parking status.

The system is connected to the Blynk IoT platform, allowing users to monitor parking availability remotely through a mobile application. This integration enhances user convenience by providing real-time updates and reducing the time required to search for

parking spaces. The proposed solution is cost-effective, reliable, and scalable, making it suitable for smart city applications. Overall, the system improves parking efficiency, reduces traffic congestion, and contributes to better utilization of available parking resources.

KEYWORDS

Smart Parking, Internet of Things, Mobile Application, Show available parking lots as per location, Parking System, NodeMCU.

INTRODUCTION

In recent years, rapid urbanization and the exponential growth in the number of vehicles have created significant challenges in managing parking spaces in metropolitan and urban areas. Finding an available parking slot has become a time-consuming and frustrating task for drivers, often leading to traffic congestion, increased fuel consumption, and environmental pollution. Traditional parking systems, which rely on manual monitoring and lack real-time information, are inefficient and unable to meet the demands of modern smart cities. As a result, there is a growing need for an intelligent and automated parking management system that can optimize space utilization and enhance user convenience.

The emergence of the Internet of Things (IoT) has opened new possibilities for developing smart solutions to everyday problems, including parking management. IoT enables communication between physical devices through the internet, allowing real-time data collection, processing, and monitoring. By integrating sensors, microcontrollers, and cloud-based platforms, smart parking systems can provide live updates on parking availability and automate various operations such as vehicle entry, exit, and slot allocation. This not only reduces human intervention but also improves efficiency and accuracy.

In this project, an IoT-based smart parking system is developed using an ESP32 microcontroller, which acts as the central processing unit. Ultrasonic sensors are employed to detect the availability of parking slots with high accuracy, while infrared sensors are used for vehicle detection at entry and exit points. An RFID module is incorporated to ensure secure and authorized access to the parking area. A servo motor is used to automate the gate operation, and a 16×2 LCD display provides real-time information to users at the parking site. Additionally, a GSM module is integrated to send alerts and notifications regarding vehicle entry, exit, and parking status.

To enhance user interaction and remote monitoring, the system is connected to the Blynk IoT platform, which allows users to view parking availability in real time through a mobile application. This integration enables efficient parking management, reduces the time required to find a parking space, and minimizes traffic congestion. The proposed system aims to provide a cost-effective, reliable, and scalable solution for smart parking, contributing to the

development of intelligent transportation systems and smart city infrastructure.

LITERATUREREVIEW

earlier days, parking systems were mainly based on manual monitoring, where security personnel were responsible for managing vehicle entry, exit, and availability of parking slots. Drivers had to search manually for vacant spaces, which often resulted in traffic congestion, increased fuel consumption, and wastage of time. These traditional systems lacked real-time information and efficient management, making them unsuitable for rapidly growing urban environments. To address these issues, automated parking systems were introduced, which utilized basic technologies such as infrared sensors, loop detectors, and camera-based monitoring systems to detect vehicle presence and indicate slot availability. Although these systems reduced manual effort, they were limited by high installation costs, lack of remote access, and minimal user interaction.

With further advancements, RFID-based parking systems were developed to enhance security and automation. In these systems, users are provided with RFID tags that are scanned at entry points for authentication, allowing only authorized vehicles to access the parking area. This significantly reduces unauthorized access and improves operational efficiency. However, such systems still lack real-time slot monitoring and remote accessibility, as they primarily focus on entry and exit control rather than complete parking management.

The introduction of the Internet of Things (IoT) has revolutionized smart parking systems by enabling real-time data communication

between devices and users. IoT-based parking systems integrate microcontrollers such as ESP32 or Arduino with sensors and cloud platforms to provide live updates on parking availability. These systems allow users to monitor parking spaces remotely through mobile applications or web interfaces, thereby reducing the time spent searching for parking and minimizing traffic congestion. Sensor technologies play a crucial role in these systems, where infrared sensors and ultrasonic sensors are commonly used for vehicle detection. While IR sensors are simple and cost-effective, they are often affected by environmental conditions such as sunlight and noise. In contrast, ultrasonic sensors provide higher accuracy and reliability, making them more suitable for real-time parking applications.

