A cloud-based automated parking system for smart campus

IOP Conf. Series: Materials Science and Engineering **767** (2020) 012049 doi:10.1088/1757-899X/767/1/012049

A cloud-based automated parking system for smart campus

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Abstract. Finding a vacant parking space is becoming a real problem especially in areas with limited parking spots such as airports, shopping centres, offices, as well as universities. Searching for available parking slots is normally time consuming and always results in frustration especially when time is the major constraints. Moreover, vacant parking is hard to be noticed due to unsystematic parking system. This will result in longer searching time which can also lead to traffic congestion. In addition, lack of security enforcement on cars entering universities campus is also one of the main issues contributing to insufficient parking spaces. This might cause some unauthorized cars to take opportunity to get inside the campus without any approval and consent from security department. Therefore, A Cloud-based Automated Parking System for Smart Campus is developed in this project. It consists of a sub-system that is developed to display availability number of parking slots so that it will assist authorize users to easily find their parking spots. The proposed system can also recognize car plate number through Automated Car Plate Recognition (ACPR) mechanism which is located at the campus main entrance gate to avoid unauthorized cars from getting in. This has strengthened security level inside campus and ensure the safety of students and staffs. All the information collected are sent into the cloud and stored inside a database system. The information regarding vacant parking can also be displayed using the developed mobile apps.

1. Introduction

Rapid development in smart cities leads to the realization of many innovations that spans across wide varieties of sectors and societies. One of the dominant applications include smart parking system which taken into consideration the mechanism of finding available parking spots. The development of smart parking involves the integration of various sensors and microprocessors to assist real-time parking information updates and systematic management system. The idea of smart parking is triggered by the common difficulties in finding vacant spot especially in crowded area in cities, shopping centres and universities. Finding a vacant parking spot can be troublesome especially in a hurry situation.

In this project, we narrow down our focus to develop a smart and automatic parking system for Smart Campus which is part of Smart City development. In this project, a smart parking system is developed to provide fast and accurate real-time parking information to drivers (students, staff, visitors) even before they arrive at their destination. The aim of this project is to provide convenient parking system, as well as making parking more easy, faster to be found and thus, less stressful.

This project is developed as part of Smart Campus realization with the purpose to lessen the use of manpower with the help of electronic devices to provide an efficient parking management system. Smart Campus is aimed to achieve a remarkable reduction in energy consumption. It has been introduced in

different areas inside campus, including the smart watering system, smart electric usage control, air quality control, smart parking system and other as shown in figure 1. Smart Campus can also enable the realization of Green Campus, which is based on the concept of energy saving. As an example, if the sensor detects no human presence, electricity will be automatically turn off to save energy and cost.

Figure 1. Smart Campus facilities [1].

Considering the significance of having an efficient parking system, this project emphasises on implementation of Smart Parking system in Smart Campus. Various types of electronic sensors are used in this project to monitor and guide users to identify the number of available parking slots in the campus. In addition to provide convenience and accurate parking information to users, the development of this smart parking also facilitates to solve security issue by enabling recognition of authorize and unauthorized vehicles.

Smart parking system in this project is designed to solve the ever increasing difficulties in finding available parking slots in campus. Due to limited spaces, available parking slots are hard to be noticed or found in campus. This is especially true throughout semesters where students and staff are rushing for class and available parking are hard to be found near facilities. Moreover, when parking area is almost full of cars, free parking spots are becoming harder to be noticed, making it more time consuming for drivers. In this case, drivers need longer time to search for the available parking slots.

Another common problem in campus is difficulties in recognizing unauthorized visitors. Until recently, most security inspection on cars entering any campus are done manually by security guards. Security guards may inspect passengers individually or just checking the car stickers whether they are belong to the university or not. Upon inspection, if they neither staff nor students, visitors' identification will be manually recorded on papers. The obvious problem with this manual inspection and recording is visitors' ID may be impersonated. This might be difficult to manually identify the authorized and unauthorized vehicles and caused them to take opportunity to get inside without the approval and the consent from security department. In addition, jotting down the car plate number and visitor ID will not solve the unauthorized visitors since it is almost impossible for the security guards to manually and compare with previous records (if there is any). Moreover, authorize car stickers can be simply stick onto cars by unauthorized visitors, which could be worsening the situation. For instance, many theft of equipment inside campus is a major problem that might be done by unauthorized visitors. These problems are hence becoming the matter of utmost importance in developing smart campus and thus require efficient solution. Therefore, in order to prevent any undesirable circumstances, a smart parking system need to be developed.

