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Smart Multi-Vehicle Parking System Using IoT

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Abstract: In this era of modernization, vehicles on the road nowadays outpacing the supply of available parking space. The development of the smart parking system is essential in many places to overcome issues around the world. Nowadays, the parking areas are available more for light vehicles, instead of medium and heavy vehicles. Hence, in this project, the system allowed different types of vehicles such as light, medium and large size vehicle to fully utilized the available parking spaces. The main objective of this project is to provide precise occupancy information for the drivers which can help to reduce the time spent looking for a parking slot. Subsequently, the main feature of the smart multi-vehicle parking system is to detect the vacancy slot in the parking area by using ESP8266-01 and Arduino Mega 2560. Both of the mainboards will communicate with each other using TX and RX pin, at which the data is sent and give parking assignation to the user. The Blynk application allows the customer to choose their suitable vehicle types for parking space. The core sensor used in detection for the parking space and weather is based on the LDR sensor. Smart streetlights will be an add-on feature in this system as it ensures the parking system can work even in a dark surrounding. Thus, it will turn on when the surrounding of the parking space starts to become gloomy. Besides that, the LCD provides real-time information for the customer too, thereby users are capable to know the availability of the parking space even at distant. The reservation feature is one of the limitations of this project, as the parking spaces are only for first come first serve. In conclusion, this multi-vehicle smart parking system with the user interface is user-friendly and convenient to use as it allows different types of vehicles to park.

Keywords: Smart Parking System, Vehicle Detection, Wireless Sensor Network, Light Dependent Resistor Sensor

1. Introduction

Nowadays, the expansion of urbanization and an increase in the population of the world lead to the increment of the aggregate demand for parking areas, especially in the cities. However, the quantity of vehicles in the globe is rapidly outpacing the offered parking spaces, resulting in drivers searching for parking space has become a daily routine. The challenge of finding parking places for the vehicle is the

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unorganized parking places such as unpaved, slot without lines and lot index, streetlight and roof are not providing. Consequently, the drivers spent a lot of time seeking a parking space due to less information provided to them. Therefore, a smart parking system is a solution that combines human innovation and technology which is introduced to ease the parking process. The growing need for smart cities is the implementation of the smart parking system and smart transportation. However, there are different concepts and designs of the smart parking system, as compared to other countries such as round type, tower type, cart type, multi-layer circulation, etc.

The development of the smart parking system implies an IoT-based system that will convey the data information via web or mobile applications. Internet of Things (IoT) is a system that allows devices on Internet connections to communicate with others and can send data through networks without the involvement of human interactions [1]. In this project, the main components needed are the microcontroller, Arduino Mega 2560, which helps to develop the parking system. The function of the Arduino Mega 2560 is to detect the availabilities of each parking slot and the sensors are embedded on the floor of the parking system.

Meanwhile, the ESP 8266-01 Wi-Fi module is used to connect the Blynk application. A set of C++ programming code is programmed to sense the presence of the car, control of the gateway, display of the LCD and other functions in the parking system. Besides that, the sensor also plays a significant role in the smart parking system, as it helps to sense the vehicle at the parking space. All the data will be sent to the Blynk cloud to provide support for the system. The installation of the sensor will be studied and placed at a suitable place. The LDR sensor module is being programmed and the data detection is then assigned the occupancy information to the mobile application Blynk with the help of the Wi-Fi module, ESP8266-01.

Therefore, the purpose of doing this project is to produce a real-life solution to the vehicle parking problem that faced frequently. It helps to minimize the users' time and increase the efficiency of finding the parking, as well as save the environment by reduces fuel consumption. Developing the smart parking system will help to gain its operation efficiency for the public necessities and helps in accelerating the improvement of the quality of life for the citizens [2]. By applying a smart parking system to the city, it can help people to plan their trips yet save time [3].