Additionally, some smart parking systems incorporate GSM modules to send SMS notifications regarding vehicle entry, exit, and parking status. Although GSM-based communication is useful for alert systems, it is limited in terms of interactivity compared to modern IoT platforms. Recent developments have focused on integrating cloud services and mobile applications such as Blynk, which offer real-time monitoring, user-friendly interfaces, and efficient system control. Despite these advancements, existing systems still face challenges such as high implementation costs, lack of full system integration, and dependence on stable internet connectivity.

Based on the literature, it is evident that combining IoT technology with efficient sensors and secure authentication methods can significantly improve parking management systems. Therefore, the proposed system utilizes an ESP32 microcontroller, ultrasonic sensors for accurate slot detection, RFID for secure user

authentication, a Blynk-based mobile application for real-time monitoring, and a GSM module for alert notifications. This integrated approach overcomes the limitations of previous systems and provides a smart, reliable, and efficient parking solution suitable for modern smart city applications.

PROPOSED SYSTEM

The proposed system presents an IoT-based smart parking solution designed to overcome the limitations of traditional and existing parking systems by providing real-time monitoring, secure access, and automated control. The system is built around the ESP32 microcontroller, which acts as the central processing unit responsible for collecting data from sensors, processing it, and communicating with cloud platforms. Ultrasonic sensors are deployed in each parking slot to accurately detect the presence or absence of vehicles by measuring distance, ensuring reliable slot status detection under various environmental conditions. Additionally, infrared sensors are installed at the entry and exit points to detect vehicle movement and trigger system operations accordingly.

To enhance security and restrict unauthorized access, an RFID module is integrated into the system. Each user is provided with a unique RFID tag, which must be scanned at the entry point for authentication. Upon successful verification, the ESP32 sends a signal to a servo motor to automatically open the gate, allowing the vehicle to enter the parking area. A 16×2 LCD display is used to provide real-time instructions and parking information to users, such as slot availability and system status.

For remote monitoring and control, the system is connected to the Blynk IoT platform, which

enables users to view the availability of parking slots in real time through a mobile application. This eliminates the need for manual searching and reduces traffic congestion around parking areas. Furthermore, a GSM module (SIM800L) is incorporated to send SMS notifications to users regarding vehicle entry, exit, and parking status, ensuring effective communication even in the absence of internet connectivity.

The overall system operates in an automated manner, where sensor data is continuously monitored, processed, and updated on the cloud platform. When a vehicle occupies or vacates a parking slot, the system immediately updates the status in the mobile application. This integrated approach not only improves parking efficiency but also enhances user convenience, security, and system reliability. The proposed system is cost-effective, scalable, and suitable for implementation in smart city environments, offering a practical solution to modern parking challenges.

METHODOLOGY

The methodology of the proposed IoT-based smart parking system involves the integration of sensing, processing, communication, and control mechanisms to achieve efficient parking management. The system is centered around the ESP32 microcontroller, which acts as the main controller responsible for acquiring data from various sensors, processing it, and updating the system status both locally and remotely. Initially, all components including ultrasonic sensors, infrared sensors, RFID module, LCD display, servo motor, GSM module, and Wi-Fi connectivity are initialized to ensure proper system operation.

Ultrasonic sensors are installed in each parking slot to continuously monitor the presence or

absence of vehicles by measuring the distance between the sensor and the object. When a vehicle occupies a slot, the measured distance decreases below a predefined threshold, indicating that the slot is occupied. This information is sent to the ESP32, which processes the data and updates the parking status. Simultaneously, the updated slot availability is transmitted to the Blynk IoT platform via Wi-Fi, allowing users to monitor real-time parking status through a mobile application.

