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Efficient Parking Management with Iot-Based Smart Parking System

Nikhath sultana*[1], atiya*[2], syed imroze ahmed*[3], dr. Mohammed abdul bari*[4]

*[1] *BE Student, Dept. of Computer Science Engineering, ISL Engineering College*

*[2] *BE Student, Dept. of Computer Science Engineering, ISL Engineering College*

*[3] *BE Student, Dept. of Computer Science Engineering, ISL Engineering College*

*[4]*Professor, Dept. of Computer Science Engineering, ISL Engineering College*

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Abstract— This paper presents an automated smart car parking system that utilizes IR sensors to detect vehicles and provide feedback on available parking spaces in complex multi-storeyed parking structures. The system is designed to navigate drivers to the nearest available parking space using visual aids, effectively reducing search time. This cost-effective system is ideal for use in malls, IT hubs, and other parking facilities, and eliminates the need for expensive equipment and complex lines of code. The paper provides an overview of the system, including its functional and non-functional requirements, tools, and technologies used for prototype development and deployment. The system also includes a web-based application that allows users to reserve a parking space in advance. Field testing and demonstration results are discussed, highlighting the system's effectiveness in managing parking spaces and reducing labour requirements. The system's development and deployment offer valuable insights into creating a smart parking system that can enhance the overall user experience in a range of parking facilities. In summary, the automated smart car parking system presented in this paper provides an efficient and effective solution for managing parking spaces in multi-storeyed parking structures, thereby reducing search time and improving the overall user experience.

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I. Introduction

In today's world, as the population continues to grow, managing the increasing number of vehicles on the roads has become a significant challenge. One of the most common problems faced by drivers is finding a suitable parking space, especially in crowded areas like malls, IT hubs, and parking facilities with hundreds of cars parked[1]. Drivers often waste time and fuel searching aimlessly for an available spot, which not only causes frustration but also leads to congestion and long wait times.

To address this issue, a smart car parking system can be implemented to provide real-time information on the availability of parking spaces[2]. This system uses sensors and LED lights to detect whether a parking space is occupied or vacant, making it easy for drivers to find an available spot quickly. By providing drivers with destination-specific driving within the parking structure, the system can significantly reduce search and wait times, making the parking experience more convenient and hassle-free.[5] Universities are no exception to this

problem, with many parking buildings located around the campus, which are often manually operated by cashiers and security guards.[9] To improve the parking experience for students, faculty members, and staff, our team aims to revolutionize the current parking system at university campuses using IoT technologies.[6] Through surveys and interviews with users at Chulalongkorn University, we have identified that the main pain point is searching for an available parking spot, which can take more than 15 minutes.[9]

Therefore, our team has identified the following problem statements to be addressed:

- How might we revolutionize the current parking system at a university campus with IoT technologies to create a more convenient environment for students, professors, and staff?

- How might we allow users to make reservations for a parking spot before arriving at a parking building?

- How might we minimize the parking staff required?

To better design and improve our project, we have researched existing smart parking systems and learned valuable lessons from their implementations.[7] By integrating IoT devices and cloud-based servers, our team targets to develop and prototype a smart parking system for parking spot reservation at a university campus, which is in line with the smart campus initiative and the cashless society theme being implemented at many university campuses around the world.[8]

II. Literature Survey

The IoT (Internet of Things) is an integration of various technologies that enable social services to be improved utilizing smart sensors and smart objects. Smart devices can be accessed and operated at any moment and from any location via IP (Internet Protocol) connectivity Different types of systems can be designed for parking for example: every visitor is given a tag and it will be authorized before entering the parking space ensuring the security measures. There can be a display for the number of vacant slots at the entry and exit gates. There can be an advanced system where user can beforehand book the slot and payment also be done by some application. In this way many approaches can be used to design Smart Parking system based on our requirements. As IoT is a continuously growing technology, a lot of research has been done in this field.