2. Literature Review

2.1 Type of Smart Parking System (SPS)

A smart parking system (SPS) is an IoT-based parking system strategy designed to send data via web or mobile applications. It will embed in-ground sensors, cameras or other new technologies to detect the availability of the vehicles in the parking areas [1]. The SPS brings more convenience as the information is provided together with guidance. The data can easily be gathered for the system to use and will send it to the drivers as well [4]. For example, the Parking Guidance and Information System (PGIS) is a system that will use Variable Message Signal (VMS) and other methods, including radios and phones, to provide dynamic information on parking within the controlled areas to the patrons [5]. These systems combine traffic monitoring, communication and other technologies to provide the service [6]. With the aid of these parking systems, it can help to enhance many highway authority policy objectives to develop safety, efficiency and environmentally friendly transportation network [7]. Other than that, the image-based parking system introduces image processing techniques to extract the vehicle number from digital images. When the vehicle arrived at the barrier of the parking area, the sensor will automatically register the car plate number and then stores the data into the cloud database. The database helps to update the vacancy status of the parking system automatically [9].

However, the Electronic Parking System (EPS) uses the antenna to read the number of In-vehicle Unit (IU) at the entry and exit of the car park [10]. It allows users to make reservations through calls, SMS or online applications for the parking space that is being detected as a vacancy slot. The transit-

based information system is a system that helps to provide the patron with real-time information on the parking slot, road traffic condition as well as the schedule of public transportation [11]. The primary purpose of this system is to encourage citizens to use public transport by providing them with a place to park their vehicles and make use of public transportation[12]. Lastly, the wireless parking system used the component such as light sensor, temperature sensor and acoustic sensor to send the information data to an online database server which can produce real-time information of the availability of the parking [13]. For transmission of the data from the wireless sensor, the transceiver is used to send and read the information from the transponder unit.

2.1 Type of Vehicle Detection Sensor

The vehicle detection system, as a real-time scene, plays a significant role in the smart parking system to provide a clear statement. In the detection technology, the model of detectors is differentiated into two types, namely, the vision-based method and the sensor-based method. In the vision-based method, the mode of detection is more toward the image processing techniques with the aid of the camera. The sensor-based detection methods can be said to be intrusive or non-intrusive sensors [14].

Based on the research conducted by Sabbea, M. O. B. (2017), [15] ultrasonic sensors will transmit sound waves between 25 kHz and 50 kHz. It used reflected sound energy to study and detect the status of a parking space. This researcher claimed that the ultrasonic sensor brings some limitations on particular sensitivity to temperature changes and extreme air turbulence. Kianpisheh, A., Mustaffa N., Limtrairut P., & Keikhosrokiani, P. (2012), [16] proved that the ultrasonic sensors depend on sound instead of light and they work much better in the outdoor environment. However, the working principles of the IR sensor are to transmit the modulated infra-red signal to sense the presence of the vehicle. Despite the simplicity and low cost, the IR sensor does bring some disadvantages of overcrowded and rowdy environment will restraint its functionality. As compared to the surveillance camera, the IR sensor will consume less memory [17].

Besides, with the aid of video camera sensors in SPS is a high-cost sensor that can ease the collection of parking information in the vehicle parking field. It can generate a large amount of data information that difficult to transmit in the wireless network [18]. Based on the research of [19], they employed the vision-based method with the use of surveillance cameras, by implementing the techniques of image processing to determine the vacancy of vehicles in parking. Both of the Prewitt edge detection or the density of the grayscale is found out that it is lack accuracy due to some problems such as indoor and outdoor environments, shadows effects and distortion effects.

