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# Modelling a Smart Parking Management System (SPMS) based on Integrated IoT

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**Abstract** : Rapid automobile production and use in recent years has made parking difficult, especially in metropolitan cities. This problem intensifies during busy hours and weekends. Many huge retail complexes have a parking problem. One must search for all parking lanes to park a car. Developing a Smart Parking Management System (SPMS) is the greatest way to help drivers find parking spaces. Internet-of-Things (IoT) has also improved people's lives and society. This work seeks to construct a simple IoT-based Car Parking Management System and create a website that displays parking spot status. Four IR sensors, one servo motor, three red LEDs, and an LCD make up this IoT-based Smart Car Parking System. All these components are connected to NodeMCU ESP8266, the system's controller. NodeMCU handles the process and updates the website with parking availability. Users can easily find available parking spots before heading to the lot. The website allows one-hour advance booking. The status of each parking place is likewise displayed on the entry LCD. This technology solves the city's parking problem and delivers a reliable IoT-based parking management system.

**Keywords**: IoT, Car parking system, Website, IR sensors, NodeMCU ESP 8266

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## 1. Introduction

The parking issue has become more critical, especially in cities. Vehicles are essential modes of transportation at present [1]. Since it is necessary for living today, the production of vehicles has increased drastically. It is common for a house to have at least two cars in Malaysia. Also, vehicles are affordable for low-income families [2]. Besides, people migrate to cities due to the rapid advancement of information and communication technology. Rapid urbanization has led to a rise in the number of vehicles on the road, resulting in an increased demand for parking spaces [3]. All the issues mentioned above have contributed to finding available parking spaces. However, most currently existing parking lots lack a systematic approach. Most of them are manually managed and inefficient. One issue that often arises in a parking lot is wasting time looking for vacant parking spaces. Drivers will be circling parking lots until they find a free spot. If the parking on the lower floors is full, the driver may choose to move to the upper floors, but there is no guarantee that they will find a spot. The driver may wind up driving all over the parking lot looking for a free space [4]. This is where the idea of developing a Smart Car Parking Management System comes into play. The IoT-based Smart Car Parking Management System uses IoT technology to deliver data from the sensors to the server and enable users to check the parking slots' status on the website. Since the IoT has emerged as one of the most popular technologies in the world today, it provides excellent solutions to humanity in various essential areas, including the issue of finding vacant parking [5]. This is what makes the IoT-enabled smart car parking management system "smart" [6]. An early stage of literature review has been mentioned in the article [12][16].

There are two components to the system: hardware and software. The prototype comprises three parking slots, and each parking slot is installed with an IR sensor that functions to sense parking spot occupancy. Since the main motive is to create a simple prototype and lack the number of digital pins in the NodeMCU, only one pathway is designed for entry and exit. Therefore, one IR sensor and a servo motor are used at the entry and exit gate to detect the cars entering and exiting and automatically open and close the gate. The system also includes a NodeMCU, which controls the entire process and is used for connectivity purposes. The red LEDs indicate that the slot is occupied or that the car is parked. The status of each slot will be displayed on an LCD near the entrance. As part of the software development, a website is created. The website first displays the current booking of the user, followed by the current car park status, current booking status, and finally, the booking history of the particular user. The website allows them to book a parking spot one hour ahead and cancel it if necessary. The user needs to click on the "In" option before going into the car park, and the user has to click the "Out" option when leaving the car park. The current car park status of both LCD and website gets updated instantly.

## 2. Literature Review

### 2.1 Towards a Smart Parking Management System for Smart Cities

The proposed architecture by [7] is intended to assist drivers in reducing their search time and providing them with an innovative and efficient method of parking their vehicles. This prototype is primarily designed for multi-story parking garages, with payment handled using a smartphone app. As seen in [12], SQL databases were linked to a servlet that allowed data to be sent and received. Besides, a code managed the servlet and used the Message Queuing Telemetry Transport (MQTT) protocol to transmit data to the Application/Controller. The MQTT protocol was a crucial component of the system since it collected and processed data as needed. The data collected from the parking infrastructure and cars were saved in a database that was accessed by a JDBC controller and an Apache Tomcat server. The Phidget was used in this project which operated as the car park barriers, which moved (open or close) after the controller received the correct input. The mobile application provided information based on the user's current position/state within the parking garage. This mobile application allowed the user to enter and exit the car park, identify the closest available spot within the car park, view spot details for their parked vehicle, and pay the parking fee.

