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Smart Parking System Using IoT Sensors

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***Abstract* — Due to the increasing difficulty of finding vacant parking slots in urban cities, Smart Parking System has been developed to solve the problem. It is a system that can show the status of all parking slots in an area which allows drivers to find parking easily. The objective of this paper is to design a Smart Parking System by using Internet of things (IoT) sensors and evaluate the system's performance. In this paper, ultrasonic sensors will be used as the IoT sensors while the microcontroller of the system is the NodeMCU ESP8266. The ultrasonic sensors will be placed in each parking slot to detect the presence of a vehicle. When the sensor detects a car, it will send this information to the microcontroller and the microcontroller will update the parking data stored in the cloud server via an internet connection. The users can then access the parking information in the cloud with their mobile devices by scanning the Quick Response (QR) code provided or directly visiting the cloud online. In addition, unique designs are proposed to solve some common problems faced by the parking systems such as the ultrasonic sensor might be malfunctioning and the sensor is unable to differentiate between a vehicle and a pedestrian. The performance of the system will then be evaluated based on its accuracy. From the results obtained, the system prototype achieved an accuracy of 100 %. Comparing this system with other Smart Parking Systems proposed, it proves that this method has higher cost-efficiency and reliability. This shows the significance of this research since higher system reliability and cost-efficiency can increase the confidence of the parking area owners to implement this Smart Parking System which can save the driver's time and reduce air pollution.**

Keywords—Smart Parking System, IoT sensors, Mobile Sharing Services, Cloud server

I. INTRODUCTION

It is undeniable that the Internet of Things (IoT) is one of the important emerging technologies that gives a huge impact on human society. The rise of IoT had led to an advancement of technologies in different sectors such as industry, education, security, and transportation. It helps to create a network that allows the interconnection of different devices via the internet and enables the sharing of data between the devices. Through the network, interaction and communication between distinct electronic devices such as a sensor and a microcontroller become possible [1]. It also simplifies the technology for mobile sharing services through the IoT Cloud, which is an integration of the IoT and cloud technology. Although IoT and cloud computing belong to two distinct fields, their elements and characteristics are complementary to one another [2]. Cloud computing is a technology that involves the delivery of computer services such as the access, analysis, and storage of data over the internet. Through the integration of IoT and cloud services, some limitations of IoT technology can be resolved. For example, the current IoT technology still suffers from technological constraints such as low storage and poor processing power due to limited resources. With the help of cloud services, IoT Cloud can now easily handle the delivery, analysis, and storage of data [3].

Benefiting from the exponential growth of the Internet of things (IoT) and cloud technologies, different kinds of applications and systems have been integrated with an Internet Protocol (IP) module that allows the systems to access the internet [4]. Smart Parking System is one of them which is used to show the parking availability of a particular parking area for 24 hours [5]. This system consists of both hardware and software. The hardware parts include physical components such as the microcontroller and the IoT sensors like infrared (IR) sensors, ultrasonic sensors, and acoustic array sensors. These IoT sensors allow the system to detect whether a particular parking slot is occupied by other cars or not. Besides, the Smart Parking System will normally involve a cloud server to store and analyze the data collected by the sensors. A user interface (UI) such as a mobile application or webpage will be designed to share the cloud data with the users.

The Smart Parking System is a timely and specific solution to overcome the parking issues caused by the rising number of cars in recent years, especially in

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cities where the population density is very high. According to research, it takes an average of 7.8 minutes for a driver to find a vacant parking slot in such areas [6]. As this Smart Parking System directly informs the drivers about the location of all the vacant parking slots, the drivers can directly park their car in the available parking slot without wasting their time circling around the parking area. This helps to solve the traffic congestion problem which is the major issue faced by most urban cities. Since the usage time of the vehicle is reduced, it can help the drivers to save the cost of car fuel and further minimize air pollution in the city as fewer harmful gases are released by the vehicles [7]. Moreover, as the Smart Parking System users can access the system through their mobile phones, it increases the novelty of this system as it can assist the drivers in planning their destination. For instance, if a driver plans to visit a particular shopping complex, he or she can review the parking information through the Smart Parking System before driving. If he or she found that there is no available parking slot in the particular shopping complex, the driver can consider visiting another shopping complex.