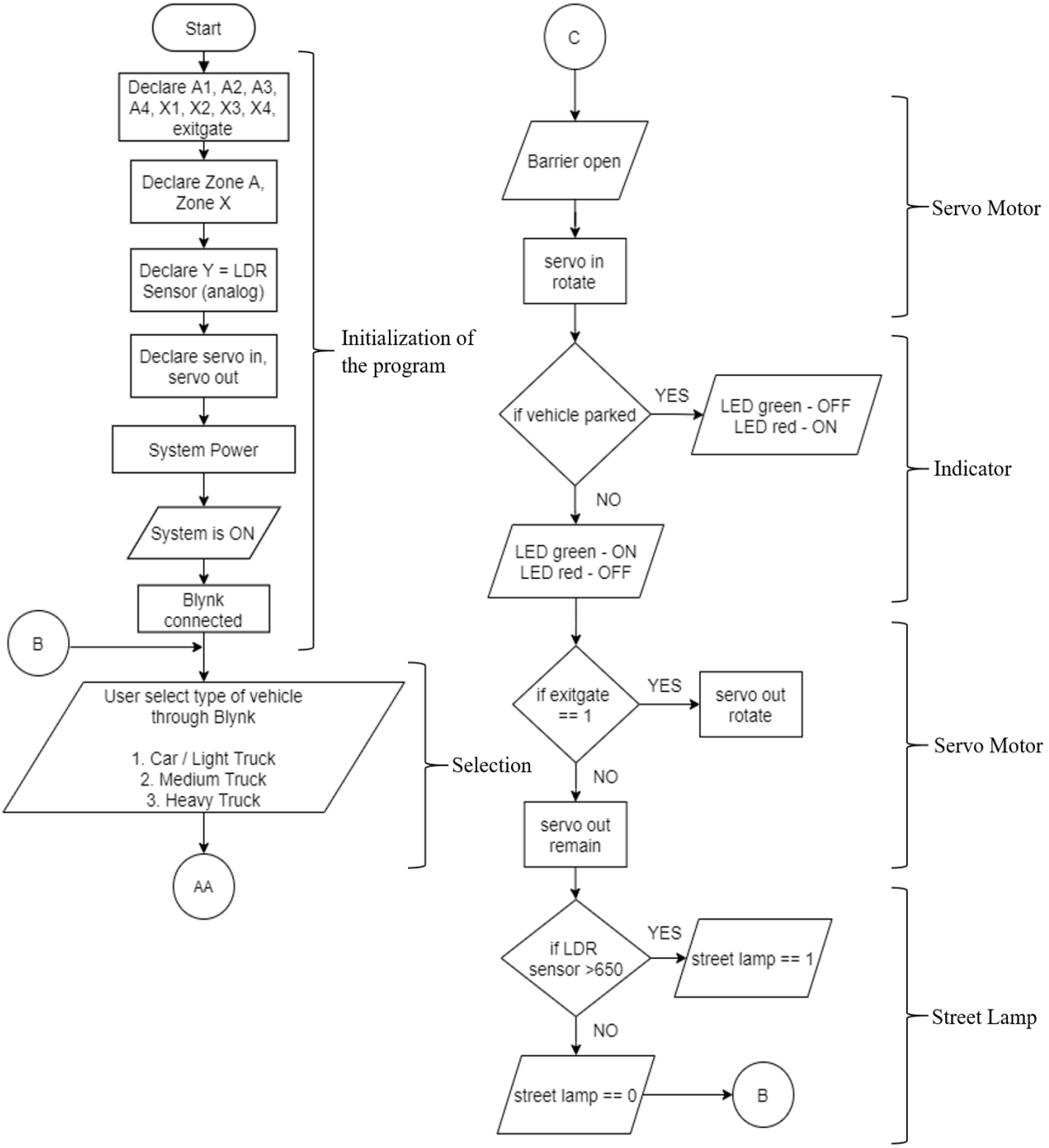
Furthermore, the other researcher claimed that the installation of the RFID to the parking slot would increase the ease of data collection that can be used for the analysis process [20]. The location is the primary concern of this implementation as it requires a lot of studies to place the RFID tag so that it can obtain the result with high accuracy. Besides, the weight detection system can be implemented in the SPS which is mainly used to count and classify the type of vehicles. The weight detection system makes use of a piezoelectric sensor placed through the road. However, it is extremely imprecise in the presence of heavy vehicles. There are no additional components for the application of these sensors, thus making it expensive [21].

The light-dependent resistor works based on the shadow detection method. The resistance of the LDR sensor module is as high as 1 Mohms. Whenever there is the presence of light, it faced a drastic drop in its resistance [22]. For instance, when the vehicle is parked at the slot, it will overlap the contact of the light with the sensor's surface aperture, creating a shadowing effect proposed by the previous researcher. The LDR sensor is more reliable and consumes less memory than the other sensor. The deployment cost of this sensor is affordable [23].

3. Methodology

3.1 Flowchart

The flowchart of the entire proposed project smart multi-vehicle parking system's algorithm is as shown in Figure 1. The purpose of constructing the flowchart is to show the step-by-step tactic of the program task. The declaration of the variables is highly important in order for the program to understand each representative used in the algorithm. The input representative shape used in the flowchart is to enable the user to do types of selection of vehicles on the given system. Therefore, the decision procedure uses the do-while loop to check the user's input whether it is fulfilling the given condition.