### 2.2 Novel Architecture of Parking Management for Smart Cities

The research by [8] focuses on the conceptual design of the Intelligent Parking Assistant (IPA), which aims to improve current parking management systems. It is gradually establishing itself as a leading "smart city" example. The IPA will feature slot occupancy sensors, a rollway post/barrier for each parking space, a wireless transceiver to interact with other IPA modules, and a unit controller (processor) mounted in the rollway post. This article also discusses the IPA's architectural paradigm and software module. Several modules are used such as user Interface Module, Function Module, Manager Interface Module, Parking space Controller Module, and Communication Module. The IPA software module consists of User Computer Interaction, Parking Spot Access Control, Monitoring Module, and System Administration.

### 2.3 A Novel Parking Management System, for Smart Cities, to Save Fuel, Time and Money

The suggestion by [9], which comprises hardware and software modules, is discussed in this paper. The Raspberry Pi device was utilized, together with other elements such as an ultrasonic distance sensor, a Raspberry Pi camera, display boards, and jumpers. On the software side, python modules with efficient data handling were used [15]. Besides, this paper also discusses the different actions modeled for the drivers and tests to ensure the system works perfectly. The prototype worked well since the entire design was 5 seconds fast, and the system correctly identified the car licence plate 92% of the time. Therefore, this prototype was well-suited for use in huge parking areas.

### 2.4 A Prototype for IoT based Car Parking Management System for Smart Cities

The proposed prototype by [10], is represented in **Figure 1** of this study. The Raspberry Pi board was used in this architecture; it is a tiny board that functions as a computer. This basic debit card-sized board replaced the whole central processing unit and is accessible on the market at reduced rates. The prototype was based on the Raspian (small OS) operating system, similar to Linux. Therefore, smaller applications will be able to use it as a server. This system, which employed IoT technology, allowed users to remotely access, control, and communicate with objects. There are various components to this parking management system. 'Online booking,' 'parking entrance system,' 'parking exit system,' and 'parking management are the terms used.