At the entry point, an infrared sensor is used to detect the arrival of a vehicle. Once a vehicle is detected, the system activates the RFID module to scan the user's RFID tag for authentication. If the scanned RFID tag matches the stored authorized data, the ESP32 sends a control signal to the servo motor to open the gate, allowing the vehicle to enter the parking area. In case of unauthorized access, the system denies entry and displays an appropriate message on the LCD screen. The LCD display also provides real-time information such as available slots and system notifications to guide users effectively.

Similarly, at the exit point, another infrared sensor detects the departure of a vehicle. The system updates the corresponding parking slot as vacant once the vehicle leaves, and this change is reflected immediately in the Blynk application. Additionally, the GSM module (SIM800L) is used to send SMS notifications to users regarding entry, exit, and parking status, ensuring communication even in low internet connectivity scenarios.

The entire system operates in a continuous loop, where sensor data is constantly monitored, processed, and updated in real time. This ensures accurate parking management, reduces human intervention, and enhances system

efficiency. By combining sensor-based detection, RFID authentication, IoT connectivity, and automated gate control, the proposed methodology provides a reliable, scalable, and intelligent solution for modern parking systems.

HARDWARE COMPONENTS

ESP32 microcontroller



The ESP32 microcontroller serves as the central processing unit of the system. It is a powerful, low-cost microcontroller with built-in Wi-Fi and Bluetooth capabilities, making it highly suitable for IoT applications. The ESP32 collects data from all connected sensors such as ultrasonic and infrared sensors, processes the information, and sends it to the cloud platform for real-time monitoring. It also controls output devices such as the servo motor and LCD display based on the processed data. Its multiple GPIO pins and high processing speed allow seamless integration of various modules in the system.

Ultrasonic sensors



The ultrasonic sensors are used for detecting the occupancy status of parking slots. Each sensor works on the principle of sound wave reflection, where it emits ultrasonic waves and measures the time taken for the echo to return after hitting an object. Based on this time, the distance between the sensor and the object is calculated. If the measured distance is below a predefined threshold, the system identifies the slot as occupied; otherwise, it is considered vacant. Ultrasonic sensors are preferred due to their high accuracy, reliability, and ability to function effectively under different lighting conditions.

Infrared (IR) sensors



The infrared (IR) sensors are installed at the entry and exit points of the parking area to detect vehicle movement. These sensors consist of an IR transmitter and receiver. When a vehicle interrupts the infrared beam, the sensor output changes, indicating the presence of a vehicle. This signal is sent to the ESP32, which triggers subsequent actions such as RFID scanning and gate control. IR sensors are simple, cost-effective, and suitable for short-range detection applications.

RFID module (RC522)



The RFID module (RC522) is used to provide secure and authorized access to the parking system. It operates using radio frequency signals to communicate with RFID tags assigned to users. When a user presents an RFID tag near the reader, the module reads the unique identification number stored in the tag and sends it to the ESP32 for verification. If the ID matches the authorized database, access is granted; otherwise, entry is denied. This ensures that only registered users can utilize the parking facility, enhancing system security.

Servo motor



A servo motor is used for controlling the parking gate. Unlike conventional motors, a servo motor allows precise control over angular position, making it ideal for opening and closing gates. Upon successful RFID authentication, the ESP32 sends a signal to the servo motor to rotate to a

specific angle, opening the gate. After a predefined delay, the servo returns to its original position, closing the gate automatically. This ensures smooth and controlled gate operation.

LCD display



The 16x2 LCD display is used to provide real-time information to users. It can display messages such as the number of available parking slots, entry/exit status, and system alerts. The LCD is interfaced with the ESP32 using I2C communication, which reduces the number of required connections and simplifies wiring. This display enhances user interaction by providing clear and immediate feedback.