2. Objective

The main objective of this project are as follows:

- To develop a smart parking system that can detect vehicle occupancy and management of parking slots.

In order to solve the aforementioned problems, the Smart Parking system proposed in this project can assist users in two aspects. Upon arriving at university's main gate, drivers (staff, students or visitors) will be provided with information on numbers of available parking slots. This information will be displayed at the LCD screen near the main gate. For convenient purposes, this information can also be accessed through their mobile apps (for students and staff only). In addition, once drivers reach the parking compound, there is also an on-spot display at the parking area. The mobile phone application enables immediate information to disseminated about the available parking slots before they arrive at the parking area. User can choose not to install the mobile application as there is also an on-spot display that is installed at the main gate entrance on campus. Not only that this will reduce fuel consumption, but also air pollution, in accordance with providing smart campus.

- To increase security and safety level in smart campus.
  To increase the campus security level and cater the problem of unauthorized visitors, an Automatic Car Plate Recognition system is built. This part of the system is designed to prevent unauthorized cars entering campus without approval from security department.

The Automated Parking System for Smart Campus in this project is integrated with Internet of Things (IoT) that allows physical devices which are embedded with electronic components like sensors or software to collect and exchange data through internet. Various sensors are used to record the information of environment and sent to cloud for storage purpose. Information that are stored in cloud is then shared to the user through Graphical User Interface (GUI) which is either Android-based GUI or website-based GUI. Users can also send the data from GUI to cloud for certain purpose such as reservation of free parking slots. Thus, information exchange between devices and cloud through internet will take place.

3. Related Work

Research on developing a smart parking system have attracted significant attention from researchers as part of the efforts in developing smart cities. Most of the smart parking systems found in literature are based on RFID, WSN, Bluetooth, Wi-Fi and Zigbee.

3.1 Available parking information

Aydin et al., 2017 [1] had developed a system that can navigate users to the nearest free parking slots. This system also allows users to do reservation of free parking slot before they arrived at the parking area. This method consists of two parts. First part is related to the method of sending real time parking slots updates to internet. Second part concerns on the detection and determination of the nearest empty parking slots. A parking sensor is installed to send the parking status to a gateway, and this parking sensor send data by using 802.15.4 transceiver. GPS module is also used to find nearest empty parking slot with the help of the genetic algorithm.

Another smart parking system is proposed by Wang et al., 2017 [2] which adopts framework of cloud computing and Internet of Things. This proposed system is divided into four levels which are parking application, internet, devices and Internet of things platform levels. All data collected from sensors and other electronic devices are sent into cloud using Arm-based microcontroller. This system is able to point out the shortest and optimal path for user to the parking spots. LED indicators, zone controllers, signs and vehicle detectors are used to help the vehicle drives to quickly find the empty parking slots.

Moreover, few detection sensors are also deployed such as camera based detector, magnetic sensor, infrared based detector and ultrasonic sensor.

An E-parking system has been developed by P. Sadhukhan, 2017 [3]. This system is built up using various types of electronic components like ultrasonic sensor, alarm IC module and different type of software algorithm like Central Parking Management System (CPMS). Same like the other smart parking system, this system allows drivers to obtain information regarding the free parking slots. Not only that, it is also equipped with an integrated component called parking meter that can estimate the duration of the parking lots is occupied. R. Grodi et al., 2016, [4] also introduced a smart parking system that is similar with previous system. However, this new system will update users with real-time information through its website or mobile application. *Node.js* is used to set up a web server so that customer can obtain the parking information from any of their smart devices. Fang and et al., 2017, [5] also introduced a system that is using the similar concept with Grodi et al., 2016 [4].

3.2 Automatic Car Plate Recognition System

In order to allow only authorized users to enter campus and control/manage the access of unauthorized ones, Automatic Car Plate Recognition (ACPR) could be one of the necessary methods that can be implemented. Several related papers have been found and can be divided into two parts which are traditional method and the android platform method. S. H. M. Kasaei and S. M. M. Kasaei, 2011 [6] proposed an ACPR system that not only can recognize the car plate, but can also recognize motorcycle plate number. In this system, one new improvement is made as compare to other ACPR system is that the dilation operator is implemented. Dilation operator is able to separate characters even when they are too close to each other. After dilation operation, template matching will be carried on with all the characters that are stored inside a database.