One of the possible places to implement the Smart Parking System is the shopping complexes [7]. In such places where the total number of parking slots is limited, this system can directly guide the customers to the vacant parking slots without wasting their precious time. Therefore, customers can spend more time in the shopping complex to purchase the goods that they need. Besides, as all the parking information is stored in the cloud, the system can be easily modified to calculate the parking fees required for a particular vehicle that occupies the parking slot. Moreover, the management team of the shopping complex can also perform data analysis based on the parking information. For example, they can summarize the total number of customers visiting their shopping complex in one month and compare it with the previous data for the evaluation of performance. The Smart Parking System can also be applied in residential areas such as an apartment. By applying Radio Frequency Identification (RFID) technology, it is possible to limit the users of the Smart Parking System, and only registered users with an RFID card can use the parking area. This can help to increase the security level by preventing malicious individuals such as car theft from entering the parking area. Besides, it is also possible for the residents to reserve a particular parking slot through the Smart Parking System by providing their personal information such as their phone number and car plate number.

II. LITERATURE REVIEW

Since many developed countries have implemented the Smart Parking System to increase the living quality of their residents, many papers and articles have been published to improve the system. Each article proposed its own way to build and improve the performance of the Smart Parking System.

One of the Smart Parking Systems is proposed by the researchers from International Islamic University Malaysia. In this research, the authors aimed to reduce the implementation cost of a Smart Parking System by using a camera to replace the conventional sensors used by previous literature. For the design of the system, the authors used a 360° camera placed in the center of the parking space to record the condition of all the parking slots. The photo taken by the camera will then be processed by the Raspberry Pi model which is a small processor to identify the parking condition of the parking slots by a method called the Edge Detection Technique. The Edge Detection Technique is one of the common image-processing techniques which is used to detect and identify the boundary of objects [8]. The users of the system can then access the parking slot information by installing the mobile application on their phones [9]. It is undeniable that this article creates a seminal work by implementing image processing techniques to replace parking sensors. The advantage of this system is it reduces the cost of implementing a Smart Parking System in a huge parking area. For conventional Smart Parking Systems that use sensors, as the number of parking slots increases, the number of sensors required will also increase which will lead to a surge in the implementation cost. By using a 360° camera, as long as the camera can cover the entire parking area, the cost of implementation will not be affected by the size of the parking area. However, there are still some limitations to this system. The first disadvantage is the performance of the system depends on the quality of the camera. If the camera cannot take a clear image of the parking area, the processor may fail to identify the presence of a vehicle in the parking slot which will reduce the accuracy of the system. Besides, factors such as the brightness and weather of the parking space will also affect the performance of the system.

Another group of researchers proposed a Car Park Management System by modifying the conventional Smart Parking Systems. The objective of this article is to develop a system that can help drivers for searching an empty parking slot with an additional management capability. For the design, IR sensors are used to detect the presence of a car in a particular parking slot, the information detected by the IR sensors will be sent to the database via a Wi-Fi connection. For administrative purposes, the database will collect and record the time when a car enters or exits a particular parking slot. An LCD screen that is connected to the database will then display the location of all available parking slots to the drivers when they enter the parking area. All the parking slots are continuously monitored by the sensors and will be updated instantly on the LCD screen if a vehicle parks or left the parking slot [10]. Compared to conventional systems, the uniqueness of this article is it added the ability for the system to perform administrative purposes by collecting the date and time of a car entering or exiting the parking slot. The advantage of this system is the parking zone owner can calculate the parking fees required for a particular driver based on the time recorded by the system. On the other hand, the drawback of the system will be the low system reliability due to the use of IR sensors. This is because the performance of the IR sensor depends on the surrounding light intensity and will be affected by the color of the object. The darker the surface of the object, the more IR rays will be absorbed by the object's surface, and fewer rays can be detected by the IR sensor [11]. In other words, the IR sensors may give false results to the system such as indicating there is an available parking slot although it was already occupied by a car.