An Advanced car parking system is proposed in [1], in this the very first requirement is the authorization of the user which is ensured by RFID card. Sensors are installed at slots and as soon as a vehicle enters or exits the slot, information is immediately updated on the displayed screens placed both at the entry and exit gates. These gates will only be opened if authorized RFID card is used despite the presence of free parking slots.

In [2] cloud-based approach is suggested where ultrasonic or infrared sensors will detect any vehicle or obstacle. Users can check the availability of parking space using an android application, they can also book the slots and make payments, their entry and exit 21 time will be noted and when the user have parked the vehicle they should confirm their occupancy using the application.

III. System Architecture

The system architecture of the proposed smart parking system includes multiple hardware and software components working together seamlessly.

The hardware components consist of:

- IR sensors (one for each parking slot) to detect the presence of a vehicle
- Red and green LEDs (also one for each slot) to indicate the status of the slot
- An ultrasonic sensor at the entrance to detect incoming vehicles
- An ultrasonic sensor at the exit to detect outgoing vehicles
- A LCD display at the entrance to show the number of occupied and available slots
- A barrier gate that opens and closes based on the ultrasonic sensor readings

The software components consist of:

- An Arduino sketch to program the microcontroller to read and control the hardware components
- A booking website for users to reserve a parking slot in advance
- A database to store the booking information and slot availability data

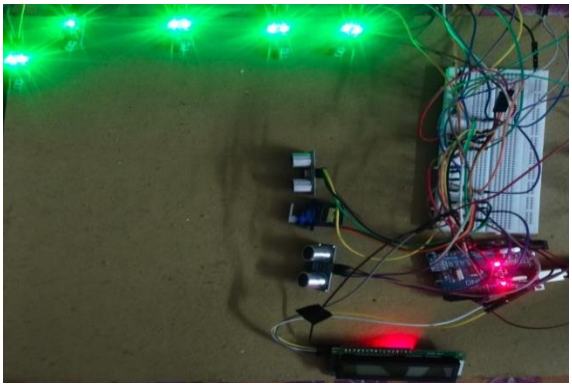

Fig. 1 Hadware connections

IV. Implementation

The methodology for developing a smart parking system with 5 slots can be divided into two parts: hardware and software development. For hardware development, the required components such as IR sensors, LEDs, ultrasonic sensors, and an LCD display will be connected to the Arduino microcontroller board. The IR sensors will detect the presence of a car in each slot and the red or green LEDs will indicate if the slot is occupied or vacant. The

ultrasonic sensors will detect the car's presence at the entrance and exit and open the barrier accordingly. The LCD display will show the number of available and occupied parking slots.

For software development, a website will be created using HTML, CSS, and JavaScript for users to reserve a parking slot. The website will display the available slots and allow users to select a slot and make a booking. The user's booking information will be stored in a database.The code for Arduino will include programming for reading IR sensor values, controlling the red and green LEDs, and controlling the ultrasonic sensors to open and close the barrier.

Fig. 2 Arduino program

In the research paper, the methodology section will describe the steps taken to develop the smart parking system, including the hardware and software components used, the design and implementation of the system, and the testing and evaluation of its performance. The methodology will also detail the code and connections used in the system, as well as the user interface of the website. The section will aim to provide enough detail so that another researcher could replicate the system if desired.

Attributes	On module/page	Validation
Name, phone no, Email-id, address	Admin Registration	Should be not null
Password, Retype password	Admin Registration	Should match the password
Username, password	Login	Should match with the system database
Vehicle details	Update vehicle details	Must be retrieved from the database
Customer details	View customer details	Should retrieved from the data base

Fig. 3 Website details

V. Systemflow Diagram

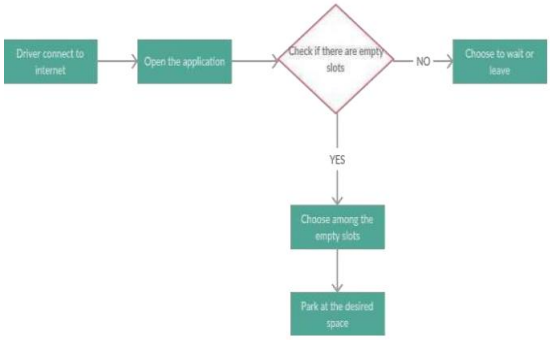

Fig. 4 System flow diagram

The user accesses the website and selects the desired time slot and parking spot. The website sends a request to the database to check for availability. If available, the user is directed to make the payment. Once payment is confirmed, a confirmation message is sent to the user, and the spot is reserved for the specified time.