GSM module (SIM800L)

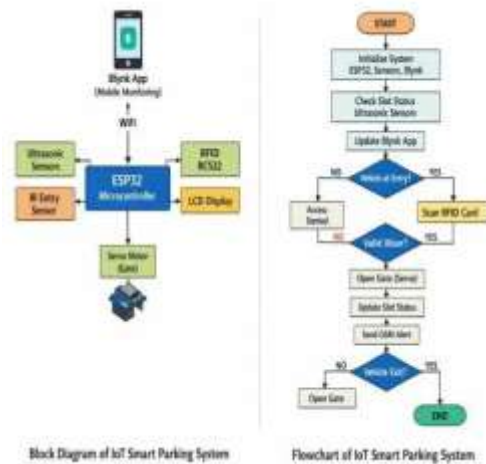


The GSM module (SIM800L) is incorporated for communication purposes, especially for sending SMS notifications. It operates using a SIM card and communicates over the cellular network. The module is used to send alerts to users regarding vehicle entry, exit, and parking status. This feature is particularly useful in scenarios where internet connectivity is limited or

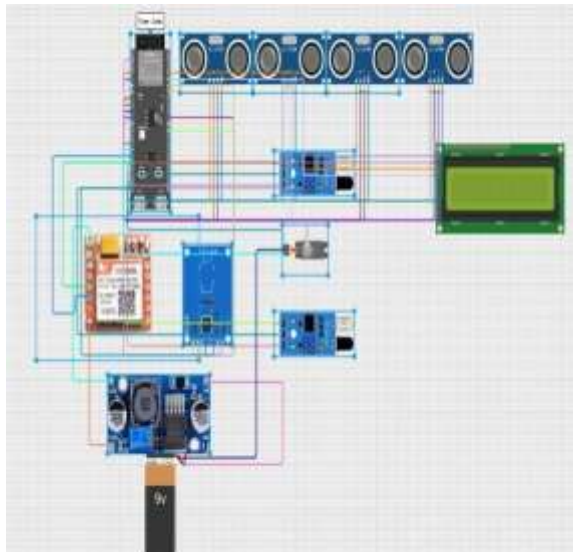
unavailable, ensuring continuous communication with the user.

SYSTEM ARCHITECTURE

BLOCK DIAGRAM



CIRCUIT DIAGRAM-



RESULT

The proposed IoT-based smart parking system was successfully designed and implemented, and its performance was evaluated under real-time operating conditions. The system

effectively monitored the availability of parking slots using ultrasonic sensors, which provided accurate and reliable detection of vehicle presence. Each parking slot status was updated dynamically, and the corresponding information was displayed both on the LCD screen and the Blynk mobile application. This real-time update capability ensured that users could easily identify available parking spaces without manual searching.

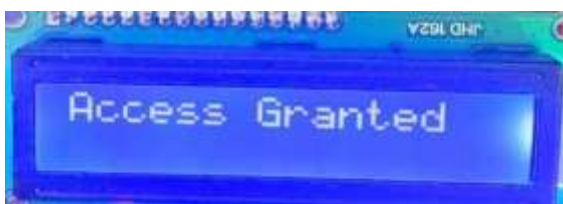
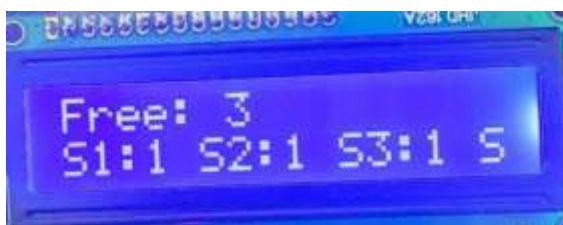
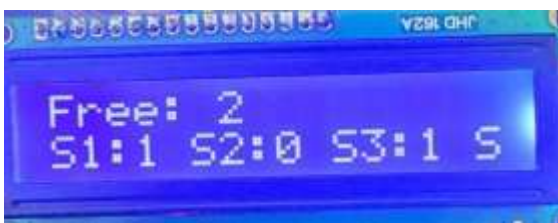
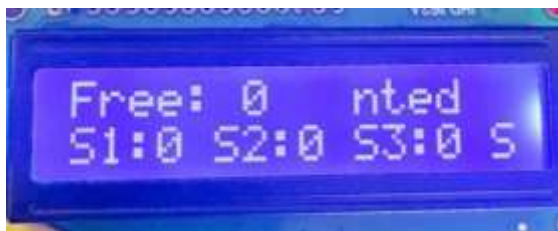
The RFID-based authentication system functioned efficiently by allowing only authorized users to access the parking area. When a valid RFID tag was scanned at the entry point, the system verified the user credentials and triggered the servo motor to open the gate smoothly. In cases of invalid or unregistered RFID tags, access was denied, and appropriate messages were displayed on the LCD. This demonstrated the system's ability to maintain security and prevent unauthorized entry.

