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Internet of Things based Smart Parking System

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Abstract: A smart parking system is a parking area which is developed with various technologies to serve users better. Parking areas enhanced their security by collecting and verifying the vehicles plate when checking out. Wide options for smart payment are also available at most parking areas. Thus, these smart parking allows customers to optimize shopping time by helping them find a nearby parking spot, provide realtime information on parking space and provide smart payment services. This study aimed in developing Auto Gate Smart Parking System which applies the concept of Internet of Things. The methodology used in the development is Input Process Output model in steps which include analysis requirement, design and testing, and evaluation. This system that uses an Auto Number Plate Recognizer (ANPR) through Raspberry Pi to detect the vehicle's plate number and with the help of ultrasonic sensor, Raspberry Pi camera, database and an Arduino board. Testing was conducted by registering vehicle plate number into the database through Google Form and the system was tested with the registered plate number vehicle. It has shown that the system had effectively recognized the vehicle's plate numbers which makes it easy for parking for small organizations to control their parking area. The system provides convenience to users as no direct interaction is needed for access. Given the current situation in facing Covid-19, it is very important to have contactless systems. Therefore, this Auto Gate Smart Parking will be a great tool to be used in an authorized parking area.

Keywords: Smart Parking System, Internet of Things, Arduino

1. Introduction

A smart parking system is built by intelligent actions from combinations of hardware, software and data communication to manage a vehicle parking area effectively [1]. The existing smart parking system can be divided into five major categories which consist of Parking Guidance and Information System (PGIS), Transit Based Information System, Smart Payment System, E- Parking and Automated System [2].In the case of applying a smart parking area in University Tun Hussein Onn Malaysia (UTHM), the objective is to allow authorized staffs only into the designated parking area without causing traffic and consumes less time. The students and staff have assigned parking areas in UTHM campus, and by the

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rules of the university, students are not allowed to park at the staff's parking area. The students may not be able to access the staff's parking area, but this would be time-consuming and might cause traffic in front of the parking area. Through the survey conducted, authors found that the usage of Near Field Communication (NFC) technology are prone to be misplaced or lost by users. Therefore, author has decided on using image processing as it is more convenient as the user only needs to register their vehicle into the database and they would be able to drive into the parking area. The objectives of this project are to further optimize the campus parking system by automatic license plate recognizer, to record every vehicle that goes in and out if an incident happened and to eases user in registering their vehicles for the parking system.

2. Literature Review

In this section, the author will introduce about the smart parking and discuss the comparison between the available smart parking with the project. Smart parking is efficient parking area which is developed along with various technologies. These smart parking had been implemented since the early 1970s throughout countries such as United Kingdom and Japan [2]. Smart parking in the early times of the studies were only to help the driver to be able to retrieve the information such as availability status and remaining vacant spaces. This system is still seen to be used in major cities [4].

The Parking Guidance and Information System (PGIS) in comparison to our system is too ambitious for a controlled area as the people who can enter the campus area are only authorized people which are the staffs and the students. Auto Gate Smart Parking system is not able to give specific guidance about the location of the vacant parking spot due to low budget and holds a different objective with the PGIS system which uses static or dynamic variable message signals (VMS) to provide information. For the Transit-Based Information System, it is seen to have very distinct features with the Auto Gate Smart Parking system. The main purpose of the system is to encourage people to park their vehicles and use buses or train for transit [4] The author is unable to apply this type of smart parking system as the location of the university is not located near a public transportation base. Therefore, this parking system is not suitable to be implemented into the project.