Moreover, a group of researchers from India proposed another Smart Parking System that implements Radio Frequency Identification (RFID) technology. The purpose of this article is to develop a Smart Parking System with RFID technology to improve the security level. In this system, every registered vehicle will be assigned one unique RFID tag that stores some basic information about the vehicle such as the car plate number, the owner of the vehicle, and the user's registered contact number. Before the vehicle enters the parking area, the RFID reader installed at the gate will scan the RFID tag of the vehicle. After the vehicle was successfully authenticated, the system will check the parking availability and allocate a suitable parking slot for the vehicle. The counter of the system will decrease the total number of parking slots available after the vehicle parks on the slot. There will be an LCD screen installed to display the total number of free slots available in the parking area. If there are no empty slots available, the system will suggest the user park the vehicle in a nearby parking zone. In case the users wish to reserve a parking slot, he/she can access the website provided to book a suitable parking slot. When the vehicle leaves the parking zone, the RFID reader will scan the RFID tag of the vehicle again and the counter will increase the number of empty parking slots by one [12]. The special part of this article is the application of new technology (RFID) to improve the current Smart Parking Systems instead of using conventional sensors or cameras selected by [9]. The strength of this system is the increased level of protection for the users. As all the users should be registered before they can use the parking slots, it prevents any malicious individual from entering the parking area. In contrast, it also makes this Smart Parking System becomes too specific where only places such as the residential parking area are suitable to implement this system since all the users can be identified. Besides, the implementation cost of the RFID system is also relatively high because the price of an RFID reader and the RFID tag is not cheap [13]. As the number of registered user increases, the cost to implement the RFID system will also be skyrocketed as the demand for the RFID tag rises.

A different Smart Parking System was proposed by [14] that is based on IoT technology. This system involves an integration of multiple technologies including the Global System for Mobile Communication (GSM) and Radio Frequency Identification (RFID). The GSM is used to create a communication channel between the users' mobile phone and the system which allows the user to receive SMS or voice messages via the mobile network. The RFID technology is used for identification purposes which ensures that only registered users can use the Smart Parking System. For the system design, IR sensors are implemented to detect the presence of a vehicle and all the data collected by the IR sensors will be stored in the cloud server. Arduino Nano board is used as the system microcontroller connected to a GSM module and a Wi-Fi module. The GSM module allows the system to transfer data to the user's phone while the Wi-Fi module will be used to upload the sensors' data to the cloud server via an internet connection. Before the users enter the parking area, they should show their RFID card to be scanned by the RFID reader module in front of the gate. When the reader module had identified the users' identity, the Arduino microcontroller will check the data stored in the cloud and the parking area status will be directly sent to the users' mobile phone number. It is a unique design where the GSM technology is applied to create an interaction between the users and the system, unlike conventional parking system that uses Wi-Fi such as the system proposed by [10]. The advantage of this system is it provides convenience to the users as it does not require the users to install any mobile applications or visit any online websites and it does not rely on internet connections. The status of all parking slots will be sent to the users' mobile phones directly through SMS after they scanned their RFID cards. With the RFID card restriction, the system also guarantees the safety of vehicles because only permitted users can enter the parking area. Nevertheless, the Arduino Nano board is unable to access the internet or mobile network by itself. Therefore, the authors used additional devices such as the Wi-Fi module and the GSM module to support the microcontroller. These devices will increase the overall implementation cost of the system and the circuit connection will be more complex.

There is also a high-accuracy IoT-based Parking Monitoring System using magnetometers developed by [15]. For this system, there are four types of hardware involved in the system which are the sensor node, repeater node, gateway node, and LED display node. The sensor node is the HMC5883L magnetometer that is placed on the ground and used to check the presence of a vehicle in a particular parking slot and send the information to the repeater node. The repeater node is the device responsible for the message transmission within the system. They will send the message received from the magnetometers to the gateway node through a mesh networking protocol. Through the implementation of the repeater node, it helps to solve one of the common problems faced by wireless communication which is the distance limitation. The gateway node is the microcontroller of the system that will process all the information received and take necessary action. It will update the cloud server based on the sensor data received from the repeater node through the internet. A MySQL database will be applied to store the sensor data in the cloud server. The LED display node will show the users the total number of currently available parking spaces with an LED screen. The users can also use the mobile app or dashboard app to check the parking availability in the parking area. The authors proposed a novel idea by using a magnetometer to detect the presence of a car instead of common parking sensors such as infrared (IR) sensors applied by [10]. This idea is based on the fact that most vehicles are ferrous-based that can be easily detected by a magnetometer. The main advantage of this system is its high accuracy and reliability. From the experiment results provided by the authors, the magnetometers have 100 % accuracy for the detection of vehicles. Since the magnetometers detect the vehicle based on the magnetic field strength, the system will not be affected even when the magnetometers are covered by dust or rubbish. Besides, by the implementation of the mesh networking protocol in the repeater node, it solves the distance limitation problem of wireless connection which means this system can be easily implemented in a large parking area. Nevertheless, this parking system still has some limitations. Based on recent articles, automobile manufacturers are planning to replace the steel and iron that are commonly used in car manufacturing with carbon fiber materials that have higher strength and rigidity [16]. As the magnetometer detects the presence of a car based on the ferrous materials on the car, it is unable to detect a carbon fiber-based vehicle that does not contain any ferrous materials.