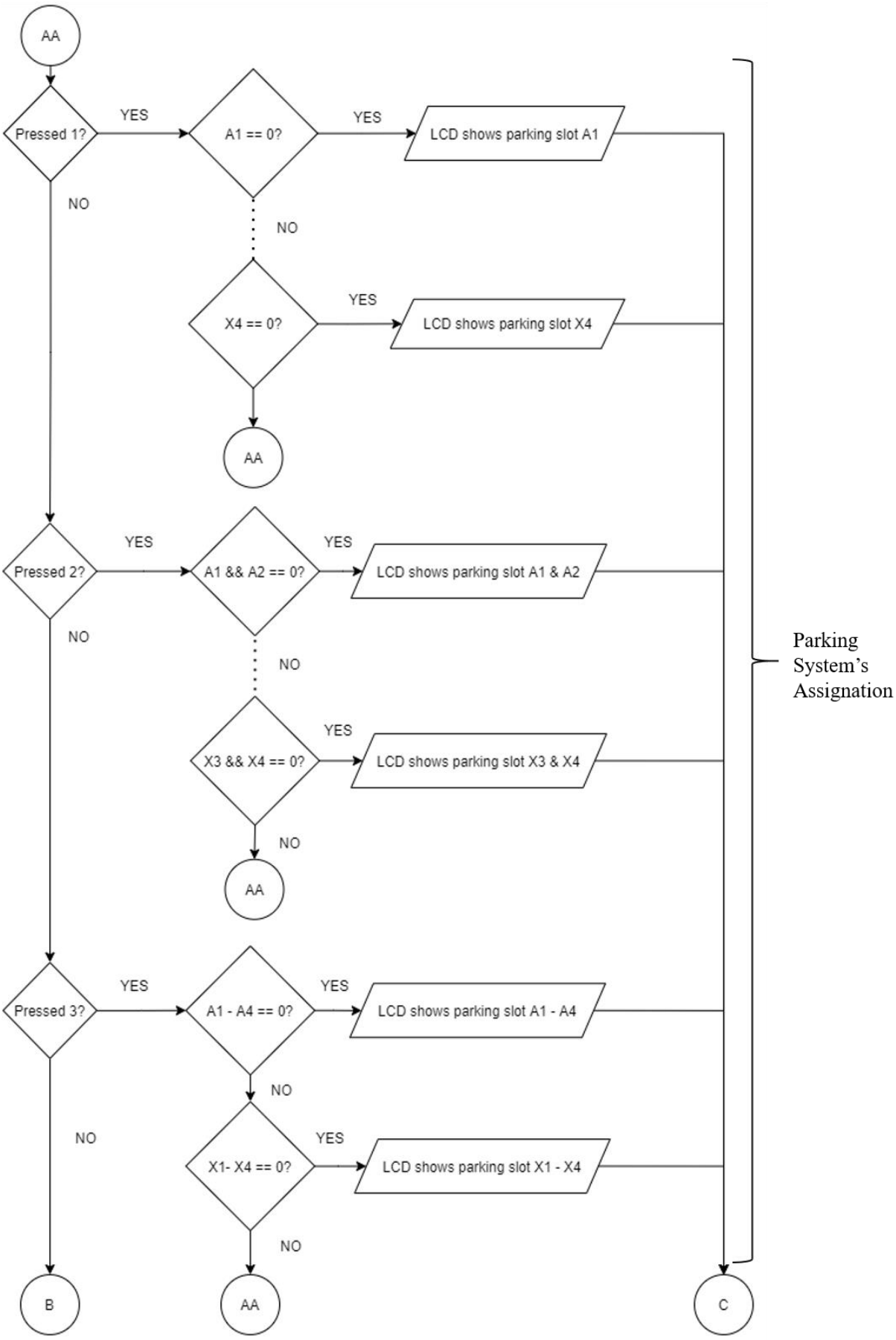


Figure 1: Flowchart of the smart multi-vehicle parking system

3.2 Block Diagram

With the aid of the block diagram as shown in Figure 2, it illustrates the interconnection between the subsystem used in the parking system. It is classified into 2 sections which are vehicle detection, and the other is sending real-time information. The vehicle detection involves the Arduino Mega 2560, LDR sensor module and LED indicators. Followed by the second part of the block diagram, the real-time information needs to equip the hardware component of ESP8266-01 and the Blynk application.