An ACPR system is also introduced in the Android-based platform. According to Mutholib et al., 2012 [7] a Graphical User Interface (GUI) is possible to build up to capture image of car plate by using the built-in camera of a smart phone. After the image is captured, the pre-processing of enhancing, filtering and straightening the raw image is done. Optical Character Recognition (OCR) is used to extract texts and numbers from the car plate through neutral network. This system is tested on Malaysia's car plate. Its segmentation of characters able to get the accuracy of 83.5% and recognizing unit able to achieve 92% accuracy and this provide an 88% of great performance for the overall system on the recognition rates.

Based on literature, there are 4 steps in implementing ACPR; (i) capture the car number plate in colour, (ii) process the image into grey scale, (iii) process the grey-scale image into binary image (iv) compare with characters that are stored inside database.

4. Proposed System

A smart parking system in this project can be divided into two parts: (i) available parking detection and notification (ii) secure authorization through Automatic Car Plate Recognition (ACPR). This section presents the details of system overview and illustrates design. Brief introduction on this project will also being carried out in this section.

The overall system overview is as shown in the figure 2 while the prototype of the system is as shown in the figure 3(a) and figure 3(b). The system is consisting of two main parts: (i) the main entrance gate and (ii) the parking compound. At the main gate entrance, an ultrasonic sensor is installed to sense the presence of cars, whereby upon detection of any vehicle, the camera which are placed at an appropriate position will capture the image of the incoming cars for recognition. When the ultrasonic sensor sense any car existence at the main gate, microcontroller will give instruction to turn on the camera for recognition and authorization purposes.

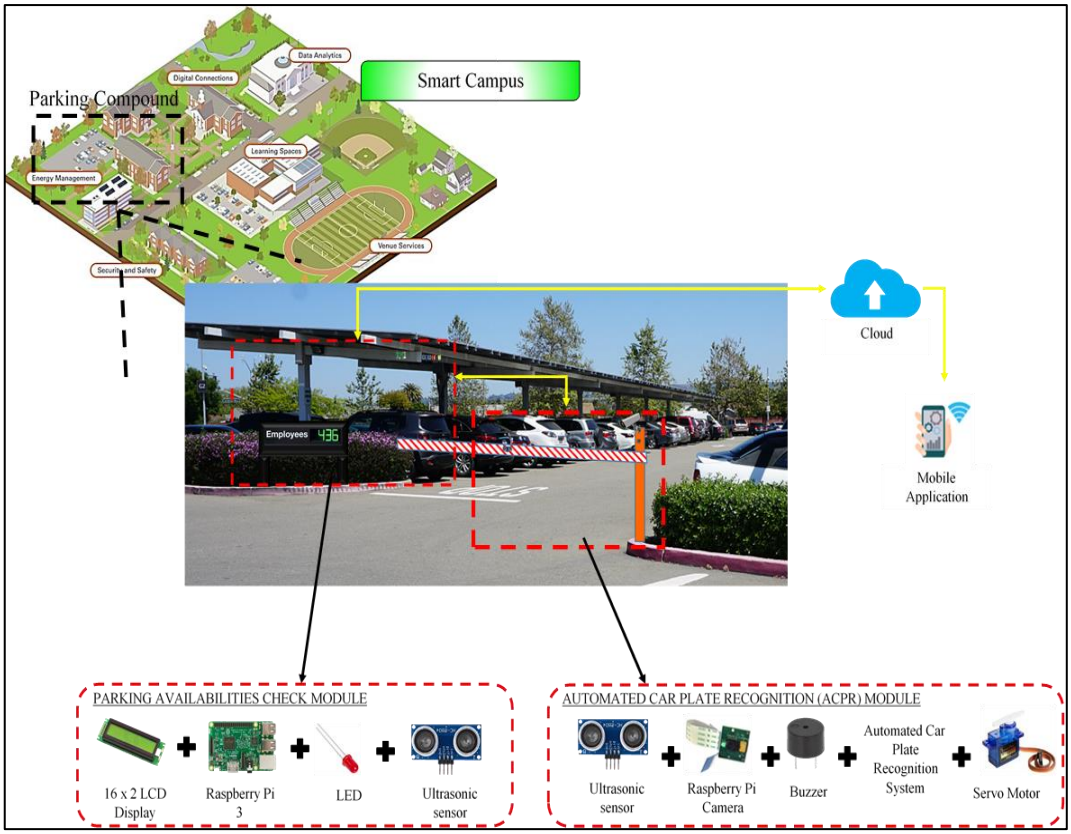

Figure 2. Smart Parking System Design.

