Automated Parking System

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Abstract. The problem of traffic congestion in public parking areas often causes difficulties for users searching for parking spaces. To address this issue, the Smart Parking System (SPS) has been proposed to reduce traffic congestion, save users' time in finding parking spaces, and improve the efficiency of public parking operations. The system uses an ESP32 controller and infrared (IR) sensors to provide real-time information on the availability of parking spaces. Users can access this information through a mobile application or electronic display boards installed at the parking location. Through the use of this technology, SPS is able to detect vehicles entering and exiting the parking area, activate automatic barrier gates, and direct users to available spaces more efficiently. The study results show that SPS not only reduces traffic congestion and parking search time but also enhances the user experience and the efficiency of public parking operations. Designed to be a cost-effective and durable system, SPS is suitable for use in any public parking area and by any company providing parking services. [1][2][3]

Keywords: Smart Parking System, traffic congestion, real-time data, ESP32, infrared sensors, vehicle detection, user experience, public parking operations, cost-effective solution.first.

INTRODUCTION

The Automated Parking System (APS) offers an innovative solution to address the problem of traffic congestion and enhance the user experience in indoor parking areas. Utilizing advanced technology, this system provides real-time information on the availability of parking spaces.

By installing IR sensors at each parking spot and employing an ESP32 controller to collect and process the data, users can easily access the information on available spaces through a mobile application or electronic displays at the parking location. The integration of this technology not only simplifies the process of finding a parking spot but also improves the efficiency of parking management and reduces the time spent searching for a vacant space.

Moreover, the APS is designed to be cost-effective and durable, making it suitable for deployment in any indoor parking facility. The seamless integration between the ESP32 controller and IR sensors ensures the system operates efficiently, providing long-term benefits to both users and parking operators.

Research findings from ElakyaR et al. [4] highlight the potential of IoT-based smart parking systems to automate parking management and reduce the time wasted searching for spaces in congested urban areas. Their system utilizes Arduino devices with IR sensors to detect vehicle presence, RFID cards for user authentication, and a cloud-based database to store real-time parking data. Users receive SMS notifications on availability and can check the status through a mobile application. This approach has been shown to reduce user time and effort in finding parking, alleviate traffic congestion and fuel wastage, enhance security through RFID verification, and provide a cost-effective IoT-based solution for parking management.

Similarly, the study by P.Naveen et al. [5] proposes a smart parking assistance system using IoT technology to help drivers easily locate available parking spaces, reduce traffic congestion, and prevent accidents caused by frustrated drivers searching for parking. Their system employs an Arduino board with ultrasonic sensors to detect whether parking slots are occupied or vacant, and an Android mobile application called "iParker" for users to view available slots and make reservations. The parking slot status is indicated using colored LEDs - green for empty, yellow for reserved, and red for occupied, while the Arduino Ethernet shield enables communication between the sensors and the mobile application. The proposed system has been successfully implemented and tested, demonstrating its effectiveness in allowing users to pre-book parking slots and view real-time parking availability.

While automated parking systems offer significant benefits, they also face several limitations that can impact their effectiveness and widespread adoption. These include issues with sensor reliability, especially in adverse weather conditions; high installation and maintenance costs; heavy reliance on properly functioning technology; inflexibility in accommodating various vehicle sizes or changes in parking layout; potential user acceptance challenges, particularly among older adults; privacy concerns related to vehicle detection and data collection; vulnerabilities to connectivity and power supply disruptions; the need for continuous maintenance; difficulties in integrating with existing infrastructure; cybersecurity risks; and the lack of human intervention in handling exceptional situations. Moreover, the system's dependence on complex technology means that any failures in sensors, networks, or software can disrupt the overall parking operations. These challenges highlight areas where automated parking systems require improvements to enhance their functionality, user acceptance, and overall efficiency in managing parking facilities.

METODOLOGY

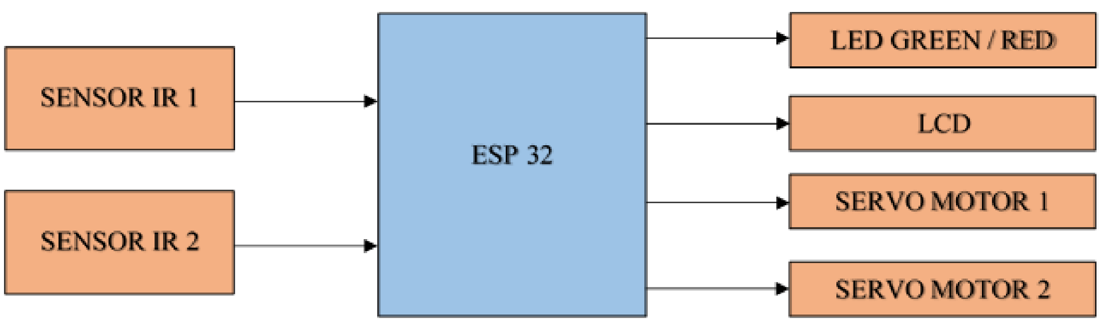

FIGURE 1. Automated parking system block diagram

The Automated Parking System (APS) using IoT technology is designed to efficiently manage parking facilities by providing real-time information on the availability of parking slots. The system consists of several key components that work together to streamline the parking process.

At the heart of the APS are ultrasonic sensors installed at each parking slot. These sensors continuously monitor the slots and detect the presence or absence of vehicles. The sensor data is transmitted to an Arduino board, which serves as the main controller of the system. The Arduino board processes the sensor data and updates a cloud database with the real-time status of each parking slot.

To enable communication between the Arduino board and the cloud database, an Ethernet shield is used. This shield allows the Arduino board to send the parking slot status information to the cloud, where it is stored and made accessible to other components of the system.