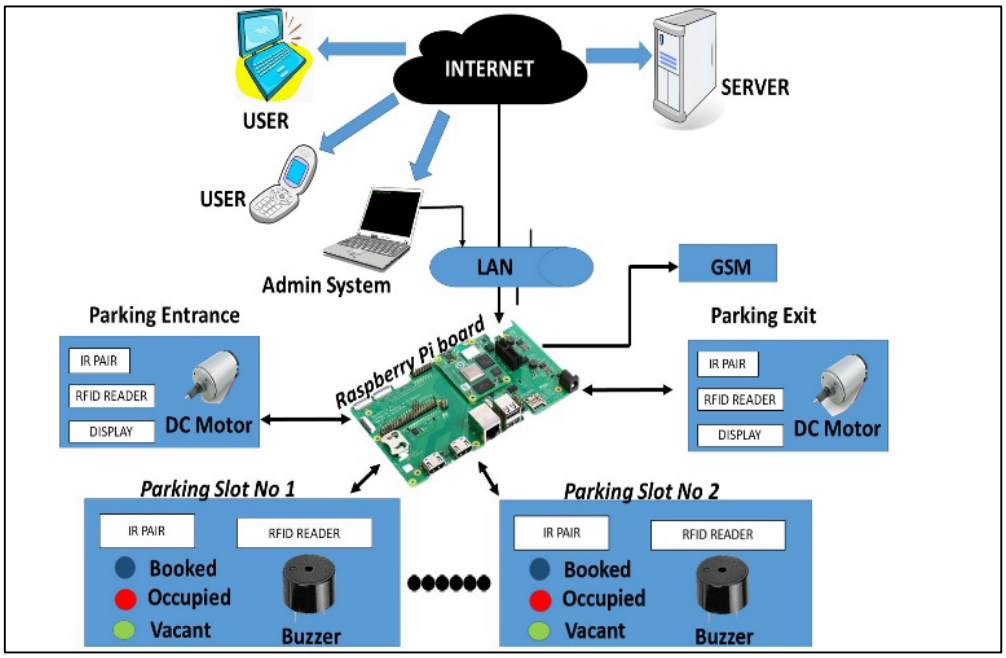


**Figure 1: The Prototype of IoT based Car Parking Management**

## 3. Methodology

### 3.1 System Overview

The IoT-based Car Parking Management System helps with parking. This revolutionary device automates indoor parking lots. This section explains system structure [14]. NodeMCU microcontroller has IR sensors, LCD, servo motor, and red LEDs. The NodeMCU chip is a self-contained system (SOC) with an embedded TCP/IP protocol stack [13]. Infrared sensors detect vehicles. IR sensors send data to ESP8266 NodeMCU. NodeMCU receives and stores data in MySQL. At the entry/exit point, an infrared sensor and servo motor detect vehicles entering and exiting. Gate opener servo motor. If a slot is available, the servo motor rises and lowers the barrier in five seconds. If all slots are filled, the servo motor won't raise the barrier. A car park entry LCD displays the availability of parking slots and the state of each space, and it updates each time a car enters or leaves. The prototype has three spaces. Each parking spot has an IR sensor [11]. Each parking place has a red LED that lights up when a car is parked there. Besides a prototype, a simple website provides the real-time status of each parking place. Users can book and cancel parking. The user must book an hour in advance. In the "My Booking" section, users can examine their current booking, the car park status, reserved slots, and their booking history. Once a user books a slot, the website and prototype offer a "Delete" option. This option cancels the reservation. The customer must click "In" five minutes before the scheduled time. This verifies that the user enters and parks in the designated space. When leaving, click "Out." Users can reset passwords and update profiles. Administrators can check parking status and booked slots.

### 3.2 Discussions

Several components in this work are implemented such as NodeMCU V3 based ESP8266 Module Board, Infrared Sensors, SG90 Servo Motor, 16x2 I2C LCD Display. Details of this work are described in the Section 3.3 until 3.7.

### 3.3 Prototype of the system

The functionality of the system is shown in **Figure 2**.