III. MATERIALS AND METHODS

In this research, a Smart Parking System based on IoT sensors will be presented. The sensor used in this system will be the HC-SR04P ultrasonic sensor to detect the presence of a vehicle in the parking slots. All the sensor data will be stored in the Adafruit.io cloud server. The microcontroller of the system will be the NodeMCU ESP8266. It has a built-in Wi-Fi chip which allows it to communicate with the cloud via the internet. For the operation of the system, the ultrasonic sensors will first be placed in each parking slot to detect the presence of a vehicle. The parking slot status is represented by "Occupied" or "Available" in the cloud to indicate whether it is being occupied or not. The microcontroller will be responsible to update the parking data stored in the cloud server based on the feedback from the sensors. The users can access the parking information in the cloud with their mobile devices by scanning the Quick Response (QR) code provided or directly visiting the cloud online. After the system prototype is built, experiments will be conducted to evaluate the accuracy of the system.

To use the ultrasonic sensor for the detection of a vehicle, the basic operating principle of the sensor should first be reviewed. Unlike other sensors, the feedback from an ultrasonic sensor is not merely digital (either 0 or 1). The data received from the ultrasonic sensor will be the duration of the wave travelled when the emitted wave is reflected by an object's surface and returned to the sensor. From the duration received, the distance between the sensor and the object can be calculated. Therefore, the vehicle detection will be based on the distance between the sensor and the object detected. For the system design, ultrasonic sensors will be placed in front of each parking slot to detect the presence of a vehicle. By considering the size of the parking slot and car length, it is assumed that the vehicle will park in front of the sensor at a distance within 10 cm. Hence, when the distance between the object detected is within 10 cm, the system will update the parking slot status as "Occupied" in the cloud. In contrast, when the sensor does not detect anything within 10 cm, the status of the parking slot will be updated as "Available".

The User Interface (UI) of this system will be in the form of a webpage that shows all the data stored in the Adafruit.io cloud server. Figures 1 and 2 depict the laptop and phone view of the system's dashboard that shows the parking slot information respectively.

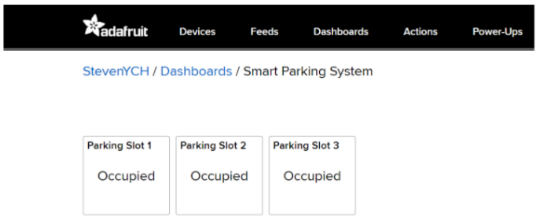

Fig. 1. Laptop view of the system's dashboard.

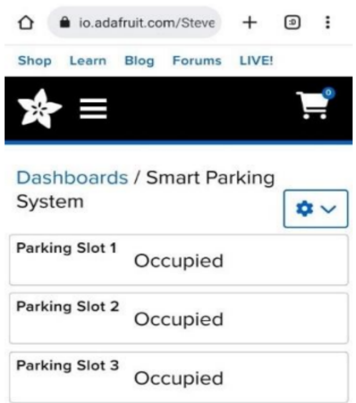

Fig. 2. Phone view of the system's dashboard.

In order to achieve mobile sharing services for the system, a QR code that links to the cloud server will be provided in front of the parking area. By scanning the QR code, it will directly guide the user to the cloud server webpage. One of the advantages of using QR codes instead of other methods is it does not require the users to install any mobile application on their phone or force the users to memorize any URL link. The users just need to scan the QR code to obtain the link to the cloud server to access the parking information. However, they can still directly visit the cloud online if they had saved the URL link previously. Besides, the QR code is also easy to be stored or saved on smartphones. Instead of keeping a long URL, the users just need to take a picture of the QR code to save it on their phones.