Screenshots:

a. Hardware connections

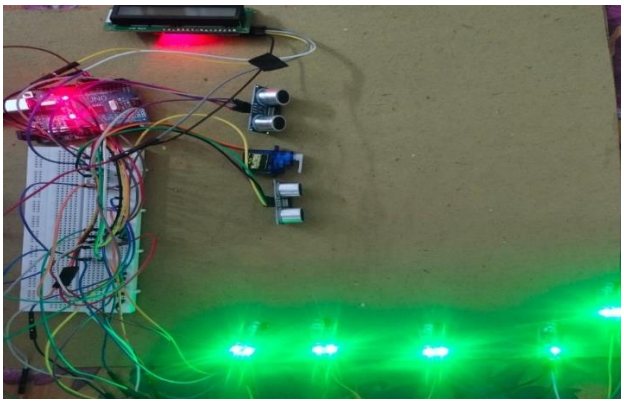

Fig. 4 Hardware connections

b. website overview

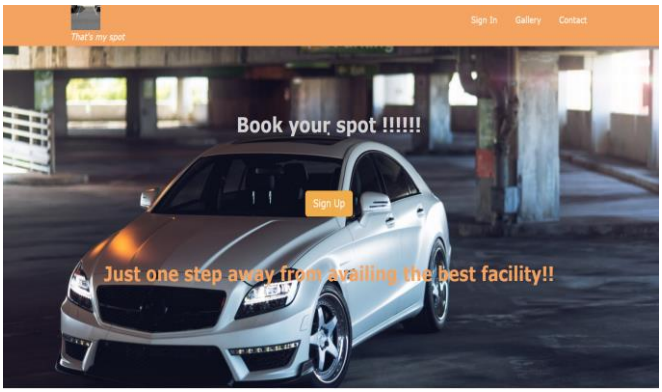

Fig. 5 Website overview

c. Signup and Login page

Fig. 6 Signup and login page

VI. Conclusion and Future Work

In conclusion, the development of a smart car parking system is a step in the right direction for a more efficient and sustainable future in transportation. The integration of IoT technologies, as demonstrated by the prototype system described above, offers a promising solution to the inefficiencies of traditional parking systems. The use of sensors and controllers, along with a web-based application, enables users to seamlessly check for parking spot availability, make reservations in advance, and even make online payments.

Furthermore, the flexibility of the design allows for installation in various spaces, regardless of size constraints. The system's ability to detect obstructions and accurately switch LEDs based on vehicle presence is a testament to its reliability. In addition, the use of data analytics to analyze parking datasets, including prime parking times and utilization rates, could provide valuable insights for improving the system further and identifying possible revenue streams. Overall, the development of such a system shows that with the correct implementation of simple electrical components, it is possible to create an automated parking solution that reduces aimless driving, fuel consumption, and time spent searching for parking spaces. The potential benefits of smart parking systems like these are vast, and they have the potential to revolutionize the parking industry and improve the overall transportation experience.

Future work for the parking system could include the addition of advanced features such as automated billing, integration with mobile payment systems, and integration with navigation apps to guide drivers to available parking spots. The system could also incorporate real-time data analysis to identify patterns in parking usage and optimize parking availability and pricing. Additionally, the system could be scaled up to accommodate larger parking lots and multiple parking facilities. Finally, the system could also be adapted for use in other industries beyond parking, such as logistics and transportation, to optimize vehicle flow and reduce congestion. These potential future developments could make the parking system more efficient, convenient, and user-friendly for both drivers and parking lot operators.

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