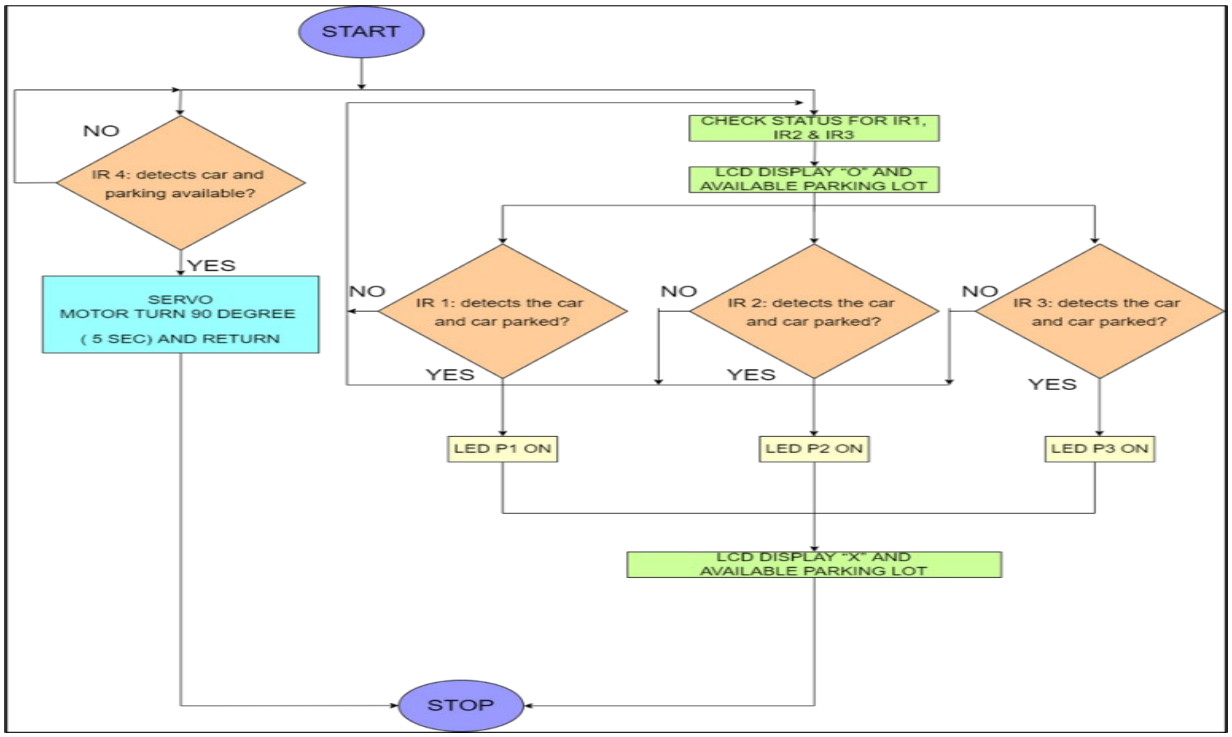


**Figure 2: The Flowchart of the Prototype**

When the system starts, infrared sensors at the entrance or exit and three parking spaces begin sensing. If all or a few slots are unoccupied, the servo motor will rotate 90 degrees, signalling that the gate is open and allowing a vehicle to access the parking area when the IR sensor detects a vehicle. After 5 seconds, the servo motor resets. Once the automobile is parked, the entrance LCD updates the parking slot's status and the number of vacant spaces left. If parking spaces 1 and 2 are occupied and 3 is empty, the LCD will read P1: X, P2: X, P3: O, and Available: 1. "X" signifies the space is occupied, "O" means it's unoccupied, and "Available: 1" means there's one open slot. When the automobile is parked, the red LED lights up to indicate the space is taken. The LCD will display P1: X, P2: X, P3: X, and Available: 0 if all three slots are occupied.

### 3.4 The website of the System

A user has to register first before login into the website. Then, after the user fills up the login credentials, the user will see a few sections: "My Current Booking," the status of each slot, the "Reserved Slots," and the booking history. The user must check the current parking status and the reserved slot records to make a reservation. If there is an empty slot, the user must click on the "New booking" option. The user makes the reservation one hour in advance. On the other hand, if all the slots are occupied, the user must wait until someone cancels the booking or leaves the parking area. Then, if the user wishes to cancel the booking, they can click on the "Delete" option. Five minutes before parking, the website will display an option "In" to indicate that the car was parked in the reserved slot. Once the car is parked, the LCD and the website update the slot's status to occupied and not available. When the user wishes to leave the car