DESIGN AND IMPLEMENTATION OF ROTARY AUTOMATED CAR PARKING SYSTEM

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DECLARATION OF ORIGINALITY

I hereby declare that this project report is based on my original work except for citations and references which have been duly acknowledged. I also declare that it had not been previously and concurrently submitted for any other Certificate or degree of award at APU or other institution.

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DESIGN AND IMPLEMENTATION OF ROTARY AUTOMATED CAR PARKING SYSTEM

ABSTRACT

The main aim of this project is to design, develop and implement an Automated Rotary Car Park System. In this project, a Graphical User Interface using MIT APP Inventor which is an IOT platform, was developed to allow the user through his/her mobile application controls the whole rotary car parking system in such an easy and automated way as well as a prototype for the rotary car park had been designed and built-up where it could hold up 5 vehicles slots in order to test and apply the developed IOT system. The performance of the pervious developed proposed systems were mainly dependent on non-automated methods for controlling the parking & retrieving process, which lead to physical interface from the user to either park or retrieve his/her car, that's why devloepding an automated system which mainly depend on the IOT technology was the main aim and innovation for the system comparing to what had been proposed before. Finally, the system proved to be efficient and facilitate the parking and retrieving process as well as save time and effort for the user as compared to the various techniques developed in the literature.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

SYMBOL, ABBREVIATION OR NOMENCLATURE	FULL MEANING
BEM	Board of Engineering Malaysia
DC	Direct Current
GUI	Graphical User Interface
IC	Integrated Circuit
IDE	Integrated Development Environment
IOT	Internet of Things
mA	Micro Ampere
mm	Milli Meter
MOSFET	Metal–Oxide–Semiconductor Field-Effect Transistor
RM	Malaysian Ringgit
RPM	Revolution Per Minute
RPS	Rotary Parking System

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CHAPTER 1

INTRODUCTION TO STUDY

1.1 Introduction

In this fast-changing era, each individual has his/her own car (or more than one) thus, this leads to various problems such as: Congestion in the big cities as well as in the metropolitan areas. Not only does it cause heavy traffic jam but also waste of time for people who wants to park. Therefore, the essential solution for these issues is to build car park system (Rahman, 2019).

There are many types of car parks for instance, surface level park, tower car parks, underground car parks and rotary car parks. The design of these various types of car park relies on plenty of countless factors such as: Area, number of cars needed to be occupied, the smoothness of parking and retrieving process and the cost. Rotary Parking System (RPS) is the design in which cars are parked on a rectangular pallet in a vertical way in which the pallet that hold the car could rotate clockwise or anti-clockwise with the help of chains and motor (Ismail, 2018).

It goes without saying that RPS has numerous advantages: Perfect for saving built area this is because it could hold more cars than the traditional parking in a small area, easy installation and construction process and helps in reduction of traffic jams. Therefore, RPS is considered the perfect choice for building a new car park (Yadav, 2020).

Internet of Things (IOT) could be defined as a technology wave in the global information industry that comes after the Internet, IOT could be seen as an intelligent network which connects all things to the Internet for the purpose of exchanging information and communicating through the information sensing devices. Through IOT we could achieve a global intelligent identifying, locating, tracking, monitoring, and managing things as well as devices that are connect to the internet (Chen, 2014).

In this project, RPS model that hold 5-vechile will be designed and built-up. Apart from that RPS control system will be developed based on innovative technological IOT solutions to make the process of using this rotary car parks more easy, smooth, save and smart.

1.2 Research Problems

The Insufficient space for the cars in the big cities to park leads to unorganised way of parking cars. In consequent, this leads to road blocking and traffic jams is the big cities. Furthermore, constructing an ordinary and traditional car parks designs are leading to other major problems which are wasting the drivers' time to find a free parking slot. In other words, the traditional parking the drivers take time while driving in the panels of the park or if the park is designed with many levels, in some cases the driver will need to search for a free space among the levels and that is a waste of time consequently leads to unsatisfactory for the population (Skrzyniowski, 2016).

In addition to that, lack of fully automated rotary car park systems is the main issue. In which most of the rotary car park proposed systems need a physical deal from the user with the control panel for the parking and retrieving car process. Thus, a smart IOT web or mobile applications needed to be developed.

1.3 Aim and Objectives

Aim:

The aim of this project is to develop an enhanced Rotary Automated Car Park System which can hold 5 vehicles slots via innovative IOT Solutions in order to facilitate the process of Parking & Retrieving the Car.

Objectives:

1. To design a Rotary Car Park Model that hold 5-cars.
2. To develop a fully Automated Smart system through a GUI IOT mobile application for the users to control the rotary parking system in the process of parking and retrieving.
3. To evaluate the accuracy of the developed system in the process of parking and retrieving.

