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IOT-Enabled Vehicle Space Identification And Booking System

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Abstract
With a significant increase in the number of vehicles in recent years, drivers often waste time searching for available parking spots or waiting in queues to enter parking areas. This not only leads to fuel wastage but also contributes to air pollution. An effective solution to this problem is the implementation of an innovative parking management system. In order to allow drivers to examine available parking spaces and book a spot before arriving at the parking area, this project focuses on building a smart parking management system. Because the system is web-based, drivers don't need to download any mobile apps. It uses sensors to determine which slots are available, and each slot has an indication affixed to show whether it is reserved, occupied, or empty. The ESP32 modules in charge of these indicators store their data on the Firebase cloud. The sensors are calibrated to distinguish between open and occupied slots based on a threshold distance. According to experimental findings, the sensors attain a 94.72% accuracy rate. But from the moment a reservation is made until it is finally confirmed, there is a ten-second wait.
Keywords- *ESP32, Firebase, IR, IoT, QR Code.*

1. INTRODUCTION-

Empirical evidence suggests that the annual number of registered vehicles is rising significantly. At the turn of the millennium, there were around 5 million registered vehicles. Over the subsequent two decades, this figure surged roughly fourfold to 21 million and continues to rise.

One immediate consequence of this exponential growth is the escalating demand for parking spaces, particularly in locations like shopping malls where expanding parking areas is often impractical. Consequently, parking spots fill up rapidly, leaving many drivers without available spaces. Unfortunately, drivers often lack prior knowledge of parking availability, leading to wasted time searching for empty slots or waiting in queues. Studies reveal that most of the drivers struggle to find vacant parking slots, particularly in multi-level parking facilities A. Kianpisheh et al., (2011). The drivers spending an extra ten minutes looking for parking on weekends or public holidays, the situation becomes worse D. B. L. Bong et al., (2008). Driver annoyance, air pollution, traffic congestion, and petrol consumption are all made worse by inadequate parking M. Y. I. Idris et al., (2009), A. Kianpisheh et al., (2012). The Internet of Things (IoT) has proven effective in addressing various challenges M. Galina et al., (2019), M. Y. I. Idris et al., (2009). Its capacity to transmit information over the internet facilitates real-time information sharing and remote control. For example, sensor data from one location can be instantly transmitted to remote users, who can then provide feedback to control system actuators.

Using a smart parking management system is one possible way to address the parking issue. The time spent looking for parking is decreased, and fuel efficiency is increased, thanks to a system that tells guests about parking spaces that are available in particular areas, such stadiums or shopping centers.

The goal of this research is to create a cost-effective smart parking management system that allows drivers to

book spaces and get information about available places. The system also has indications to let drivers know if a slot is reserved, filled, or empty. Through the use of Internet of Things technology, drivers with smartphones and an internet connection can access the system. In addition, the system makes use of low-power components to minimize energy usage and preserve performance.

1. OBJECTIVE

At the core of our mission is the ambition to revolutionize urban mobility by addressing the challenges associated with parking in densely populated areas. To tackle these challenges, we have developed a comprehensive Smart Parking System that integrates cutting-edge technology and innovative solutions. To track parking spot availability in real-time, our system makes use of a network of Internet of Things (IoT) sensors that are thoughtfully placed across parking facilities. These sensors continuously collect data on parking occupancy, allowing us to generate accurate and up-to-date information on available parking spots. This information is then made accessible to users through our user-friendly mobile application or web platform. Users may quickly find neighbouring parking spots, reserve spots in advance, and find their way to the authorised parking locations with ease thanks to our Smart Parking System. By streamlining the parking process, we aim to reduce the time and effort spent searching for parking, thereby improving overall convenience for drivers. Furthermore, our system contributes to the reduction of traffic congestion and carbon emissions by optimizing the utilization of available parking spaces. By guiding drivers to vacant parking spots more efficiently, we help minimize unnecessary vehicle idling and circling, which are common contributors to urban traffic congestion and air pollution.

By encouraging the economical use of urban resources and infrastructure, our Smart Parking System supports wider sustainability objectives in addition to its useful advantages for users. By encouraging the adoption of alternative transportation modes and reducing reliance on personal vehicles, we support efforts to create more sustainable and liveable cities. Through the seamless integration of technology, data-driven insights, and user-centric design, we strive to enhance the urban parking experience while advancing the broader goals of sustainability and efficiency in urban mobility.