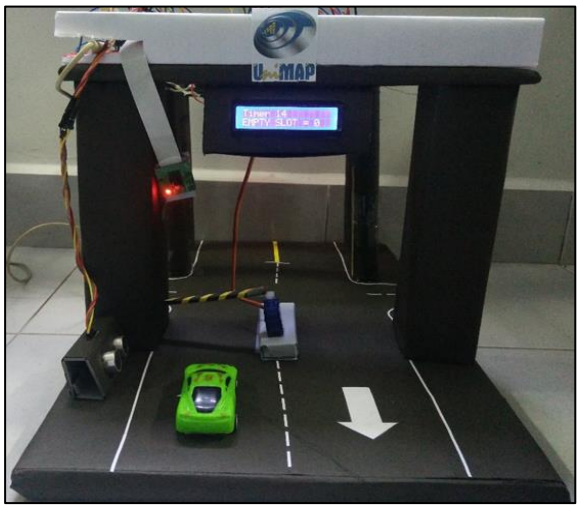

Figure 3(a). Front view of prototype.

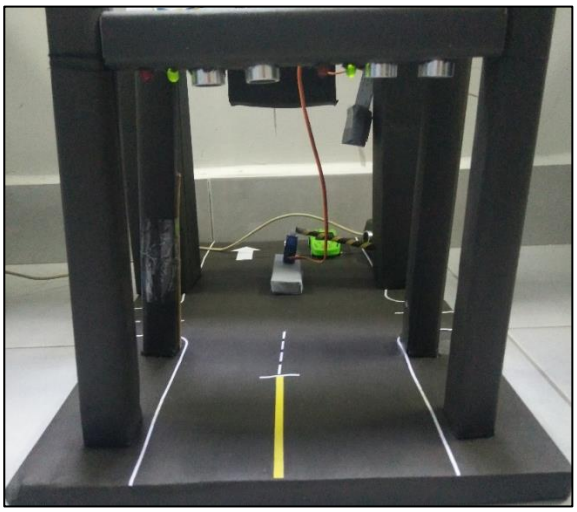

Figure 3(b). Back view of prototype.

After the image is captured, the Raspberry pi which is the microcontroller will collect the information and send it into Firebase which acts as a Cloud and database in this system. The Cloud will store the information sent by the microcontroller which will then perform data comparison with the existing car plate numbers that are already stored beforehand by the authority. After the comparison is completed, the microcontroller will instruct gate to be opened if car plate number is matching the one in the database.

On the other hand, the gate will remain close if the system fails to identify the matching car plate number. Security units will then act to check and record the visitor's ID and the purposes of visiting for security purposes.

Next, to collect information about the available parking spots, ultrasonic sensors are placed above each of the parking slot. The sensors send the information about the empty slots to the microcontroller (Raspberry pi) which will in turn calculate the total empty spaces. The LCD screen that is placed at the main gate entrance will then be updated with the latest number of empty parking slot. Information of empty parking slot is also being updated into the Firebase cloud. Users can also access the updated information regarding the remaining parking spots when they are not in the parking area through mobile application that has been developed. The overall structure of Cloud-based Automated Parking System is as illustrated in Figure 4. This project involves 4 stages.

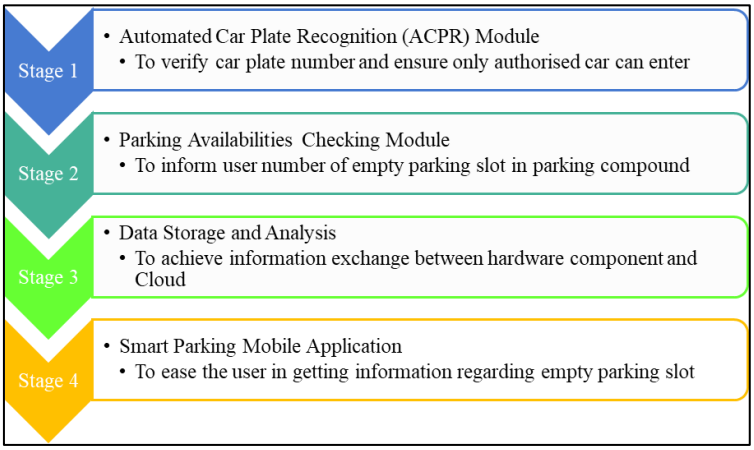

Figure 4. Overall Structure of system.