park, similarly, an option will get displayed on the website, which is "Out." This is to indicate that the user is leaving the car park. Similarly, the LCD and website will update the status accordingly. As for the administrator feature, the admin will log in, and the admin can view the current parking status and the records of the booked slot.

### 3.5 Block Diagram

**Figure 3** represents the block diagram of the IoT-based Car Parking Management System. This prototype is developed with three parking slots, P1, P2, and P3. The infrared sensors 1, 2, and 3 installed at the parking slots and infrared sensor 4 installed at the entry/exit gate are all connected to the NodeMCU ESP 8266, which acts as the controller. The servo motor, LCD, and red LEDs are the output devices, where the servo motor operates the common single entry and exit gate. The LCD will display the status of each slot and the total vacant spaces. Finally, the red LED lights up when the slot is occupied. The NodeMCU receives input from infrared sensors to navigate the user to an available parking space, sends the data to the MySQL database, and finally displays it on the website. The state of the parking slots is displayed in a table form on the website, and users can book and cancel the booking.

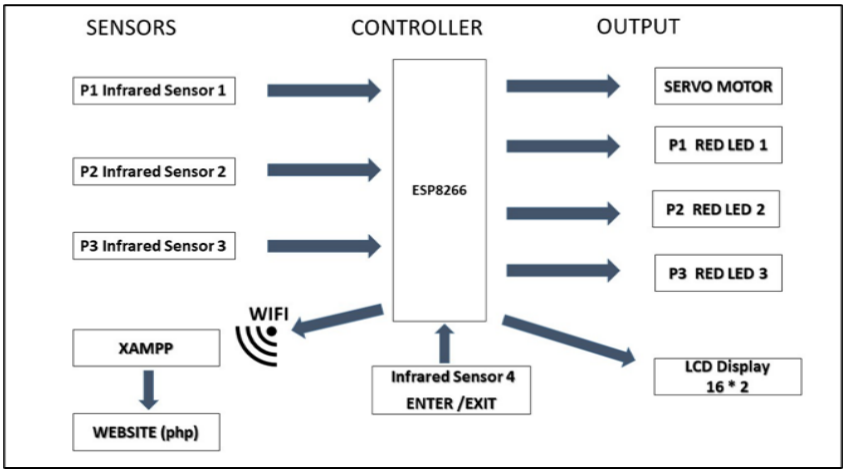


**Figure 3: The Block Diagram of the System**

3.6 Hardware Implementation and Setup

As described in **Figure 4 and Figure 5**, the prototype comprises a NodeMCU ESP8266, the main controller. In addition, one IR sensor is installed at the entry/exit gate to identify vehicles entering and exiting the parking lot. Each slot is occupied with an infrared sensor to detect the parking slot's availability. The servo motor is installed at the entry/exit gate to open and close the gate. At the entrance, there is also an LCD that displays the availability of parking slots in the parking area and the state of each slot.