2. MOTIVATION

Urbanization has led to a surge in population growth, particularly in metropolitan areas, resulting in a notable increase in city traffic. As a consequence, finding parking spaces during peak times has become a significant challenge for drivers. This not only consumes valuable time but also leads to unnecessary fuel consumption, contributing to environmental degradation. The perpetual search for suitable parking spots exacerbates traffic congestion, leading to gridlock situations on city streets. This congestion not only frustrates drivers but also has broader implications for urban mobility, impacting public transportation systems and emergency response times. Moreover, the increase in vehicle emissions associated with prolonged idling and circling exacerbates air pollution, posing health risks to urban residents and contributing to climate change. The environmental impact of urban traffic congestion extends beyond local air quality concerns, with global implications for carbon emissions and climate resilience. Furthermore, smart parking solutions can be integrated with existing urban infrastructure and transportation systems, providing a seamless and integrated approach to urban mobility management.

In conclusion, while the challenges posed by urban traffic congestion are significant, the adoption of reservation-based smart parking solutions offers a promising path forward. By addressing the root causes of parking inefficiency and traffic congestion, smart parking systems contribute to a more sustainable and resilient urban future.

3. LITERATURE REVIEW

Intelligent Parking [10] proposed a system utilizing the Google Maps application, with ultrasonic sensors collecting data stored in the cloud. The Android application provides user-friendly information about available parking slots, with each slot equipped with an LED display to facilitate finding the appropriate parking space. An IoT-based parking system using Google Hemant Chaudhary et al., (2017). was introduced to enable users to reserve parking spaces. The current parking place is located by the mobile application, and open spots at entry

and exit gates are detected by an infrared sensor. A signal is delivered to open the gate upon approval of each RFID tag, which is used to authorise individual admission into the parking area Nastaran Reza et al., (2016). An Advanced Car Parking System Pavan Kumar Jogada et al., (2016) uses a web server for booking, Google Maps with GPS for navigation, and Arduino and Raspberry Pi to identify open spots. The results are shown graphically on the map.

IR sensors for detection, RFID tags for authentication, and ZigBee for communication were the components of an efficient car parking system Yashomati R et al., (2016). that was suggested. An Android app is used by an Android-based smart car parking system to deliver information about available parking spaces, allowing users to enter information about the area, state, and car number as well as the location and desired parking time. LEDs show the state of parking spaces, and user information is kept in a MySQL database. The licence plate of the car is captured by cameras, which confirm that it is owned by a legitimate owner.

4. SYSTEM DESIGN

ESP32 and IR Sensor:

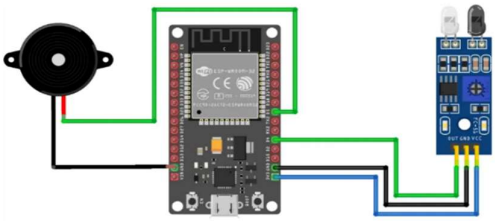

Figure 1. Interfacing ESP32 and IR Sensor

Interfacing an IR (Infrared) sensor involves connecting the sensor to microcontroller and writing code to read the sensor's output.

Hardware Setup:

Sure, here's the revised version:

1. Connect the IR sensor to the ESP32 microcontroller. IR sensors typically have three pins: VCC, GND, and OUT.
2. Attach the positive power pin of the IR sensor to either the 3.3V pin or the 5V pin.
3. Connect the GND pin of the IR sensor to a ground (GND) pin on the ESP32.
4. Link OUT pin of the IR sensor that supports digital input.

ESP32 and QR Sensor:

Figure 2. Interfacing ESP32 and QR Sensor

Interfacing a QR (Quick Response) code sensor involves connecting the sensor to the microcontroller and writing code to read and process QR codes.

Hardware Setup:

- Connect the QR sensor to the ESP32 microcontroller. QR sensors typically have three pins: VCC, GND, and OUT.
- Connect power pin to QR to Positive pine and ground pin to negative.
- Connect the GND pin of the QR sensor to a ground pin (GND) on the ESP32.