1.4 Justification for This Research

This project will be beneficial for the congested large cities, thus constructing RPS will give the option to have many available slots for cars. Not only that but also, it does not require large space area to be built on it. It goes without saying that it saves time for the users to park their car consequently, less time will be consumed than the ordinary car park designs, this is because the RPS let the user park the car without searching for a free space due to the constant availability of the free slots. Besides, this project will be fully automated IOT based system and that will make the process of parking and retrieving is easier for the drivers

1.5 Organisation for The Rest of The Chapters

The rest of this project report is organised as that chapter 2 will cover the literature review, that illustrate 10 previous researches related to designing the rotary car parks and developing the smart controlling system of the rotary park.

Chapter 3 will cover the proposed tools and techniques, the 2D & 3D design concept of the rotary car park, the proposed methodology, the innovations and enhancements. Moreover, the professional engineering practices, estimated cost and project management of the project. Chapter 4 covers the detailed of the final implementations of the proposed project like the final block diagram, hardware and simulation results.

In chapter 5 all the required & essential testing as well as the discrepancy between theoretical and experimental and potential causes of error is illustrated. Not only that but also, the project management of the in the form of a Gantt chart followed by projected final cost and requirements for moral and Engineering ethical consideration as well as the sustainability aspects had been explained.

Chapter 6 will outline the conclusion relating to the objective of the proposed system as well as the project limitations and recommendations for further improvements in the future.

1.6 Summary

This project is to design, develop and implement an automatic rotary car park system that hold 5-cars and be controlled via a smart IOT application. Chapter 1 explained the project background, the research problem, the aim and objectives of the project, justification for this research and a summary for the upcoming chapters and their main structure.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will illustrate the findings of the previous 15 similar work, which had been done by researchers in the last past 5 years about RPS. Apart from that, this chapter is organised as follows: section one is the introduction part of this chapter, section two illustrates the previous studies where the first 5 journals are about the designing prototypes of rotary car parks, while the other 5 are about the developing of the control system as well as in project phase 2 it had been added 5 more journals, which are related to the full implantation of the RPS. These reviews will enable to find the gaps related to design and system development in the previous projects to improve these weak points. Lastly, the third section will be chapter's summary.

2.2 Literature review

2.2.1 Rotary Car Park Design

Researchers (Sodiq & Hasbullah, 2017) had proposed a prototype for parking rotation system that based on Arduino microcontroller. The system tried to solve the problem of increasing in the number of cars as well as the few available spots to build car parks. The proposed system is to build and develop a rotary car park that could hold 6 cars. The methodology of this system is that it used push buttons controlled by Arduino uno microcontroller. By pushing the button, the stepper motor will rotate the pallets of the rotary car park. For instance, if button 1 is pushed then the motor will rotate to the left by 240 step, while button 2 will let the motor rotate by 477 step and so on for each button from 1- 6. These buttons are responsible for rotating the stepper motor by a specific degree, so in case a user need to park his/her car, then the user need to push the empty slot button, thus, the empty slot will be rotated to let the user park the car on this slot.

However, for the retrieving process, the user needs to visually looks at the number of parking slot of his car and then pushes the button related to this number to retrieve the car. The main limitation for this system is the lack of innovative technologies like IOT. Also, it does not have the option of having a mobile application that facilitate the parking and retrieval process. Another limitation is that: the system is not fully automated; thus, the user needs to deal physically with the control panel and bush button to park or get his car. Another drawback is the lack the helping equipment's like front mirror.

Researchers (Islam et al., 2017) had proposed the development of an eco-friendly automated RPS aims is to make Dhaka city free of traffic congestion. The main problem in the study was the great congestion in Dhaka city and it proposed the development of a rotary car park that could hold 10 cars as the main solution for this problem. The proposed methodology for the project was using Arduino Mega as the main microcontroller and 3*4 Matrix keypad, so by pressing a specific number the required sheet pallet that hold the car will rotate. In other words, the 10 sheet pallets that hold the cars are connected to a chain which connect to a DC gear motor and according to the number of the keypad the gear motor will rotate to place the specific pallet in the exit for the retrieving process. Moreover, the connection between the Arduino microcontroller and the Dc gear motor had been done through a L298N-Motor driver. The major drawbacks for this proposed system are the lack of smart innovative solutions like IOT system, the system required an interaction from the user as the user needs to press the keypad and the system is not fully automated. Another drawback is: There is no helping equipments like front mirror to help the driver in the parking process and no alarm sensor system that shutdown the whole process if detect a person enter the parking area for the safety of the user. Additionally, the system lacks the presence of the option to rotate the car slot itself for the drivers so the driver after retrieving the car will not need to drive it backward.

Researchers (Muhammad & Sami, 2018) proposed to develop RPS to solve three problems: (1) the traffic jams (2) congestion that happened due to normal car park designs along with (3) the wasted time for the drivers to find free parking slot. The main objective of the paper is to present the mechanical design, components used and the programming of the developed system.