4.1 Stage 1: Automated Car Plate Recognition (ACPR) Module

This stage consists of Automated Car Plate Recognition (ACPR) System which is made up of Raspberry pi as microcontroller, camera, ultrasonic sensor and servo motor. The flow of ACPR process can be found in figure 5. An ACPR system is implemented by connecting the system to camera to fulfil the requirement of capturing and recognizing the car plate number. This system captures any car plate number from the car that is in the range of camera capturing area. The system will then process the image captured to obtain the car plate number. This is done by comparing the captured car plate number with the information stored in pre-defined database which is developed to record all the car plate numbers of all staff and students in campus.

In this module, a servo motor helps to open and close the main gate entrance. The servo motor is connected to the ACPR system to control the in and out of visiting cars. Few conditions have been set for that purpose. For instance, the system will only allow a car to enter the campus when the captured image of car plate number matches with the registered car plate number inside the database. If the car plate number matches the one inside the database, the entrance gate will be opened, and the car will be allowed to enter the campus compound. If the car plate number is not available inside the database, the entrance gate will not lift up to prevent the user from entering the campus and the buzzer will be turned on to warn and inform security for unauthorized incoming car. This system will then go back to initial state to stand-by for next car arrival. In this case, Raspberry pi is used to send information and control the pre-defined condition. This module increases the security level of campus by avoiding any unauthorised cars from entering the campus compound. Indirectly, it also ensures the safety of students and staffs.