The infrared sensors installed at the entry and exit points accurately detected vehicle movement, enabling proper control of gate operations and system flow. The integration of the GSM module further enhanced the system by sending timely SMS notifications regarding vehicle entry, exit, and parking status. This ensured that users remained informed even in scenarios where internet connectivity was limited.

The Blynk IoT platform provided a user-friendly interface for remote monitoring, where parking slot availability was displayed in real time. The communication between the ESP32 and the cloud platform was stable and responsive, allowing seamless data transmission. The system also demonstrated efficient synchronization between hardware components and the mobile

application, ensuring consistency in displayed data.

Overall, the system achieved its objective of providing an automated, reliable, and efficient parking solution. It significantly reduced the time required to locate parking spaces, minimized human intervention, and improved overall parking management. The results confirm that the proposed system is practical, cost-effective, and suitable for real-world implementation in smart city environments.



Future Scope

The proposed IoT-based smart parking system provides an efficient and reliable solution for managing parking spaces; however, it can be further enhanced with advanced technologies to improve functionality and scalability. In the future, the system can be integrated with a dedicated web or mobile application that supports online slot booking and digital payment options, allowing users to reserve parking spaces in advance. This would further reduce congestion and waiting time at parking areas. Additionally, the incorporation of camera-based systems with automatic number plate recognition (ANPR) can eliminate the need for RFID cards and provide seamless, contactless vehicle identification. The system can also be expanded by integrating artificial intelligence and machine learning algorithms to predict parking availability based on historical data and usage patterns. This would enable smarter decision-making and better resource utilization. Furthermore, the use of cloud databases can improve data storage, analysis, and accessibility for large-scale deployments such as shopping malls, airports, and smart cities. Integration with GPS and navigation systems can help guide users directly to available parking slots, enhancing user convenience. Another potential improvement is the inclusion of electric vehicle (EV) charging stations within the parking system, allowing users to reserve both parking space and charging facilities simultaneously. The system can also be enhanced with solar-powered units to make it more energy-efficient and environmentally friendly. Security can be further strengthened by implementing biometric authentication or mobile-based access control. Overall, these advancements can transform the proposed system into a fully automated, intelligent, and scalable smart parking solution suitable for future smart city infrastructure.

Conclusion

In this project, an IoT-based smart parking system has been successfully designed and implemented to address the challenges associated with traditional parking methods. The system effectively utilizes the ESP32 microcontroller along with ultrasonic sensors, infrared sensors, RFID module, servo motor, LCD display, and GSM module to provide an automated and intelligent parking solution. Real-time monitoring of parking slots is achieved through ultrasonic sensors, while secure access is ensured using RFID authentication. The integration of the Blynk IoT platform enables users to remotely view parking availability, reducing the time and effort required to find a parking space. The system demonstrates reliable performance in detecting vehicle presence, controlling gate operations, and updating parking status dynamically. The inclusion of GSM-based alerts further enhances communication by notifying users about entry, exit, and parking status. By minimizing human intervention and optimizing parking space utilization, the proposed system helps reduce traffic congestion, fuel consumption, and environmental impact. Overall, the developed smart parking system is cost-effective, efficient, and scalable, making it suitable for implementation in modern urban environments and smart city applications. The project successfully meets its objectives and provides a practical solution for improving parking management systems using IoT technology.

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