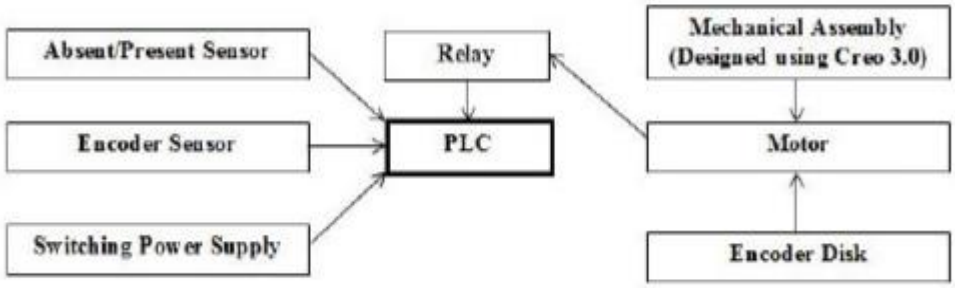


Figure 2.1 : Block Diagram for Rotary Car Park Sytem

(Muhammad & Sami, 2018)

As shown in Figure 2.1, system methodology, the input parameters that come from the sensors (the encoder and absent/present sensor) are connected to a PLC system which is responsible for the developing of the control panel. In addition to that, it is connected to the motor and the mechanical design of the rotary car park. Once the sensor sense that there is no person, and the car is placed on the slot the motor will rotate to enable a new empty slot for another user. The main limitation of this system is that there is no implementation of smart technology solution like IOT, and the user still needs to do some manual effort and deal with the control panel to retrieve his/her car, so the system is not fully automated.

Researchers (Hugeng et al., 2020) proposed an implementation for RPS based on Wi-Fi as a transferring data media. The system had been proposed to solve the problem of parking space requirements as there are increasing for the private cars which required more parking slots, so building normal car parks buildings will lead to a reduction in the green areas as well as leading to illegal parking and congestion in the city.

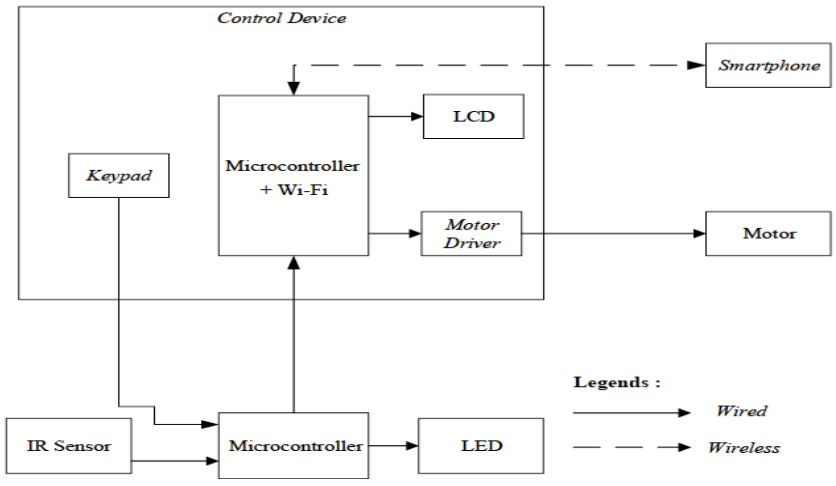


Figure 2.2 : Block Diagram for proposed IOT based Smart Car Park Sytem

(Hugeng et al., 2020)

As per Figure 2.2, the system methodology, the user will need to use the mobile application and login with the registered ID to be able to use the system, then the user can select the free slot based on the data sent by the IR sensor to the microcontroller, that appear on the GUI. Afterwards, the selected slot will rotate to the user to park the car, then the user needs to press the confirmation button on the keypad of the control system to confirm that he/she parked the car. Moreover, the user will receive a security code on his/her mobile. For the retrieving process the user will enter the security code to the control device and the slot will rotate so the user could take the car. The information is sent wirelessly by using the NodeMCU which is considered a Wi-Fi microcontroller that sends the data between the sensors and the mobile application. The main limitation of this system is that: The user has to deal with the control panel of the system to confirm his/her parking and to retrieve the car, so the system is not fully automated and not using IOT mobile application, the system lacks the option of rotating the car pallet for the drivers so the driver after retrieving the car will not need to drive it backward, and the lack of helping equipments like front mirror.

Researchers (Vishal Tayade & Swapnil ,2019) proposed an automatic RPS that aimed to park the cars in most organised way. Due to traffic jams in the big cities and the insufficient car park areas, the system had been proposed to provide car park slots in small space area along with providing safety for the car and the users.