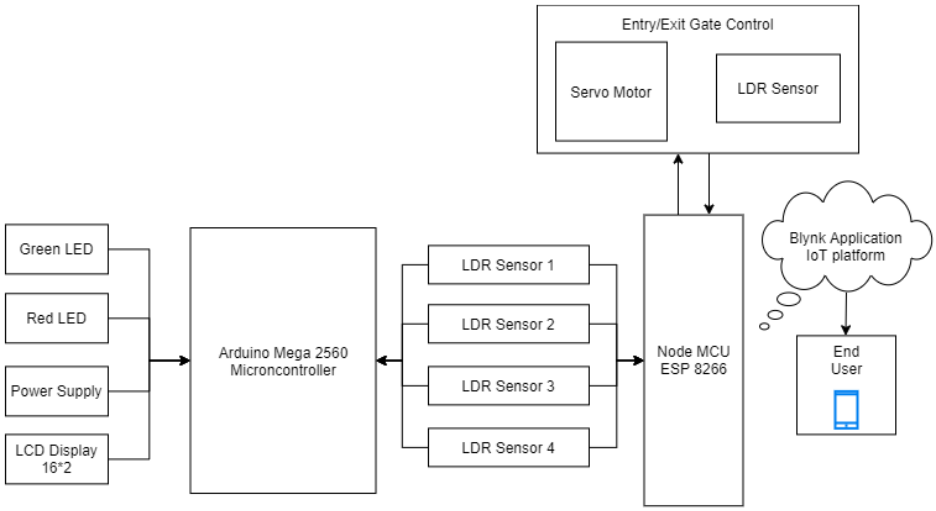


Figure 2: Block diagram of the project

3.3 Working Principles

In this project, the parking system allows multiple types of vehicles to park in. The system will start with the vehicle's classifications which are divided into 3 subcategories that according to the size and gross vehicle weight rating of the car, truck and other types of vehicles. As shown in Figure 3, a car and light truck or van will be stated as one group. Meanwhile, the categorize of the medium vehicle is starting from 7.5 tons to 25 tons, for example, transit bus, box truck, flatbed truck and much more. For the vehicles which are over 30 tons that will be considered as heavy vehicles as they need a larger parking area.

Size of vehicle (ft / weight)	Type of vehicle	Amount of car can fit in entire zone
Car, Light Truck / Van (11 – 15.8 ft / 1.5 – 2 Tons)		4
Medium Vehicle (16.8 – 23 ft / 7.5 – 25 Tons)		2
Heavy Vehicle (48.5 – 65 ft / 30 – 60 Tons)		1

Figure 3: Classification of vehicle

3.4 Truth Table

The outcome of each slot in the parking area is as shown in Table 1. For instance, if slot 1 until slot 4 still has a vacancy, the output will remain as 0, else the output will be 1. However, when slot 1 until slot 4 is fully occupied, it can be fulfilled by either 4 light vehicles or 1 medium vehicle and 1 light vehicle. Yet, the full zone can have the probability of 1 heavy vehicle being parked. The place for the heavy vehicle is available only when the entire zone, slot 1 until slot 4 is on vacancy.

Table 1: Truth table of the parking system

Slot 1	Slot 2	Slot 3	Slot 4	Output (AND Gate)
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

3.5 Bill of Material

The total cost of this product prototype is accounted for RM 216.20. The components and other related materials are listed in Table 2.