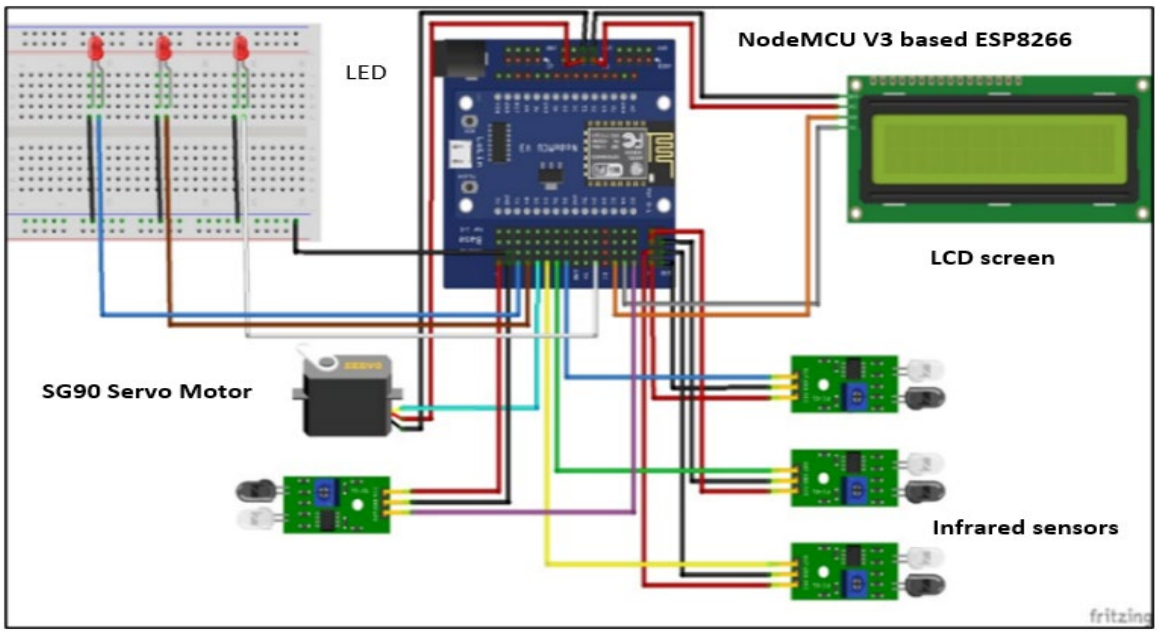


**Figure 4: The Circuit Diagram of the System**

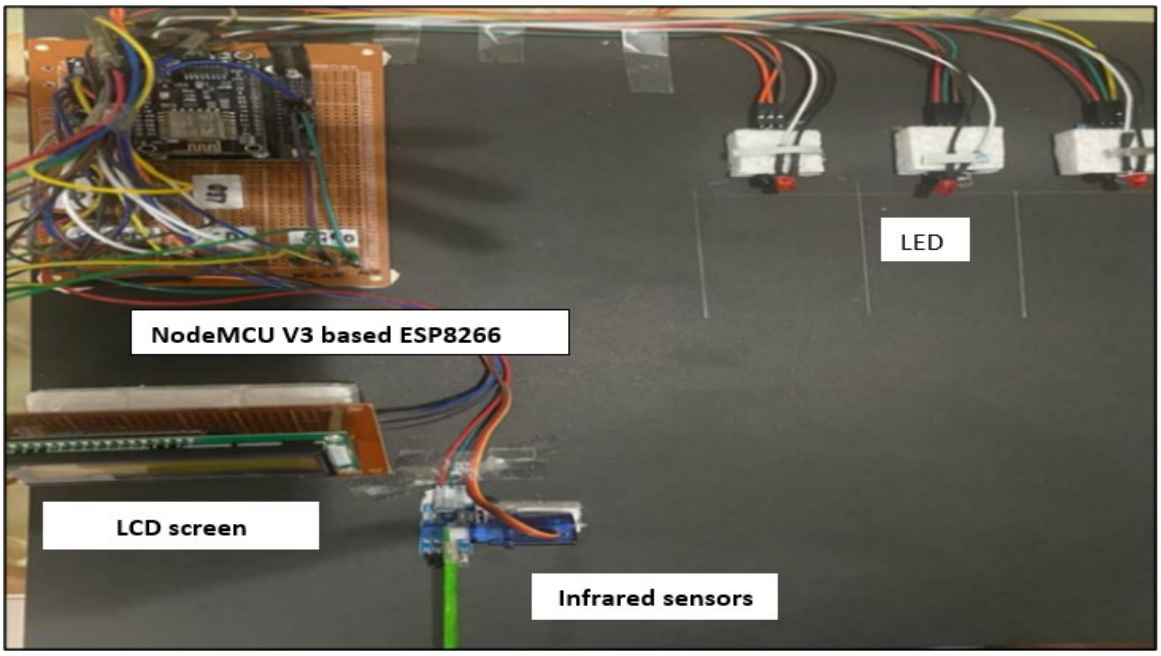


**Figure 5: The Diagram After All the Components Have Been Connected**

### 3.7 Software Implementation

First and foremost, the Visual Studio Code was downloaded and installed. Visual Studio Code is one of the best code editors for writing HTML, PHP, and related codes. Next, the XAMPP server was downloaded and set up. XAMPP is the most widely used PHP development environment. XAMPP is a free and straightforward Apache distribution that includes MariaDB, PHP, and Perl. After installing XAMPP, it was launched on the system. Then, Apache and MySQL Server were started. After that, HTML and PHP files were created. Then, in the htdocs folder of XAMPP, a s LED folder was created for the website. Finally, the website is tested locally on the computer. A database was created using the MySQL database for this system and linked to the website. The website was designed with a user login and an admin login page. Each page has an option to reset their password when they have forgotten their password. Besides, there is a link to register if the user is a first-time user on the user login page. Once the user logins, the user will see a table with the status of each parking slot. The user will be able to book an available slot and cancel the reservation if they want to. When the admin logs in, the admin will see the table and the data of the user who booked the slot, as well as the date and time of the booking.

## 4. Results

### 4.1 Results of the 16×2 LCD Module

In this section, the working of the LCD will be discussed in detail. A 16x2 LCD with I2C is installed at the car park entrance. The car park has three slots in total. When the car park is empty, The LCD displays P1: O, P2: O and P3: O and Available: 3, where P represents "Parking", O represents as still vacant, and X represents as the slot is occupied. After one car enters and is parked, the number of slots available is reduced from 3 to 2. Besides, the status of the particular slot will get displayed on the LCD as P1: X, P2: O and P3: O, for instance. If a slot is booked, the status of that particular slot will be displayed as P1: X.When the slot is fully occupied, LCD will display; P1: X, P2: X and P3: X, and Available: 0. The servo motor will not lift if there is no available parking slot. The servo motor will only lift the barrier if the vehicle exits from the car park. Then, the LCD will instantly update the slots' status and the total available slots. The results from the 16×2 LCD Module are presented in **Figure 6** to **Figure 9**.