ESP32 and Servo Motor:

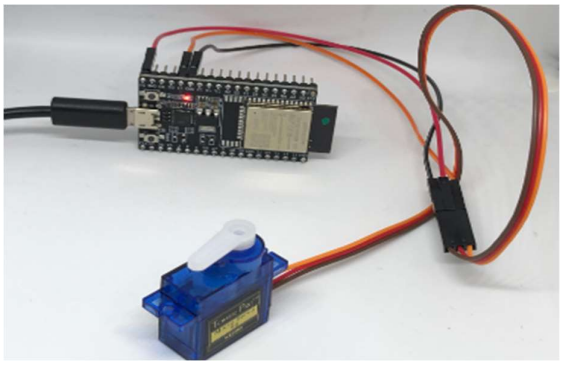

Figure 3. Interfacing ESP32 and Servo Motor

To interface a servo motor with an ESP32 microcontroller, you need to connect the motor to the microcontroller and write code to control its position.

Hardware Setup:

- Connect the servo motor to the ESP32 microcontroller. Servo motors typically have three wires: power (usually red), ground (usually brown or black), and signal (usually yellow or orange).
- Connect the power wire (red) of the servo motor to a 5V pin on the ESP32.
- Connect the ground wire (brown or black) of the servo motor to a ground pin (GND) on the ESP32.

5. PROPOSED MODEL

Each parking area is equipped with device comprising sensors with microcontrollers. Users receive real-time updates on the availability of all parking spaces, enabling them to select the most suitable option. This solution triggers a cascade of benefits, ranging from reduced traffic congestion to improved fuel efficiency, particularly in urban areas where parking is often challenging. Here is a basic flowchart outlining the entire process of the smart parking IoT system.

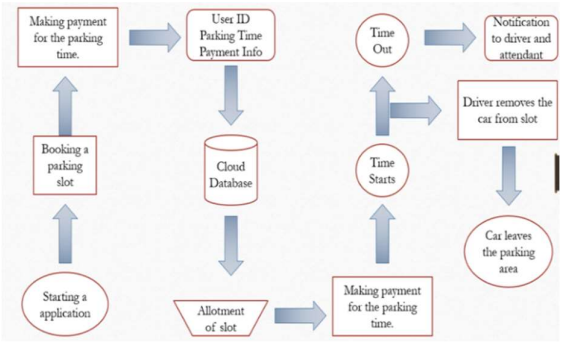

Figure 4. Flowchart of parking IoT system

The proposed system comprises several phases, each explained below:

1. *Development of Android App:*

The first phase involves the development of an Android application.

2. *Free Space Identification:*

In this phase, the system identifies available parking spaces.

3. *Authenticating User:*

The system authenticates the user Registration.

4. *Classify Parking Slot:*

Parking slots are classified based on size or availability.

5. *Book Parking Slot:*

Book parking slot with time-based amount for park vehicle

6. Visualization in Server for Owner to Analyse:

Data is visualized on the server for the owner to analyse.

To access the smart parking system, users need to register using a unique user ID linked to their vehicle number. They can configure their default payment method in the account settings. The Android app simplifies the process of reserving parking slots and completing payments. Users can search for available slots and specify their estimated time of arrival and parking duration. IR sensors are employed to ascertain the occupancy status of parking slots. LEDs are utilized to display the status of each slot, with "N" indicating availability and "D" indicating occupancy.

After booking a vacant parking slot, vehicle entry through the gate is authenticated using an RFID card reader. Parking slots are categorized for small or large vehicles as needed.

To navigate to the assigned parking space, the Android application leverages GPS location services to direct users from their current location to the parking area. Additionally, a web page showcases lane specifics, date and time, booking status, user information, and feedback options.

6. RESULTS AND DISCUSSION

A. Hardware Setup:

In figures 5, 6, 7,8 and 9, a comprehensive depiction of the parking system setup is provided. This setup incorporates a network of IR sensors strategically placed to detect the presence of vehicles within parking slots. These sensors play a crucial role in accurately monitoring parking occupancy in real-time.