Table 2: Bill of Material and Project Cost Summary

Component	Quantity	Unit Cost (RM)	Cumulative Cost (RM)
1. Arduino Mega 2560 + USB cable	1	42.50	42.50
2. ESP8266-01 + serial adapter	1	18.30	18.30
3. LDR Module	10	2.50	25.00
4. Breadboard	2	8.00	16.00
5. Miscellaneous (jumper wire, led, capacitor, resistor, Strip Board)	N/A	N/A	98.70
6. Servo Motor	1	7.10	7.10
7. LCD (20*4) with I2C	1	8.60	8.60
		Total (RM)	216.20

4. Results and Discussion

4.1 Development of Communication Platform

The ability of the system to communicate with each other is important throughout the entire system as it delivers data over a network between hardware and software. Before start using the ESP8266-01

board, it needs to check the default version running on the ESP8266-01. First of all, connect the ESP8266-01 board to the USB to the ESP8266-01 serial port shield adapter. Then, connect it to the computer and check the connected port via the device manager of the computer. Some of the settings need to be set such as change "No Line Ending" to "Both NL & CL" and the baud rate is 115200. "AT" is typed in the command line. "OK" will be replied and displayed at the serial monitor, this indicates that ESP8266-01 can communicate in 115200 bauds. "AT+GMR" is typed to check the version of the ESP8266-01. After that, the new firmware has been successfully uploaded, the result of the AT firmware version is 1.6.0.0 and the SDK version is 2.2.0 as shown in Figure 4.

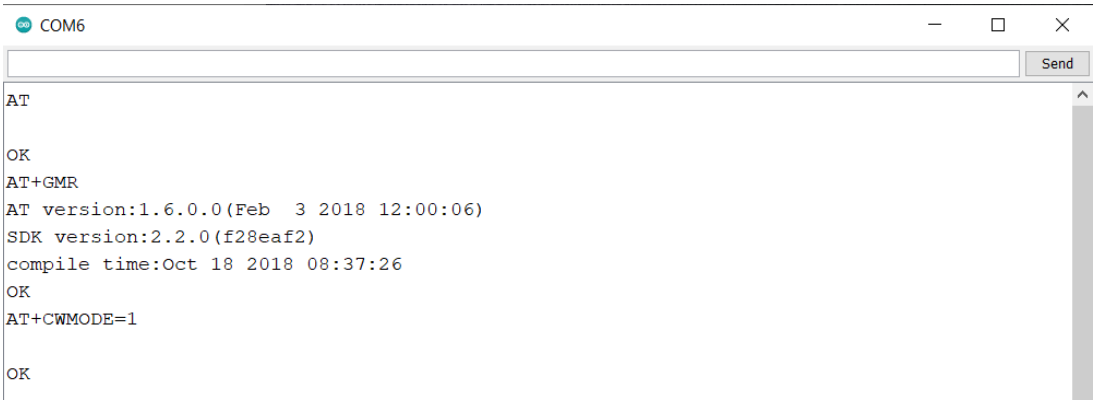


Figure 4: Check the firmware that uploaded to the board using the serial monitor

4.2 Development of the LDR sensor module

In the system, each of the sensors will be placed respectively at the parking slots, weather detection and the exit gate as shown in Figure 5. The digital output of the LDR sensor will make use in the parking slot and the exit gate, whereas the sensor in the weather detection house will use the analog output. Thereby, when the digital output sensor had reached a certain threshold level, it will indicate the presence of the vehicle due to no light received. The sensor in the parking slots are limited to a 5cm sensing range, thus the system will detect accurately any vacant space. After the Arduino Mega had received the information from the sensor, it will send it to the Blynk cloud so that the application can display an exact output throughout the system.

Figure 5: LDR sensor module mounted at parking slot, weather station and gate

The feature of weather detection is used to detect the cloudiness of the parking area so that the smart streetlamp will turn on according to the set LDR resistance. The suitable threshold value of the LDR resistance has been studied and monitored in real-time for 7 days. The monitoring process is undergone

by placed the LDR sensor from 6 a.m. until 9 p.m. in the garage of the house. The collected data has been plotted on the graph as shown in Figure 6. The horizontal axis of the graph in Figure 6 represents the time in 24-hour format, whereas the vertical axis represents the resistance of the LDR sensor. By conducting the real-time data collection, some investigation has been implemented and it found out that the best threshold value for the resistance of the LDR sensor is at 880. As the LDR sensor goes toward the value of 880, the smart streetlamp at the parking area will automatically turn on to maintain the operation on the parking areas.