For the Smart Payment System, it has a same goal with this project, which is to overcome maintenance problems, automatization and to control traffic. This system consists of contact methods which is based on the usage of smart cards, debit cards and credit cards, contactless method using contactless cards and mobile devices involving technologies such as Automated Vehicle Identification (AVI) where RFID is utilized [1] But instead of using cards as access keys to the parking area, author has chosen another method. Furthermore, to reduce risks such as loss of cards or tickets, Auto Gate Parking System uses a license plate recognizer to activate the automatic feature of this system. Plus, the approached used in this smart payment system was also not seen suitable for our system as no transaction in payment takes place. Next, for the E-Parking System, it is not suitable to apply in this project because this technology was to combine the service of parking reservations and payment systems. This process can be done by employing a confirmation code access that the customer receives upon making the reservation and payment [5]. Lastly, the comparison of Auto Gate Parking System with the Automated Parking System. The method used in Automated Parking System is not suitable as the author's system focuses on a much smaller compound which is a campus parking area. Although both systems would want to enhance the parking area in terms of security, the focused location and the infrastructure of the parking area for both systems is too different. In addition, the Automated Parking System is seen to be offering efficiency in storing the car as it can stack cars and the drivers do not have to enter the parking space. Indirectly, extra safety measures are provided for the car and the driver [6].

3. Methodology

This study used Input, Process, Output (IPO) as the method in the development of the project. In the Input Process Output model, a process is viewed as a series of boxes (processing elements) connected by inputs and outputs. Information or material objects flow through a series of tasks or activities based on a set of rules or decision points. Flow charts and process diagrams are often used to represent the process [7].What goes in is the input; what causes the change is the process; what comes out is the output [8].

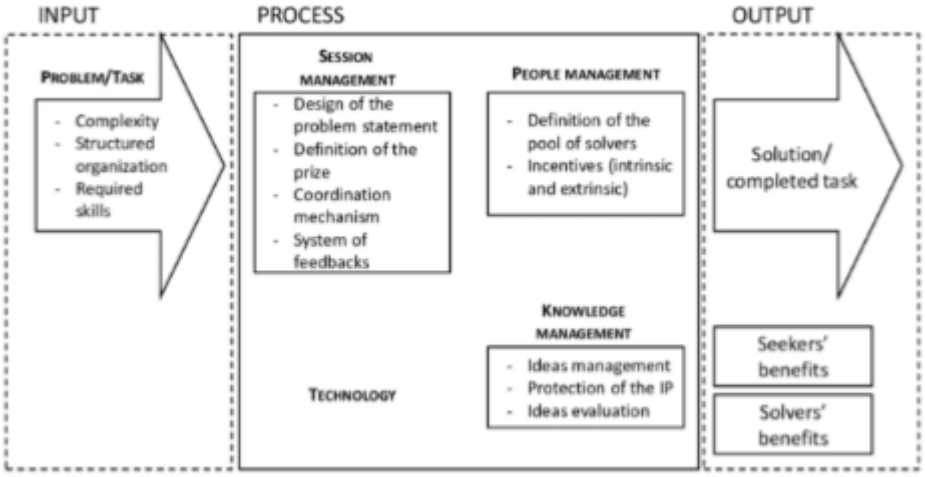

Figure 1: Input-Process-Output (I-P-O) framework for crowdsourcing [9]

The input phase will also help in listing the specific needs to conduct an operation and produce a goal oriented result [10]. During this phase, the author brainstormed for problems that may arise during the development of the project. The project background, the problem that leads to building the project [11]. A registration form had been created by using Google's form feature. Then, the vehicle license plate number will be collected as input for the data. This allowed the gate to be open when it matches a registered plate number in the database with the image processed by the camera near the gate.

The process phase is where all operations and actions were done by using any tools necessary. Software and hardware are taken into account which will influence the results [12]. In the development part of the process phase, the author had installed Raspbian OS into a Raspberry Pi. Then, the circuit construction took place. Author used OpenALPR as point of reference in creating the automatic license plate recognizer. Raspberry Pi had been installed for easier deployment, combined with Arduino for sensor related to replicate real world use (i.e connecting an existing parking gate with the new system).