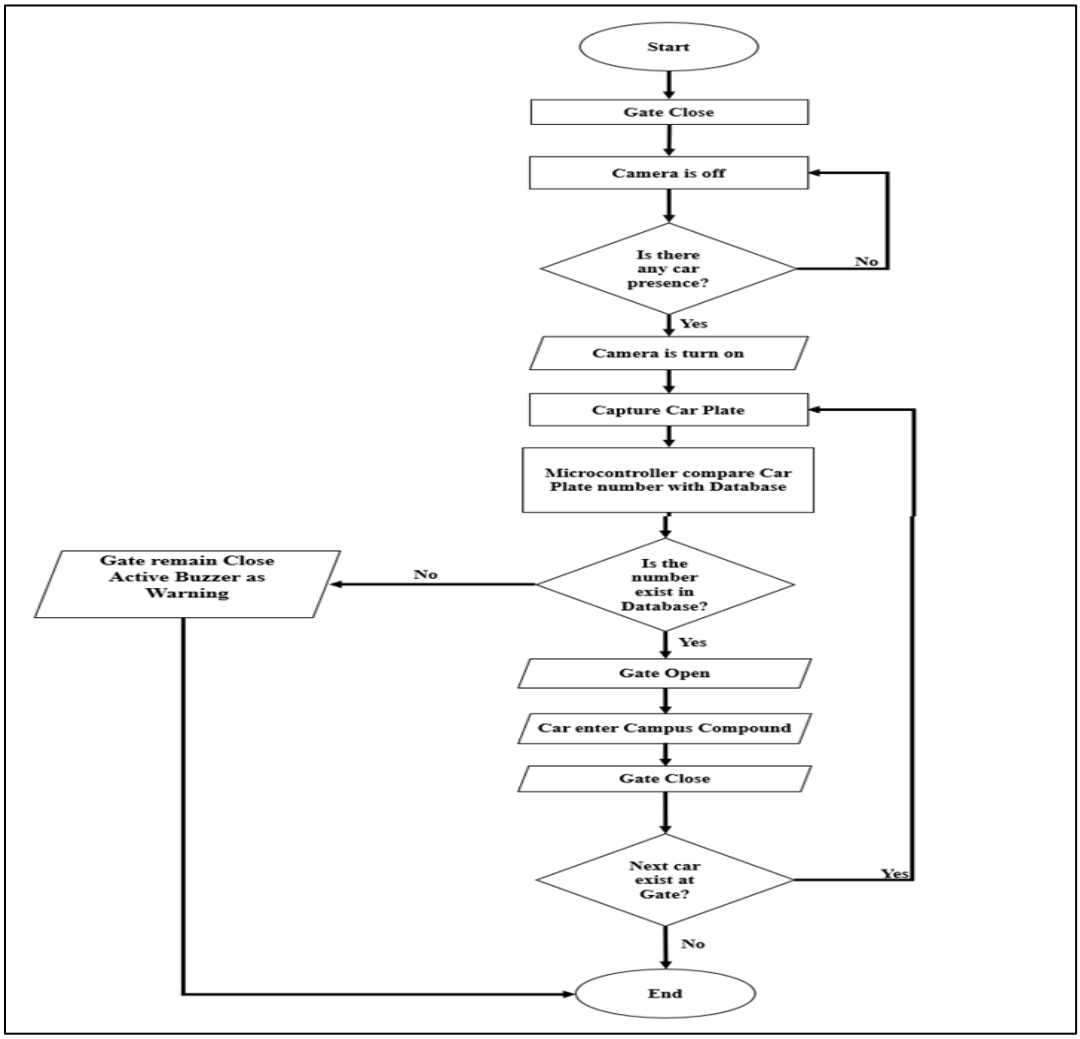

Figure 5. Flow chart for Automate Car Plate Recognition (ACPR) Module.

4.2 Stage 2: Parking Availabilities Checking Module

This stage consists of the process of checking out the available spaces for the parking compound. Several ultrasonic sensors are installed at the parking area to sense the presence of cars and empty spaces. This system provides real time information updates about the parking slot availability. The information is then sent to the Raspberry pi for processing and determination of vacant parking slots. The parking slot information is conveyed to users in two ways, which is through the LCD screen at the main gate and through mobile application (need to be installed by users). The information displayed can be used by users to plan where to park before arriving at the parking compound. Using this method, users can save time searching for available parking slots.

If there is any empty slot available, the microcontroller give instruction to LCD screen to update the number of availabilities. Green LED at specific empty parking slot will light up and numbers of availabilities in Smart Parking System application will also be updated. However, if there is no available parking slot inside the parking compound, the microcontroller will give instruction to LCD screen to display “Empty Slot: 0”, and red LEDs at parking slot will light up and numbers of availabilities in Smart Parking System application will be updated to “0”. The system will continue to check for any update in the parking availabilities. If there is any car leaving or incoming, the ultrasonic will immediately update the information to microcontroller which will then send updates to the cloud. If any car is leaving, the microcontroller will give instruction to LCD screen to update to the latest number of

available parking slots, red LED is turned off and green LED of a particular empty slot will be lighted up. The number of availabilities parking slots is also being updated inside the Smart Parking System application. Despite that, the number of availabilities of empty parking slots will remain the same in both LCD screen and Smart Parking System application if no car is leaving the parking compound.

4.3 Stage 3: Data Storage and Analysis

As mentioned in Stage 1 and Stage 2, all the collected information are sent to cloud interface (Firebase) for information storage and analysis purposes. Few information about staffs' and students' cars are also be registered or stored before-hand inside the cloud system for the data comparing purposes. This information can be easily extracted and accessed regardless of location and time.

4.4 Stage 4: Smart Parking Mobile Application

A Smart Parking mobile application is developed to give an immediate and updated information to users. All the information regarding the parking compound are conveyed to users through this mobile application. It will update the users with the number of the available parking slots and inform users when the parking compound is full. The mobile apps is convenient to users as they do not have to be presented there to check the parking availabilities. It is designed to direct the users to the empty parking slots inside the campus parking compound. This method helps in saving the users' time to search for an empty parking slot. The mobile apps also can help the authority to monitor the list of authorized cars, and allow them to register new users.

Figure 6 shows the top-level entity for the proposed system design. All the components used in this project are connected directly or indirectly to the Raspberry Pi 3. The microcontroller is connected to the Automated Car Plate Recognition (ACPR) Module, Parking Availabilities Checking Module and Cloud, while the mobile application is connected directly to the cloud.