In some places such as apartments, the parking slot data will be relatively sensitive. This is because some malicious individuals may hack into the parking system to access the parking slot information. This allows them to check whether the house owner is in the house or not before they want to carry out any crime in the house. Thus, to protect the parking slots information, the Wi-Fi connection for the microcontroller will be secured by the Transport Layer Security (TLS) protocol. This TLS protocol will encrypt all the sensor information before it is transferred to the cloud server [17].

There will be one special design to help the ultrasonic sensors to differentiate between a vehicle and a pedestrian. When the sensor detects an object, it will first wait for 3 s. After 3 s, if it still detects an object, it can conclude that the object is a vehicle and send a signal to the microcontroller. This feature can avoid the sensor from giving out false information because it may incorrectly report that the parking slot is occupied when a pedestrian passed by the sensor.

Besides, another design will be implemented to avoid the cases where the sensor is defected or blocked by dust. It is possible for a particular sensor to be malfunctioned if it is knocked by the vehicle due to poor parking or if the connecting wires are broken. Hence, the microcontroller will not be able to receive any feedback from the malfunctioning sensor. In addition, if the sensor receiver or transmitter is blocked, it prevents the transmission of the ultrasonic waves, so the sensor receiver will not receive any wave. Since no reflected wave is detected, no input signal will be received by the microcontroller and the distance is undefined. It is crucial to ensure that all the sensors are working properly so the system is providing correct information. Hence, the parking slot staff should be informed immediately if there are any defective sensors. In this design, if the microcontroller found that a particular ultrasonic sensor gives feedback of 0, it can identify that the sensor might be malfunctioning or being blocked by rubbish such as newspapers. Then, the microcontroller will send a signal to activate the buzzer. The buzzer will then alert the related staff immediately. Figure 3 shows an example where the status for Parking Slot 3 in the cloud is "Sensor Error" when the corresponding ultrasonic sensor is not functioning.

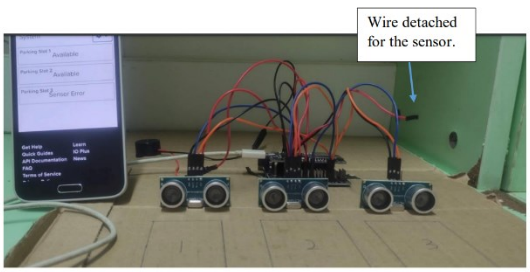

Fig. 3. Cloud status when sensor is not working.

A. Hardware Design

Figure 4 shows the placement of all the components of the Smart Parking System. Three ultrasonic sensors will be used in the prototype. For the location of the sensors, it will be placed in front of the vehicles, unlike conventional systems where the sensors are placed underground or overhead. For underground sensors, they might be easily damaged if the drivers did not park their vehicles properly and the car tyre will crush the sensors. Overhead placement is also not considered because it is hard for both maintenance and cleaning purposes. Hence, the parking sensors will be attached to the wall or placed on a small pole in front of the parking slots as shown. All the ultrasonic sensors will be connected to the NodeMCU ESP8266 microcontroller through connecting wires to receive or deliver signals. The buzzer can be placed in the staff's office to alert the staffs when the parking sensors are blocked by dust or rubbish.

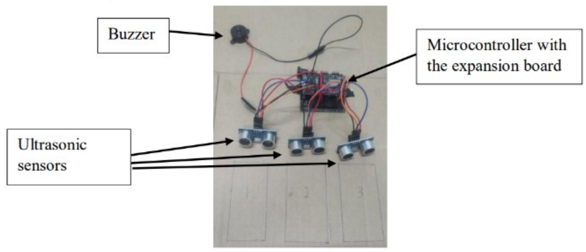

Fig. 4. Placement of the components in prototype.