In addition to the mobile application, the APS also utilizes LED indicators at each parking slot to provide a visual cue to drivers about the status of the slot. Green LEDs indicate an available slot, yellow LEDs indicate a reserved slot, and red LEDs indicate an occupied slot.

The parking management system is the final component of the APS. This system is responsible for overseeing and controlling the overall parking operations. By accessing the real-time parking slot status data from the cloud database, the parking management system can efficiently manage reservations, collect payments, and generate reports.

The integration of these components, along with the use of IoT technology, enables the Automated Parking System to provide a seamless and efficient parking experience for both users and parking facility operators. By offering real-time information on parking slot availability and automating various aspects of the parking process, the APS helps reduce traffic congestion, save time for drivers, and optimize the utilization of parking spaces.

RESEARCH FINDINGS

TABLE 1. Sensor Inputs and Outputs

IR1	IR2	Green LED	Red LED	Servo	LCD Message
0	0	Off	Off	Off	Idle
1	0	On	Off	Parking	Please park
1	1	Off	On	Off	Thank you
0	1	Off	Off	Off	Parking spot occupied

The truth table serves as a crucial guide for programmers in determining the appropriate responses based on the inputs from the two infrared (IR) sensors. The IR1 sensor detects the presence of an object, while the IR2 sensor identifies when the object is properly parked. The corresponding outputs include a green LED, which lights up when IR1 detects an object but IR2 does not, indicating that the object needs to park. Conversely, the red LED lights up when IR2 confirms successful parking. Additionally, the servo directs the object to the parking spot when IR1 detects an object without IR2's confirmation. The LCD messages provide user feedback: "Please park" appears when IR1 detects an object but IR2 does not, while "Thank you" is displayed upon successful parking with IR2's detection. If IR2 detects an object without IR1's confirmation, the message "Parking spot occupied" is shown. By utilizing this truth table, programmers can efficiently create programs that manage the entire automatic parking process, ensuring smooth operation and clear communication with users.

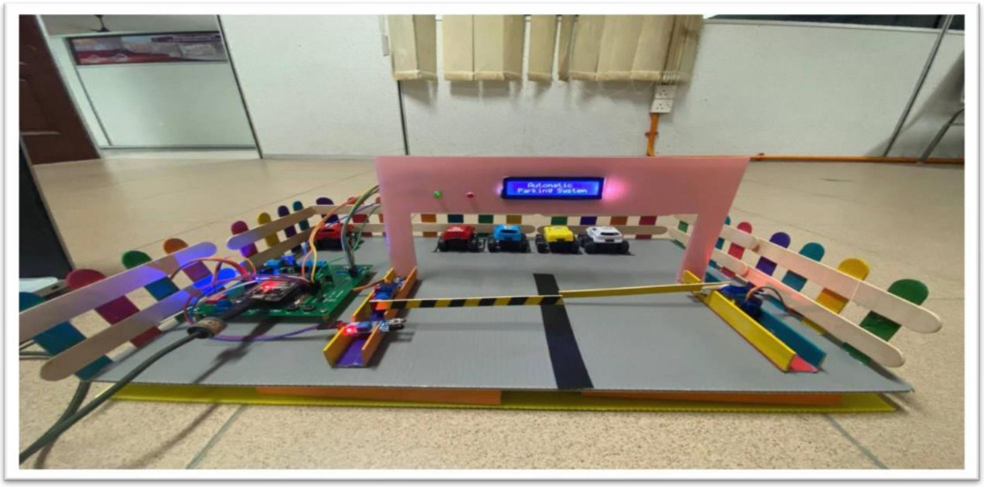

FIGURE 2. Illustrates the operational framework of an automatic parking system utilizing two infrared (IR) sensors.

The diagram of the automatic parking system highlights several key components essential for its operation. It features two infrared (IR) sensors: IR1, which detects the presence of an object, such as a vehicle, approaching the parking area, and IR2, which confirms whether the object is properly parked in the designated spot. The system also includes various outputs: the green LED activates when IR1 detects an object but IR2 does not, signaling the driver to park; the red LED lights up when IR2 confirms successful parking, indicating the completion of the parking process. Additionally, a servo mechanism controls the movement of the object towards the parking spot when IR1 detects an object without IR2's confirmation. The LCD display provides user messages based on the sensor inputs, showing "Please park" when IR1 detects an object but IR2 does not, "Thank you" when IR2 confirms successful parking, and "Parking spot occupied" when IR2 detects an object without IR1's confirmation. This structured approach ensures clear communication and efficient management of the parking process.

The diagram serves as a visual representation of how the automatic parking system operates based on the inputs from the IR sensors. It guides programmers in developing the control logic needed to manage the parking process effectively, ensuring that users receive clear instructions and feedback throughout the parking experience. This structured approach helps streamline the parking process, making it user-friendly and efficient.

The car parking system utilizing the ESP32 microcontroller represents a significant advancement in automated parking technology. This system integrates various components, including infrared (IR) sensors, LEDs, a servo mechanism, and an LCD display, to facilitate efficient parking management.

CONCLUSION

The ESP32-based car parking system effectively enhances the parking experience by automating the detection of vehicles and providing real-time feedback to users. The use of IR sensors allows for precise monitoring of vehicle presence and parking status, while the LEDs and LCD display ensure clear communication with the driver. The servo mechanism aids in directing vehicles to available parking spots, optimizing space utilization.

Moreover, the ESP32's capabilities, such as Wi-Fi and Bluetooth connectivity, open up possibilities for remote monitoring and control, further improving user convenience. This system not only streamlines the parking process but also contributes to safer and more efficient urban mobility solutions. Overall, the integration of smart technology in parking systems represents a forward-thinking approach to addressing the challenges of urban parking.

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