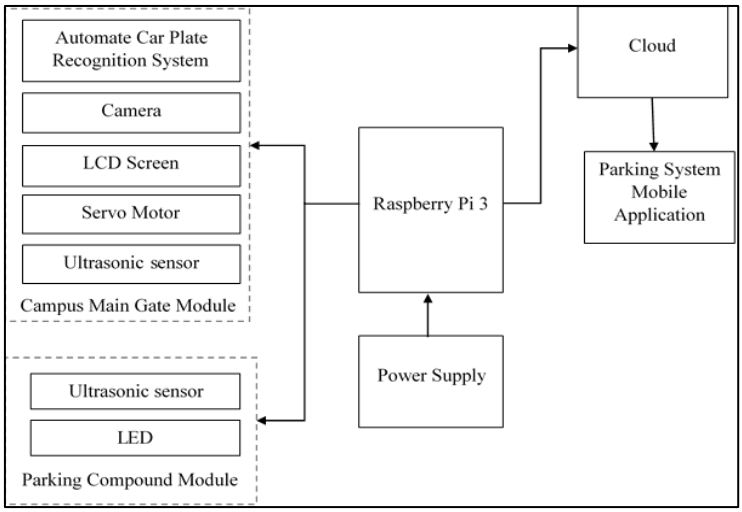

Figure 6. Block diagram for the proposed smart parking system.

5. Results and Discussion

This section discusses about results obtained from the proposed Smart Parking system. For testing purposes, the total number of parking is initially set to 2. At the initial point when the parking area is empty, all the green LED are lighting up while the red LED lights are turned off. At initial stage, the LCD that is set up at the entrance shows "Empty slot: 2". This initial condition is shown in figure 7.

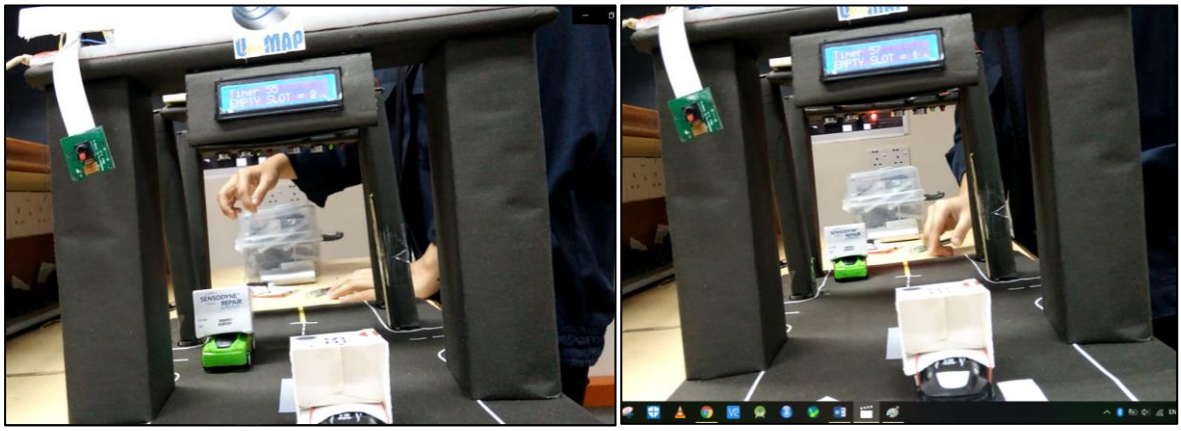

Figure 7. Initial condition: (a) Empty Parking (b) First Car entering - Red LED light up.

When the system detects the presence of any car at the gate, the ultrasonic sensor then senses the changing in distance and it will recalculate the number of available spaces and send the information to Raspberry pi. Then, the red LED at the empty slot will light up and the green LED will go dim. This latest information is sent into the database for storage and update purposes. The same process is repeated when another car is entering.

The results can also be visualized using user's mobile application as shown in the following figure. Only the registered users will be able to access this application and view the car park's information through the apps. This is to ensure that users that are not registered inside the system by the Authority cannot get any information about the parking compound via this apps. This user login page also consists a button that allow authority to enter security login.