The circuit connection of the system is shown in Fig. 5. For the microcontroller, the D2, D5, and D6 pins will be the input pins while the D1 and D7 are the output pins. The 3V pin is the supply voltage pin which will give a 3V output voltage to the components connected while the GND pin is the ground of the microcontroller. All the components will receive the operating voltage directly from the microcontroller. The red wire of the ultrasonic sensor indicates the positive terminal while the black wire represents the ground wire (negative terminal). The microcontroller will receive voltage from the external battery connected to its USB port. The blue wires are connected to the trigger pin of the ultrasonic sensor used for the emission of waves. All three ultrasonic sensors will share the same pin, D1 to activate their trigger pin. The yellow wires are connected to the echo pin of the ultrasonic sensor to receive the reflected waves. They will be connected to the D2, D5, and D6 input pins of the microcontroller. For the buzzer, it will be connected to the D7 pin of the microcontroller.

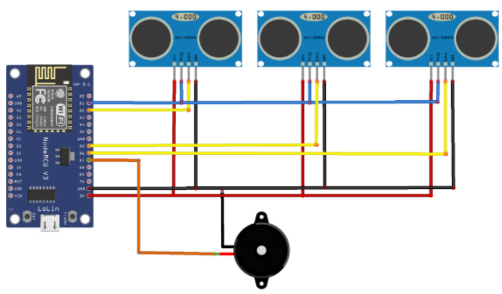

Fig. 5. Circuit connection of the system.

B. Software Design

The coding software used to develop the system will be the Arduino IDE. Some important parts of the system coding are shown in this session. Figure 6 first depicts the setup function of the system. The setup function is used to define the basic setup of the microcontroller and will be executed at the beginning of the code. The command Serial.begin (9600) is first used to start the serial communication which allows the data to be transmitted from the microcontroller. The value 9600 represents the baud rate of the system, which means that the data speed for serial data transmission is 9600 bits per second. The command WiFi.begin helps the microcontroller to connect with the Wi-Fi using the parameters defined previously. Once the microcontroller is successfully connected to the Wi-Fi, it will print a success message and provide its IP address through the command WiFi.localIP. Lastly, the SHA1 fingerprint defined previously will be checked and set up by the command client.setFingerprint.

```
void setup()
{
  Serial.begin(9600);  //Setup the system baud rate
  delay(10);

  pinMode(trig,OUTPUT);   //Define the pins
  pinMode(echo1,INPUT);
  pinMode(echo2,INPUT);
  pinMode(echo3,INPUT);

  /****************************Wi-Fi Connection********************************/
  Serial.println(); Serial.println();
  Serial.print("Connecting to ");
  Serial.println(WLAN_SSID);

  delay(1000);

  WiFi.begin(WLAN_SSID, WLAN_PASS);
  delay(2000);

  while (WiFi.status() != WL_CONNECTED)   //Print...when connecting to Wi-Fi
  {
    delay(500);
    Serial.print(".");
  }

  Serial.println();

  Serial.println("WiFi connected");
  Serial.println("IP address: "); Serial.println(WiFi.localIP());

  client.setFingerprint(fingerprint); // check the fingerprint of io.adafruit.com's SSL cert
}
```

Fig. 6. Setup function coding for the system.

Moreover, the sensor function is the function that controls the operation of the ultrasonic sensors in Fig. 7. The digitalWrite command will first activate the trigger pin of the ultrasonic sensor to generate an ultrasonic wave. Then, the pulseIn command will trigger the sensor's echo pin to read the duration required for the ultrasonic wave to return to the sensor. The distance between the sensor and the object detected will then be calculated based on the duration measured. The publish command allows the microcontroller to publish the particular parking slot status to the cloud. Lastly, the tone command will be used to activate the buzzer to create a 1000 Hz sound signal if the sensor is not functioning.

```
void sensor1()
{
  digitalWrite(trig, LOW); //Activate the trigger pin
  delayMicroseconds(2);
  digitalWrite(trig, HIGH);
  delayMicroseconds(10);
  digitalWrite(trig, LOW);

  duration1 = pulseIn(echo1, HIGH); //Activate the echo pin to read the duration

  distance1 = duration1 * 0.034 / 2; //Calculating the distance

  if(distance1 < 10 && distance1 > 2) // Publish "Occupied" if vehicle detected
  {
      delay(3000);
      if(distance1 < 10 && distance1 > 2)
      {
      slot1.publish("Occupied");
      }
  }

  if(distance1 > 10) //Publish "Available" if vehicle not detected
  {
      slot1.publish("Available");
  }

 if(distance1 == 0) //Publish "Sensor Error" if sensor malfunctioned and activate the buzzer
 {
     slot1.publish("Sensor Error");
     tone(buzzer, 1000);
     delay(1000);
     noTone(buzzer);
     delay(1000);
  }

  delay(1000);
}
```

Fig. 7. Function coding for sensor control.