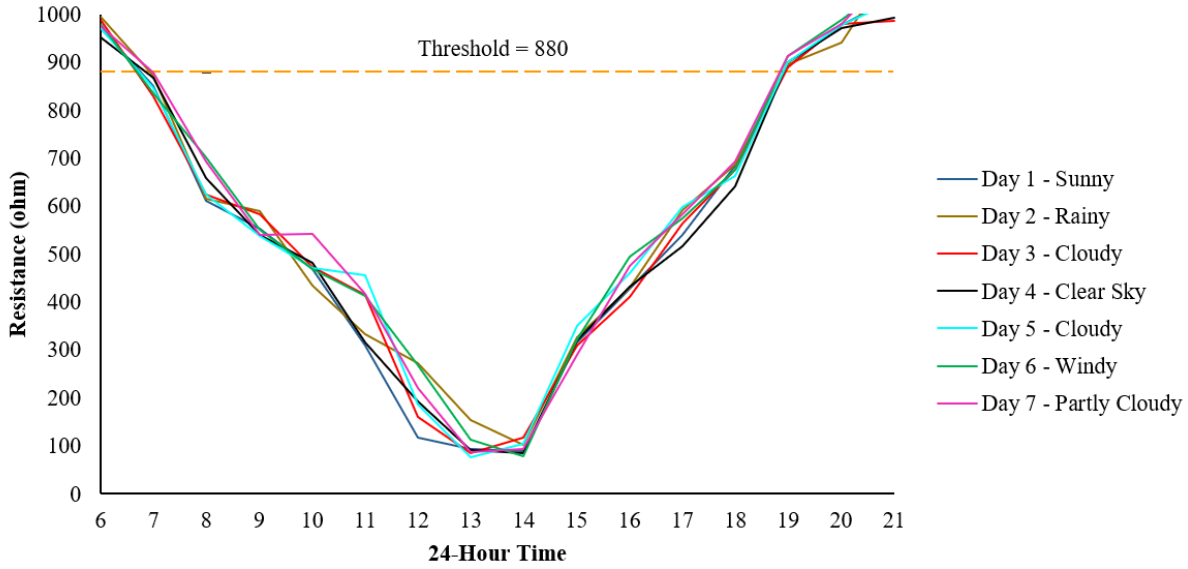


Figure 6: Real-time data collection of LDR sensor for the weather station

4.3 Development of LCD (20x4) and LED

The display system is used to show all the data which includes the real-time parking types of information and the confirmation message as shown in Figure 7 and Figure 8. The messages are the main item throughout the entire system which can help to enhance the user's parking searching experience. As in Figure 8, the last row of the LCD will vary and update instantly to display which parking types are currently available. Hence, it will be known which types of vehicles would have their parking instead of showing which slots are available. As shown in Figure 9, the LED indicator will be placed above the parking slot to indicate the availability of the parking space. Each pair of indicators will have a green and red LED. When the green LED is lighted, then the parking space is available to park for the assigned vehicle. the smart streetlamp will be implemented to support the parking system to work when the resistance of the LDR sensor goes beyond 880.