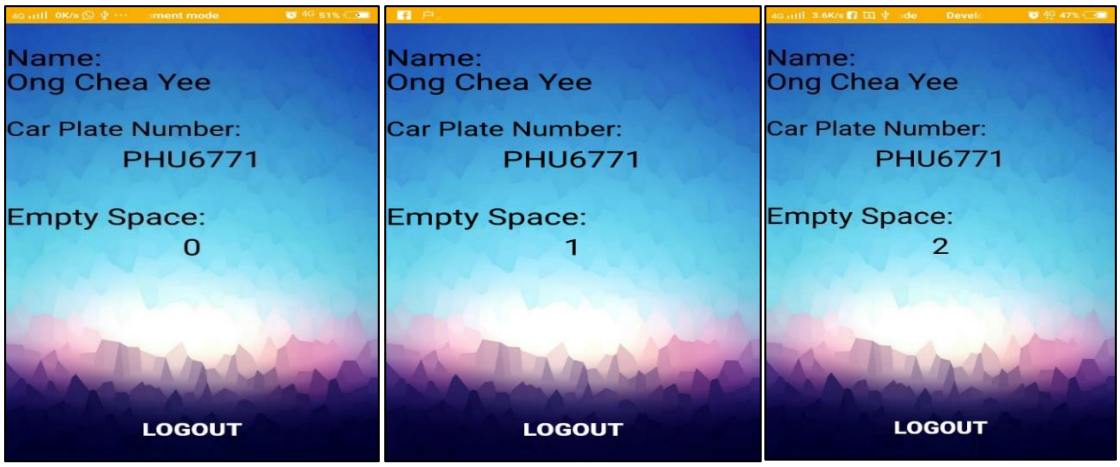

Figure 8. Updated parking information for mobile application.

After users successfully login to the apps, a User Main Page will be appeared as shown in figure 8. User Main Page shows all the details regarding the registered user which is extracted from the database. Those details included the name of user and his/her registered car plate number. The empty parking slot number that is available at current moment at the specific parking area also will be displayed in this page for users' information. The availability of parking slot will be updated real-time as illustrated in figure 8. This function fulfilled the first objective of this project which can provide convenience to users in which they can plan which parking area to park and estimate the time to arrive at the campus parking area. After finish viewing all the information needed, users can click on the logout button to quit the user main page. For ACPR, figure 9 shows the image captured by the camera. After the car plate number

photo is captured by camera and processed by the Raspberry pi, it will compare the car plate number from the extracted image with the car plate number stored inside the database.

Figure 9. Image of car plate number captured by camera.

6. Conclusion

This Smart Parking system is built to provide a convenience and safety environment to users. It is able to provide users with real-time parking information using mobile application and also displayed the information to users at the main entrance of the parking area. With this service provided, users can plan their journey in advance before leaving for campus and save their time on searching around the parking area just to look for an empty parking slot. Another features of this Smart Parking system is Automatic Car Plate Recognition which enhance the security level of the campus. While allowing only the authorised cars to enter, it helps to lower down the rate of unauthorized cars or people want to sneak in campus. This feature secures the safety of students and staffs inside campus area.

References

[1] Aydin I, Karakose M and Karakose E 2017 A navigation and reservation based smart parking platform using genetic optimization for smart cities *Proc. 5th International Istanbul Smart Grid and Cities Congress and Fair (ICSG)* (Istanbul) pp 120-124

[2] Wang M, Dong H, Li X, Song L and Pang D 2017 A novel parking system designed for smart cities *Proc Chinese Automation Congress (CAC)* (Jinan) pp 3429-3434

[3] Sadhukhan P 2017 An IoT-based E-parking system for smart cities *Proc. Int. Conf. on Advances in Computing* (Udupi: Communications and Informatics (ICACCI)) pp 1062-1066

[4] Grodi R, Rawat D B and Rios-Gutierrez F 2016 Smart parking: Parking occupancy monitoring and visualization system for smart cities *Proc. SoutheastCon* (Norfolk: VA) pp 1-5

[5] Fang J, Ma A, Fan H, Cai M and Song S 2017 Research on smart parking guidance and parking recommendation algorithm *Proc. 8th IEEE Int. Conf. on Software Engineering and Service Science (ICSESS)* (Beijing) pp 209-212

[6] Kasaei S H M and Kasaei S M M 2011 Extraction and Recognition of the Vehicle License Plate for Passing under Outside Environment *Proc. European Intelligence and Security Informatics Conf.* (Athens) pp 234-237

[7] Mutholib A, Gunawan T S and Kartiwi M Design and implementation of automatic number plate recognition on android platform *Prof. Int. Conf. on Computer and Communication Engineering (ICCCE)* (Kuala Lumpur) pp 540-543

[8] Ruckus Wireless 2017 Smart Campus Learning (Sunnyvale, CA, US) Ruckus Wireless, Inc.