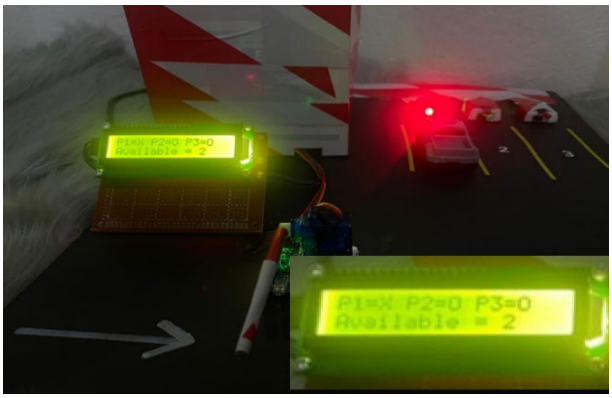


**Figure 6: LCD displays the Status of the Car Park when it is Empty**

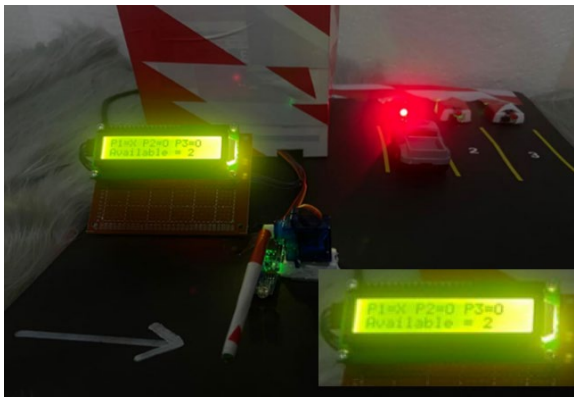


**Figure 7: LCD displays the Status of the Car Park when One Slot is Occupied**

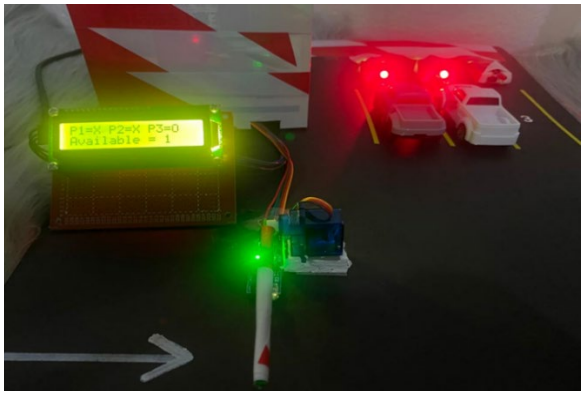


**Figure 8: LCD displays the Status of the Car Park when Two Slots are Occupied**

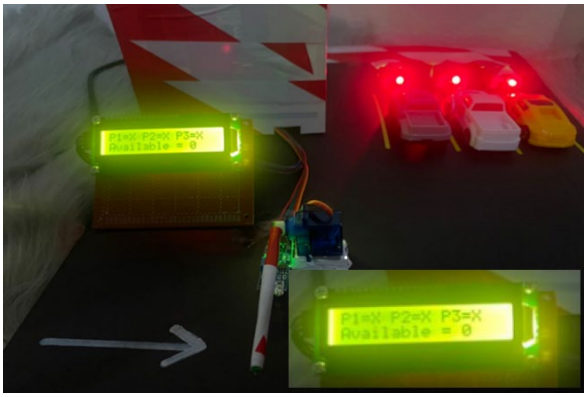


**Figure 9: LCD displays the Status of the Car Park when All Slots are Occupied**

4.1 Results of the Website of the Smart Car Parking System

Each parking spot's status is tabulated online. When all spaces are unfilled, each says "Available." "Not Available" is displayed when an automobile is parked. The user can book a spot after reviewing the car park status and reserved slots by selecting "New Booking" and cancelling if desired. Website and LCD display slot status instantly. The admin monitors each parking spot's status. **Figures 10-15** show LCD and website outcomes after each operation.

