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A Smart Parking Assistant System

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Abstract

Parking is a big problem when people visit business districts. Due to increased fuel consumption, air pollution, anxious drivers, and the crowded nature of the area, this makes it more prone to crashes. In a parking lot, there is need to keep track of open spots and assign them to users. Drivers finding available parking places in busy regions is important, especially during peak hours. The smart parking system using Internet of Things (IoT) 's main objective is to reduce traffic congestion on roads, in multi-story buildings, and in malls that are brought about by the scarcity of parking spaces. The research shows that when one is accessible in relation to the user's location. In order to effectively utilize parking spaces, this research was necessitated. At locations where drivers are compelled to waste time searching for the ideal space to park their vehicles, the well-known concept of "time money" is taken into account. The plan also highlights the smart parking system for automobiles and the reservation method made available to clients to reserve a parking space via Internet of Things (IoT).

Keywords: *Parking lot, smart parking assistant, traffic, drivers, Internet of Things*

1 Introduction

One fundamental part of a transportation system is parking. From the earliest human settlements, cities and transportation have developed significantly, and popular regions have heavy traffic. This is a result of excessively long journey times and high fuel loss, which negatively impacts the locals' socioeconomic well-being and contributes to pollution and other environmental issues by quickly increasing the amount of carbon in the atmosphere. Drivers who don't care about other people around them can stop and make improper turns just as safely as they can. Speeding in heavily trafficked areas leads to confrontations between drivers. These road explosions cause many unintentional car accidents every year, whether they are caused by passing another car furiously or just for fun. These bad attitudes can be avoided if an organization maneuvers to help drivers find an empty parking slot when they need it [1].

A city can be considered smart if most of its areas—such as the distribution of water supplies, policies for the distribution of power, the distribution of smart transportation, and the distribution of smart health-care vehicles—are made smart. We can create a smart city by making most of these entities smart.

According to [2], one major transportation issue that contributes to excessive energy consumption and air pollution is traffic congestion. The absence of open spaces is one of the main causes of traffic congestion.

Traffic management of vehicles is one of the well-known issues that every city faces. As a result, numerous projects have been completed to monitor and regulate smart route navigation and smart parking distribution systems. The internet of things development has made the concept of creating a smart city feasible, and one of its primary challenges is coming up with fresh ideas for managing parking spaces and traffic control.

The task of locating a parking spot has grown increasingly difficult in large cities recently due to the increase in the number of vehicles on the road. The future smart cities should take this issue into account in order to find a solution, which would shorten the time it takes to look for parking spaces and slow down traffic on the road. When it comes to parking systems, drivers require intelligent solutions that, using the embedded devices that are at their disposal, notify them of the available parking spaces nearby.

Key components of automated vehicle technology, such as intelligent parking systems, are explained by [3]. A parking system can provide a parking space with relatively little assistance from people. The system is also capable of capturing a picture of the car, its kind, and the best parking spot. In addition, it retrieves the license plate information, the time of entry and departure, and the duration of the vehicle's stay in the parking spot. Numerous studies have been done in examining parking management, including the volume of traffic on the roads, according to recent research conducted in major cities. This results in the drivers having annoying parking-related issues because it is hard to find a spot. Cars end up parked on the street, adding to the shortage of available places, as drivers usually waste time and energy looking for spots.

The goal of designing and implementing a smart parking assistance system using IoT is to enhance parking efficiency, optimize space utilization, and reduce urban congestion through real-time data collection and analysis. This system will monitor parking availability, aggregate data from multiple sensors, provide a user-friendly mobile interface, enable cashless transactions, and incorporate robust security measures to protect user data and privacy. By addressing these objectives, the proposed system will contribute to the development of a more efficient and sustainable urban transportation network.

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2 Related Works

This section focuses on numerous research projects that have parking management systems in support of the concept of using wireless sensor networks to find parking information about available spots.

[4] described Internet of Things-based parking system. When the car enters the reference region, the sensor detects it and sends the consumer an SMS with their unique ID. The ID will be shown on the residential area's display board by the station once it has gathered data from these centers. The LED panel at the entrance to the available slot road will show the path to the free space, which is positioned suitably. As soon as the driver approaches the lane to park their car, this system creates an ID. [5] explained how to locate a vehicle using wireless networks. When the sensor detects the vehicle the output frequency changes according to the deviation. These modifications are cross-view through the digital interface, which includes microcontroller and fast analog-to-digital converter. The all- encompassing role of the system is controlled by the growing energy-saving mechanism; In view of the need to allocate tracking time as well as the function of parked parking time. Data from the sensor is transmitted by a Bluetooth Low Energy (PLE) transmitter to any Bluetooth Low Energy (PLE) device and data server in the nearby atmosphere.