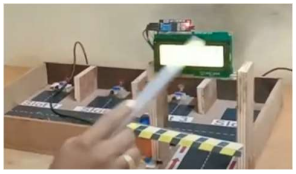

Figure 5. Hardware set up-1

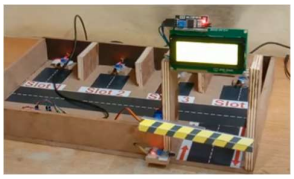

Figure 6. Hardware set up-2

Figure 7. Hardware set up-3

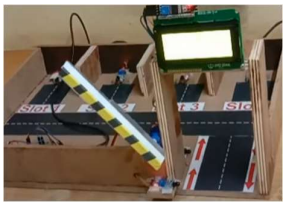

Figure8. Hardware set up-4

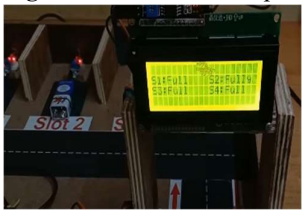

Figure 9. Hardware set up-5

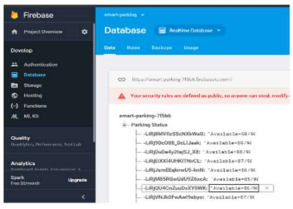

Figure10. FirebaseConnection

To simulate the functionality of the system, a detailed model has been constructed, showcasing the interactions between various components. This model serves as a visual aid to illustrate the operational workflow of the parking system, from vehicle detection to slot reservation and barrier control.

Furthermore, servo motors are integrated as barriers to regulate vehicle entry and exit points within the parking facility. These servo-controlled barriers serve as physical access control mechanisms, ensuring that only

authorized vehicles with valid reservations are granted entry.

B. Android Setup:

In

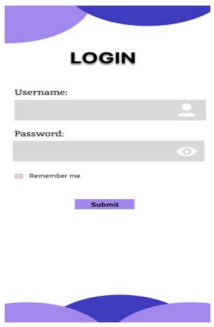

Figure 11. Login Page

Figure 12. User Registration Page

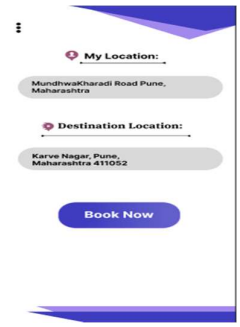

Figure 13. Finding Area Wise Parking Slot

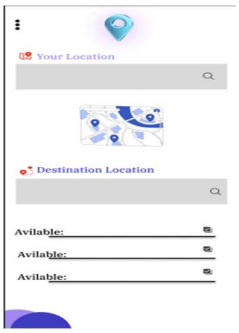

Figure 14. Available Location Area Wise

Figure 25. Red- Engauge, Green- Available, Yellow-Reserved

Figure 16. Welcome message with QR Code

Figure 17. can QR and Validate

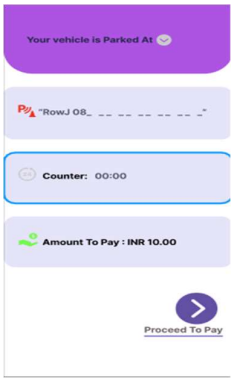

Figure 18. Display Time and Amount to be pay

Figure 11, the login page interface is depicted, providing users with a platform to authenticate their credentials before accessing the parking system. This ensures secure access to the system's functionalities.

Figure 12 illustrates the user registration page, where new users can establish accounts by furnishing essential details like name, email, and password. This process is pivotal for user management and enables individuals to access personalised features within the system.

Figure 13 illustrates the search functionality, enabling users to explore available parking spaces based on specific geographic areas or criteria. This feature enhances user convenience by facilitating targeted searches tailored to their preferences or requirements.

In Figure 14, a comprehensive overview of available parking areas is presented, showcasing the spatial distribution of parking slots within the designated premises. This visual representation aids users in identifying suitable parking locations based on their proximity and availability.

Figure 15 employs color-coded indicators to denote the availability status of parking spaces, providing users with real-time information regarding slot occupancy. Green indicates availability, while red signifies occupied slots, allowing users to make informed decisions when selecting parking spots.

Figure 16 showcases individualized QR codes generated for exit authentication and payment purposes. These QR codes serve as digital credentials for validating vehicle exit permissions and facilitating seamless payment transactions.

Figure 17 specifically focuses on the exit QR code, which users can scan upon leaving the parking facility to authenticate their departure and ensure compliance with exit protocols.

Finally, Figure 18 elaborates on the payment process, displaying relevant details such as the amount due and the duration of vehicle occupancy. This comprehensive breakdown enables users to review payment information and settle any outstanding dues efficiently.

7. CONCLUSION

The advent of Internet of Things (IoT) and cloud technology brings forth new prospects for smart cities, with smart parking playing a pivotal role in their evolution. An IoT-driven smart parking system offers real-time slot availability, parking guidance, and information, empowering users to efficiently locate parking spaces and mitigate traffic congestion. In future iterations, enhancements such as remote parking booking, integration of GPS technology, reservations, and license plate scanners can be envisaged to further refine the parking experience.

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