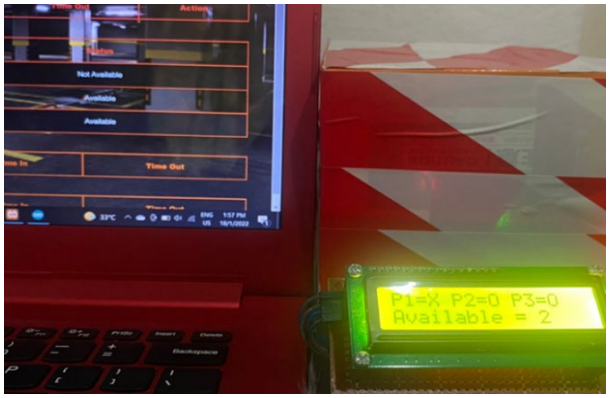


**Figure 10: The Status of the Webpage and LCD when One Slot is Occupied**

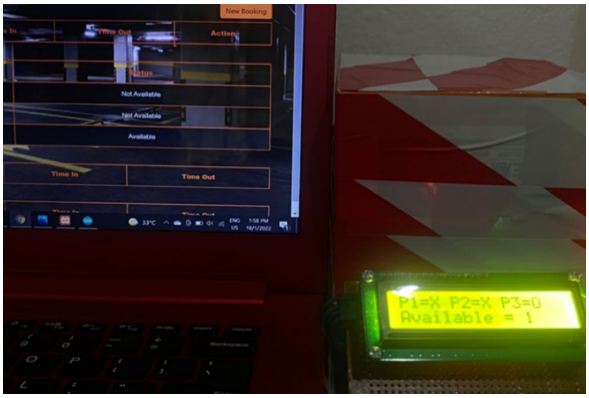


**Figure 11: The Status of the LCD and Website when Two Slots are Occupied**


**Figure 12: The Status of LCD and Website when All Slots are Occupied**

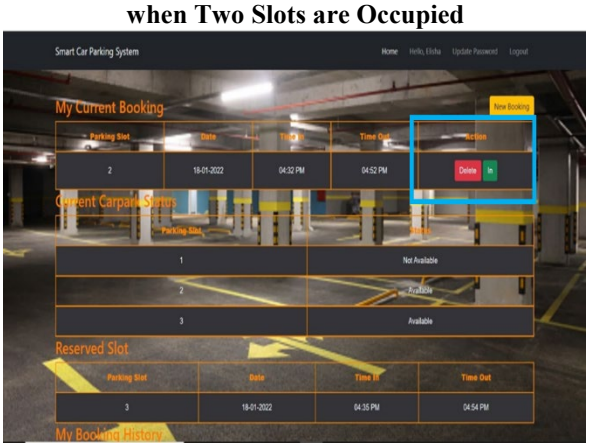


**Figure 13: The diagram depicts the in option, which enables the user to enter the parking area**

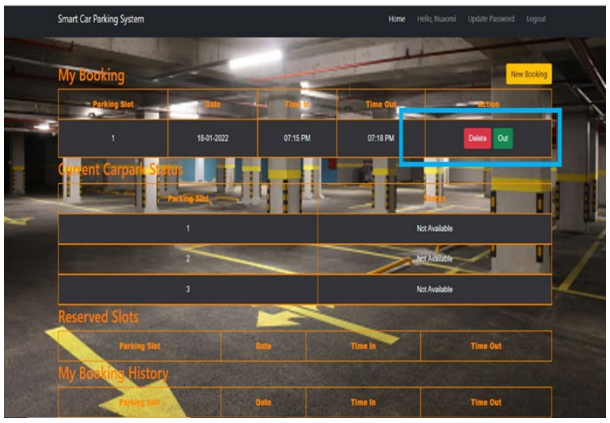


**Figure 14: The diagram depicts the Out option, which allows the user to leave the parking lot.**

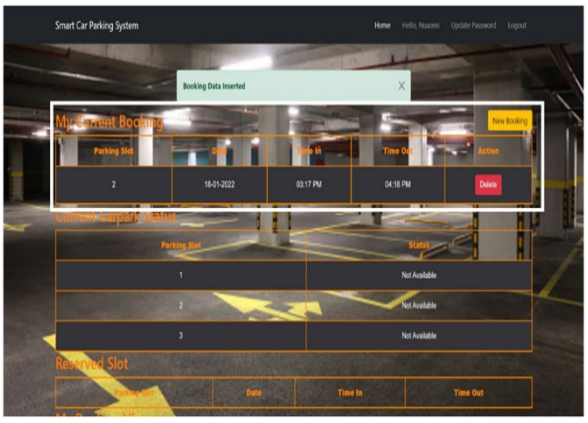


**Figure 15: The diagram depicting when a user has reserved a parking space**

## 5. Conclusion and Recommendations

### 5.1 Conclusion

A Smart Car Parking Management system has been successfully developed. The LCD monitor can display the number of available parking spaces and the status of each parking slot accurately. The web-based Smart Car Parking Management System also displays which slots are vacant and occupied precisely. The servo motor allows the car to enter if there is any vacant parking slot. When the parking lot is completely full, no cars are allowed to enter. The limitations of the parking slots are apparent. The data from the IR sensor to the web-based Smart Car Parking Management System cannot be transmitted when the internet is not stable enough. As a result, if there is no network connection, the result will not be updated. Users had to be depended on the IR sensor and the status displayed on the LCD to find the available parking slot if there is no internet connection. This system is developed using the Arduino C language and HTML. It is a simple concept for a Smart Car Parking Management System that allows future users to make modifications and advancements to execute more functions and specifications.

### 5.2 Recommendations

In the future, the Smart Car Parking Management System could be enhanced by developing a mobile application for both Android and iOS users, allowing them to monitor the car parking area directly. A payment and notification feature should be included to remind users before the parking duration expires and easily extend the duration. Besides, a simple user interface to pay for parking with only a 2-step activity should be created, allowing users to make payment by simply selecting the user's vehicle number and choosing the preferred duration for parking. Furthermore, the system should make it easy for users to pay the parking fee or compound for family or friends by registering their vehicle number in the particular user's app account. All the receipts should be generated in digital format for easy keeping. As for the web page, it should be improved more appealingly to capture vacant parking spaces readily. In addition, an LCD screen should be replaced with a larger LCD screen capable of displaying more than two rows of text. This project's infrared sensors can detect practically everything, which is a disadvantage. As a result, a machine learning-based vehicle recognition system should be implemented.

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