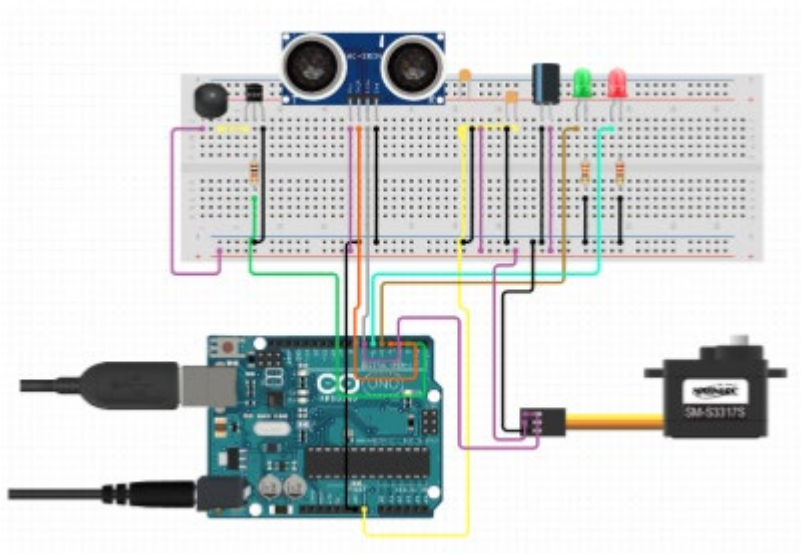

Figure 2: Circuit

The output phase took place after the development and process phase is completed. This phase enabled more analysis to be done onto this system by producing results on tests conducted [13]. The author tested the system with real-world simulation using a toy car with a registered licensed plate. Surveys had been conducted with the drivers to evaluate the requirement for the system. Figure 4 shows the design of the final output on how the gate is realized.

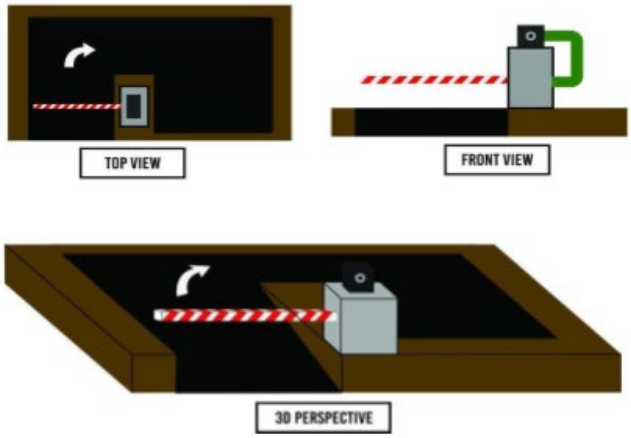

Figure 3: Prototype of Auto Gate Smart Parking

4. Project Development

Auto Gate Smart Parking system was started by planning and drawing a diagram of the prototype that was to be built. Input Process Output is a methodology where an overview is provided with the flow of tasks are explained.

The author has done some information gathering to identify the requirements of this project after identifying the problem. It is to allow the system to differentiate between a student's car and a staff's car, a database is used so that only staffs may enter the parking area. Author have chosen to create a Google Form and Google Firebase for registration input and storing of name, email, and cars license registration plate number. For the hardware, the microcontrollers carrying the tasks are the Arduino

board connected to a Raspberry Pi. Raspbian OS is installed in the Raspberry Pi and to be able to connect the board with a remote device, SSH or Virtual View feature had to be enabled. All the sensors, boards and components were built in this process. The ultrasonic sensor, buzzer, LED, and servo motor is connected to the Arduino board. Meanwhile the Raspberry Pi that relates to the camera will be used to download Automatic Number Plate Recognition (ANPR) SDK and its dependencies. These components are connected as shown in Figure 4.