IV. RESULTS AND DISCUSSIONS

There are two possible conditions for the parking slots, either the parking slots are occupied or not. Therefore, the accuracy of the system prototype will be tested based on the prototype's capability to identify the parking slot condition. In order to simplify the testing procedure, a toy car will be used to represent an actual vehicle and placed in the parking slot. For instance, if the toy car is placed in a particular parking slot and the system stated the parking slot as "Occupied", it represents that the system successfully identified the status of the parking slot. Similarly, if there is no toy car placed in a particular parking slot and the system identified it as "Available", it is also considered a successful identification. Figure 8 shows an example of the testing procedure for the prototype.

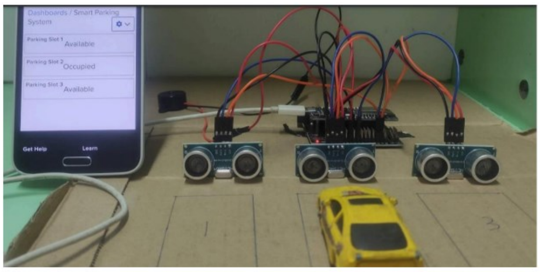

Fig. 8. Example of accuracy testing.

Figure 8 shows that Parking Slot 2 is occupied by the toy car while Parking Slot 1 and Parking Slot 3 are empty. Referring to the sensor status shown in the phone, the status of Parking Slots 1 and 3 are stated as "Available" and the status for Parking Slot 2 is "Occupied". Thus, it means that the system accurately identified the parking status for all the parking slots. All three parking slots were tested 20 times each. The toy car was placed and removed continuously from the parking slot and its corresponding status in the cloud was recorded. If the system displayed the parking slot status correctly, it will be considered an accurate trial.

From the results obtained for accuracy testing, it shows that the accuracy for all three parking slots is 100 %, where the system accurately displayed the status of all three parking slots for the 60 trials (20 trials each for the three parking slots). This proves that the Smart Parking System proposed in this report can accurately detect the presence of vehicles in the parking slots.

Additional testing was carried out to evaluate the ability of the system to differentiate between a pedestrian and a vehicle. For the system prototype, the walking pedestrians were simulated using hand movements. The system output was observed when the sensor detected hand movement that moves across it within three seconds. Under 20 trials for each sensor, the system did not update the parking slot status as "Occupied" when the hand moves across the sensor. It shows that this design can help the system not to state a particular parking slot is occupied when the corresponding sensor detects a walking pedestrian.

It is worth noticing that the system prototype built in this research is considered an approximation of the Smart Parking System in real life. In the experiment trials, it assumes an ideal situation where all the vehicles occupying the parking slot are parked properly in the slot. Therefore, the results obtained may not be able to fully approximate the accuracy of the system when it is implemented in real life. For instance, a poor vehicle parking position may affect the accuracy of the system. If a vehicle is not parked within the box drawn in the parking slot, the ultrasonic sensor may not be able to detect that vehicle. Besides, if the car is placed too far from the sensor which is not within the sensor's detectable range, the system may provide incorrect information as well.

V. CONCLUSION

In brief, a Smart Parking System based on IoT sensors is successfully designed. The evaluation of the system's efficiency is based on its accuracy. From the results obtained, the overall accuracy of the system is at 100 %. There are also two special designs implemented that help the sensors to differentiate between a pedestrian and a vehicle and notify the parking zone owner when the sensors are defective. Generally, the experimental results have shown that the Smart Parking System designed in this report has high accuracy and efficiency. Hence, it is expected to attract more people to implement this cost-efficient system. Through the wide implementation of Smart Parking Systems, the major issues faced by urban cities such as traffic congestion will soon be solved. For future development, the system prototype presented in this article will be tested in real world situation to further evaluate its performance. Moreover, the researchers might consider involving renewable energies such as solar to power the components in the Smart Parking Systems. Thus, in addition to reducing the operating costs of the Smart Parking System, it can also meet the Sustainable Development Goals (SDGs) proposed by the United Nations (UN) in 2015.

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