In the work of [6], the user manages the parking access system, which he/she will automatically connect to the parking network, establishing the connection between the client mobile and the mall/central network. When the customer enters the parking lot, a map showing the empty and full space on this floor will appear on his/her mobile app so that the customer can choose one of the free places to park his car. The time it takes for the user to park the vehicle is taken into account from the web server so as not to change the time of the user's phone and cause problems with the system.

3 Methodology

This project as stated earlier on is aimed at designing and implementing a smart parking assistance system using IoT (Internet of Things) is to enhance the efficiency and convenience of parking for drivers, optimize the utilization of parking spaces, and reduce traffic congestion in urban areas. By leveraging IoT technologies and real-time data, the system aims to provide drivers with accurate and up-to-date information about parking availability, guide them to the nearest vacant parking spot, and streamline the overall parking process. The system consists of a NodeMCU which can assimilate TCP/IP protocol that can give any microcontroller entrance to the Wi-Fi network that supports 2.4 GHz Wi-Fi (802.11 Wi-Fi standards). The system is integrated with ultrasonic sensor that helps detect empty parking spaces in the surrounding area.

3.1 Software Specification

Two software have been used majorly in the development of the smart parking system which are described below:

i. Arduino IDE**:** This project made use of an ESP32 module which serves as the central processing unit of the project. ESP32 is a low-powered, low-cost microcontroller (MCU) board, with both Wi-Fi and Bluetooth built in, and is based on a dual-core processor mechanism. ESP32 module used for this project was programmed using the Arduino C in the Arduino integrated development environment (IDE) in order to run a program on the ESP32 Development Board, we will need to write our program into the flash memory of the development board. Since it is easy to write code and flash programs with Arduino IDE, it is a good tool to use with the ESP32 Development Board. It runs on FreeRTOS, a leading operating system supported by Arduino. A big advantage of ESP32 is that it is readily supported by Arduino IDE as a “shield” which can 3. One can easily use functions from the FreeRTOS libraries when coding for the ESP32 within the Arduino IDE.

ii. Blynk: This is a hardware-independent IoT platform that includes white-label mobile apps, a private cloud, device administration, data analytics, and machine learning. You can use Blynk to create smartphone apps that allow you to interface with microcontrollers or even entire computers like the Raspberry Pi. The Blynk platform's primary goal is to make developing mobile phone applications as simple as possible.

3.2 Prototype Testing and Result

The Smart Car Parking System is designed to provide an efficient parking solution by automating the process of reserving and releasing parking slots. The system uses ESP32, ultrasonic sensors, infrared sensors, and a Blynk application to detect the availability of parking slots and allow users to reserve slots. The testing aims to ensure that the Smart Car Parking System is functioning correctly and meets its design requirements. The following tests were performed to validate the system's functionality:

i. Ultrasonic Sensor Testing: The ultrasonic sensor was tested to ensure that it accurately measures the distance between the sensor and the parked vehicle. The test was performed by parking a car in each of the slots. This is as shown in the figure 1 below.

Figure 1: Ultrasonic sensor testing

The ultrasonic sensor has also been used to send signal to the microcontroller, providing information about each parking slot either occupied or unoccupied, this information is used to

update the application, thus providing real time information about the state of the parking facility for each slot.

ii. Infrared Sensor Testing: The infrared sensor was tested to ensure that it accurately detects the presence of a car at the entrance and exit as shown in figure 2. The test was performed by driving a car through the entrance and exit and observing if the system accurately detected the car's presence. The sensor accurately detected the car's presence at both the entrance and exit. When the car is detected the barrier arm response by opening to allow the passage of car, the figures below shows the barrier opening when the infrared sensor detects a car both at the entrance and at the exit.

Figure 2: Infrared sensor testing for gate control

iii. Blynk Application Testing: The Blynk application was tested to ensure that it accurately displays the availability of parking slots and allows users to reserve slots. The test was performed by accessing the application and verifying that the information displayed on the application matches the actual state of the parking slots. Users were also able to successfully reserve parking slots. The application has been designed to display "FREE" is a parking slot is not yet occupied, once the parking slot is occupied, the indicator lamp is "green" and the state indicates "BOOKED", this is so that another user will not book an already occupied slot. Also as shown in the figure below, a slot can be booked before it is occupied, if a slot is booked, the state display "BOOKED" but in this case the indicator doesn't glow, this shows that the parking slot has been booked but not yet occupied. The figure 3 shows Blynk Application Functionality testing.