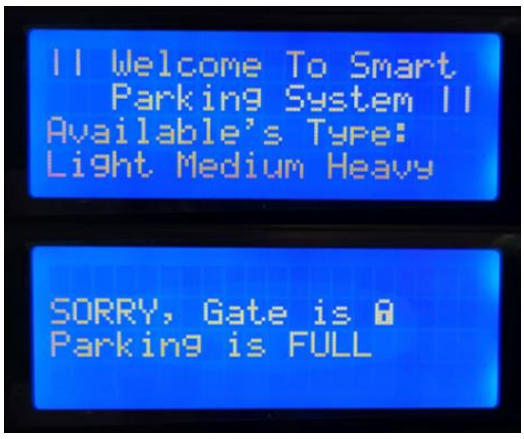


Figure 7: The main display of the system during available and fully occupied

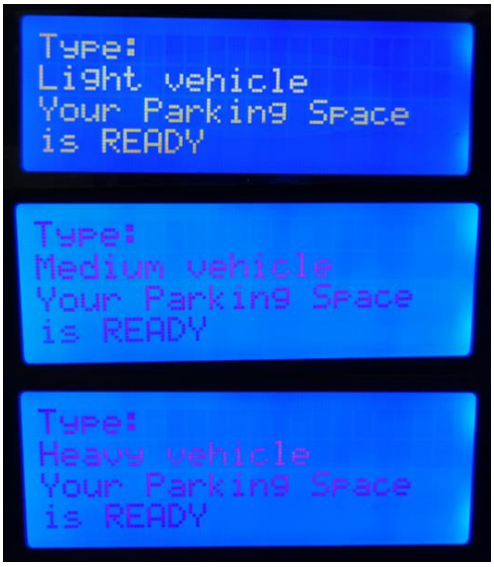


Figure 8: The confirmation message after the users have made the selection

Figure 9: Indicators and streetlamp

4.4 Development of Blynk application and shared access

The Blynk clouds technology allows the automated sharing of information on spots availability with the parkers and efficient parking space utilization. In the Blynk application, there are 4 widgets used which are LCD and buttons. When the Blynk application is successfully connected as shown in Figure 10, the users are allowed to choose their vehicle types. Both of the hardware components and Blynk applications are needed to connect with the same Wi-Fi in order to communicate with each other.

```
[9]
    ___  __          __
   / _ )/ /_ _____  / /__
  / _  / / // / _ \/  '_/
 /____/_/\_, /_//_/_/\_\
        /___/ v0.6.1 on Arduino Mega

[100] Con2:HUAWEI nova 5T
[6703] WIFI CONNECTED
AT version:1.6.0.0(Feb  3 2018 12:00:06)
SDK version:2.2.0(f28eaf2)
compile time:Oct 18 2018 08:37:26
OK
[14415] IP = +CIPSTA:ip:"192.168.43.81"
+CIPSTA:gateway:"192.168.43.1"
+CIPSTA:netmask:"255.255.255.0"
[14458] WOK
[25451] Ready (ping: 762ms).
```

Figure 10: ESP8266-01 is connected to Wi-Fi and Blynk application is ready to use

In the interface of the Blynk application, the buttons are used as the selection of the vehicle's type, which are a light vehicle, medium vehicle and heavy vehicle. All of the buttons will set as push-button

instead of a switch because the selection of the user does not need to stay in a set state. When there is no user's input to the system, the LCD will switch between the 2 messages as shown in Figure 11. The relevant information will show on the display after the user had made their selection through the system as shown in Figure 12. The parking type will always display on the LCD according to the available space in the system. In Figure 13, it indicates the parking space is fully occupied and is unavailable for the user. Thus, this clear statement can help to enhance the user's experience in this parking system.

Figure 11: Main screen of the system in Blynk application

Figure 12: Result of the respective selection

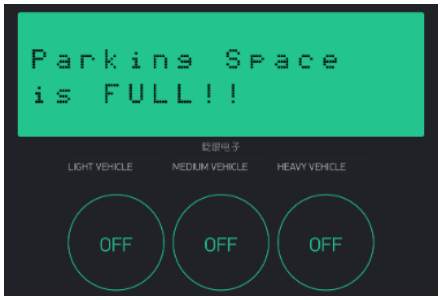


Figure 13: Display screen when the parking space is full

These shareable features can allow the customers to use the application and select their types of vehicles when arriving at the entrance gate. Other than that, the application brings convenience to the user as they can view the information of the availability on types of parking space from distant. The QR code given in Figure 14 is used to log in to the parking system application for free. Thus, this application of the system makes the customer easy to use and enhances the overall performance of the entire parking system.

Figure 14: QR code for the parking system

5. Conclusion

The prototype for a smart multi-vehicle parking system has been developed successfully. All of the stated objectives have been achieved throughout the entire project. The system used a simple mobile application, Blynk as a connection platform which allows user to select their vehicle types and allow real-time parking information. The parking system provides a QR code for the user to easily get access to the Blynk interface. Each slot of this parking system is equipped with an LDR sensor to enable the detection system. For more accurate detection for the parking system, the sensing range for the parking slot is within 5 cm, else the precision of the detection will be reduced. For the implementation of the smart streetlight in the parking area, it helps to enhance the overall performance of the system during a dark environment. Lastly, the rearrangement of the coding has slightly sped up the program on the detection and assignation parking system.

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