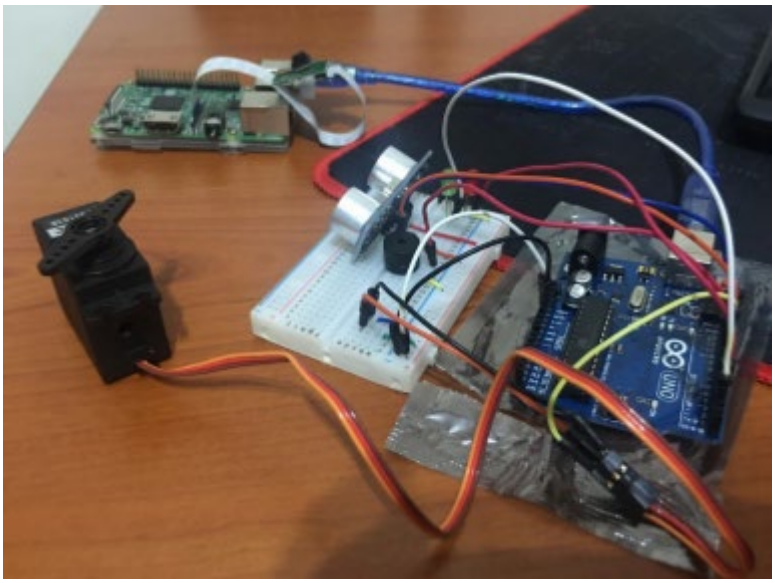

Figure 4: Connection of Arduino board with ultrasonic sensors with Raspberry Pi

The data of the vehicle from Google Form had been inserted into the Firebase which is the database used by author. Lastly, the author integrated Firebase with Arduino using Python resulting in the ability of the servo motor to move the gate up if access is granted. In this output phase, the author had conducted a testing of the completed project. All components had been tested individually and as a whole for a better accuracy and to make sure they work according to their functions.

5. Results and Discussions

This study had conducted an evaluation that consists of 18 respondents through Google Form. The author found that 70.6% of the respondents have a problem in finding parking spaces while 29.4% find it easy to spot a vacant spot. It proved that staff parking is often full, and respondents find it hard to acquire a parking space in the staff's area. Most of the respondents thought that it would be easier to use NFC cards as access key to the parking area but also agree that NFC cards are easily misplaced or lost. It justified that the automation system would be a better implementation for this project. Not only that, 82.4% of the respondents said this system will help control an access of people into the parking area meanwhile, 11.8% disagreed and 5.9% did not sure.

Testing phase is one of the important process in development of a project as it helps identify problems and weaknesses. Therefore, the authors may improve the project based on feedbacks by users after testing the system. Due to COVID-19, the author couldn't test the system with real users therefore instead the author had tested the system in the perspective of a user. Refer Table 1.

Table 1: Result of testing conducted by developer

Task	Results
Registration through Google Form	Registration was easy. Not much information was needed.
Case car present but is not registered to the system.	Buzzer omitted sound in this case. Both LEDs also light up alternatively until the car no longer detected. Access was denied.
Case car present and is registered to the system.	Servo motor lift up the gate and green LED light up. Access was granted.

Figure 5: The complete model of Auto Gate Smart Parking System

The author found that registration using Google Form is easy to use and the registration was done successfully. The buzzer worked well when tested by putting a toy car in front of the gate without registering the vehicles plate number. After registration, the toy car is again put in front of the gate and this time the gate opened and the green LED lit up as in the Figure 5 above that shows the complete prototype.

6. Conclusions

In conclusion, the author has achieved the main objective which is to secure the parking area for the staffs of UTHM Pagoh Campus by completing the three sub objectives which are, to ease user in registering their vehicle for the parking system. Next, to develop campus parking system by using automatic license plate recognizer and lastly to record every vehicle that goes in and out if any incident happens. The first objective is achieved through implementing Google Form for registration which can be done anytime and anywhere. Next, the second objective is achieved by making the parking area accessible to authorized parties only. Lastly, the third objective is achieved through using auto number plate recognizer software which records the data of the vehicle that enters and exits the parking area. From this project, author has learned on how to use various technology such as Raspberry Pi, Arduino and Python. This project achieved in becoming a convenient and contactless system and making the parking area exclusive for authorized parties only.

Moreover, during development a lot of obstacles were faced by the author. But every problem was solved eventually. There were some prominent constraints that challenged the author on finishing the

development of the project such as tight budget to build a better project with better features and technologies, and short time allocated to start the development process of the broken servo motors and many shops were closed due to COVID-19 pandemic and movement control order (MCO). From this system, it is more efficient and less time consuming for users to park in the parking space, and more importantly, our main objective which is to secure the parking area for the staffs of UTHM Pagoh Campus has achieved. Future works include improving the project to make it better in the future such as using an LCD to convey the message of an error much more easily, finding vacant spaces more efficiently and providing NFC access keys option for visitors.

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