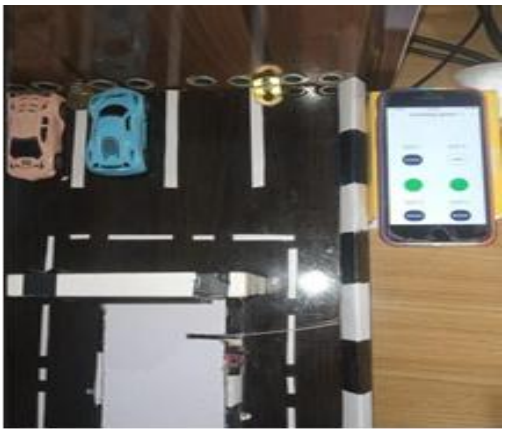

Figure 3: Blynk Application Functionality testing

iv. Slot Status Test: The system's ability to accurately detect and update the status of each parking slot (i.e. vacant or occupied) was tested. This can be done by physically occupying or vacating a slot and checking if the status is updated on the app. This is shown in the figure below, when the four slot is occupied, it is indicated on the application, that the slots has been booked and the indicator lamp are lit as well.

Figure 4: Slot Status testing

iv. Slot Booking Testing: The slot booking feature was tested by booking a slot using the Blynk application and observing if the corresponding slot becomes unavailable for the specified time period. After the time period elapsed, the slot became available again.

vi. Capacity Testing: The system was tested to ensure it can handle the maximum capacity of the parking lot. This was done by simulating the presence of cars in all slots and ensuring that the system still functions properly.

The figure below shows the system at the maximum capacity and it stills functions properly.

Figure 5: System at full capacity testing

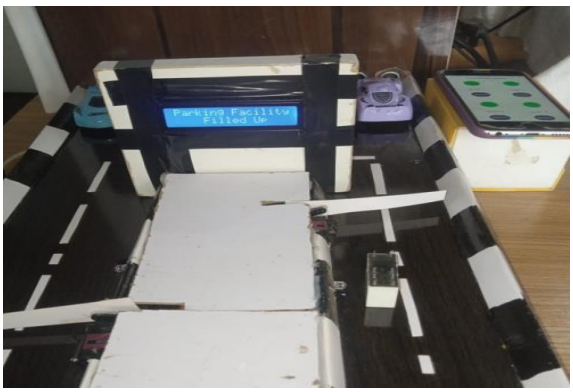

Figure 6: System display when facility is at maximum capacity

vii. Connectivity Testing: The Blynk application was tested to ensure it connects properly to the system and displays the correct slot status in real-time. The connectivity test was carried and the blynk application connects to the system in approximately **3 seconds** when the test was carried out.

viii. Power Supply Testing: The power supply of the system was tested to ensure it can handle the load of all the sensors and components and can provide uninterrupted power supply for the system.

The system has been powered using a 5V adapter and it works without giving power shortage, although, the LCD display was not properly lit and this issue was resolved by using a 9V battery to power the ultrasonic sensors, through a 5V voltage regulator.

ix. Integration testing: The integration of the sensors and the Blynk application was tested to ensure that they can work together seamlessly.

4 Discussion

The design of the smart parking assistance system powered by IoT technology has enhance parking efficiency, reduce congestion, and improve user convenience. The system integrates various components such as NodeMCU for connectivity, ultrasonic sensors for real-time parking space detection, and the Blynk mobile application for user interaction. By collecting and analyzing real-time data, the system provides drivers with up-to-date parking availability, thereby minimizing the time spent searching for vacant spots and reducing unnecessary fuel consumption. One of the key strengths of this system is its ability to automate parking management through sensor-based monitoring. The integration of ultrasonic sensors ensures accurate detection of occupied and unoccupied parking slots, while infrared sensors at entry and exit points prevent unauthorized access. Despite the advancements in IoT-based smart parking systems, several challenges hinder their real-world implementation, including dependence on stable internet connectivity, sensor inaccuracies due to environmental factors, and high deployment and maintenance costs. Cybersecurity threats pose additional risks, as unauthorized access could lead to data breaches or fraudulent transactions. Furthermore, integrating smart parking solutions with existing infrastructure remains a challenge, requiring significant upgrades in many urban areas.

CONCLUSION

The smart car parking system designed using Arduino, ultrasonic sensors, and infrared sensors, coupled with a mobile application using Blynk, is an efficient and effective solution to the problem of car parking management. The system provides a hassle-free experience to users while ensuring the safety and security of their vehicles. The use of ultrasonic sensors to detect the availability of parking slots eliminates the need for manual intervention in the parking process. This enhances the accuracy of the system and reduces the likelihood of errors. Additionally, the use of infrared sensors at the entrance and exit points ensures that the system accurately detects when a car enters or leaves the parking area, which helps to prevent fraudulent parking and unauthorized access. The mobile application designed using Blynk provides users with real-time information about the availability of parking slots. This feature enables users to book a parking slot in advance, which is especially useful in cases where parking spaces are limited. Furthermore, the application allows users to specify the duration for which they want to book the slot, and the system automatically frees up the slot after the allotted time has elapsed. One major limitation of this designed system is the need for a stable internet connection for the mobile application to function correctly. This can be a challenge in areas with poor network coverage. Additionally, the cost of implementing the system may be high, especially if the parking area is large.

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