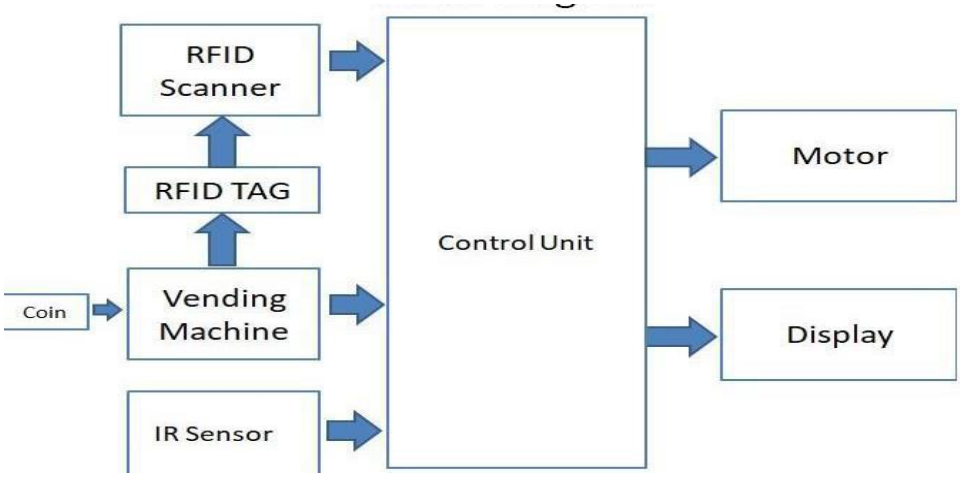


Figure 2.3: Block Diagram for Automated Rotary Car Park

(Vishal Tayade & Swapnil , 2019)

As seen in Figure 2.8, system methodology, firstly the system will check if the car park is full or not through the IR sensor and if not, it will ask the user to insert a coin and the control panel will generate a RFID card for the user and this

RFID is specialised for specific park slot. On the other hand, for the retrieving process the user scans his/her RFID card and once it is matched the specific slot will be rotated by the help of DC motor so the driver could take the car. Figure 2.4 shows the final implementation of the system and the coin accepting machine.

Figure 2.4 : Automated Rotary Car Park Result and Coin Machine
(Vishal Tayade & Swapnil , 2019)

The main drawbacks of this system are the lack of using of IOT mobile or web application, the user needs to deal with the control panel while inserting coins and to park or retrieve the car, so the system is not fully automated, the lack of front mirrors that help the driver in the parking process. Also, the system lacks the option of rotating the car slot for the drivers.

2.2.2 Rotary Car Park Control System

Researchers (Kodali et al., 2018) proposed the idea of smart parking system by using IOT, the main objective of the paper is to let the users know the available spaces that could be used for parking from their mobile web application via IOT cloud system.

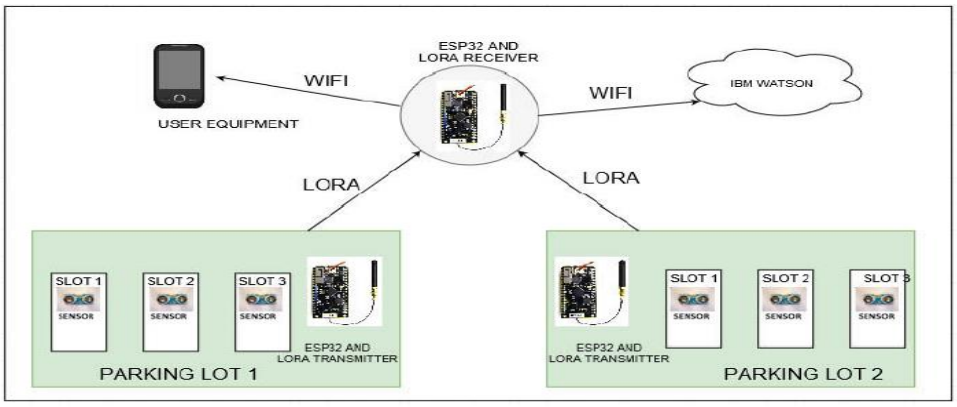


Figure 2.5: Block Diagram for proposed IOT Smart Car Park System (Kodali et al., 2018)

As per Figure 2.5, the system used ultrasonic distance sensor to detect either the car park slot is occupied or not together with sending the data to the ESP-32 Loara module which is the IOT component that responsible to get the data from the sensor and transmit to the cloud database. The cloud database is IBM Watson IOT Platform. The output of the sensor is sent to the IBM database via the ESP32 lora then the user type-in the IP address of the module so, he could check the availability of parking slots. The main limitation for this project is that: the mobile application has only one available option that enable the user to know if there is an empty slot or not, the application does not provide any other options to the user.

Researchers (S.Poornimakkani1 et al., 2018) had proposed a cloud based smart parking system to facilitate the parking process and support the drivers during the process of finding a free slot and also to book slots by automatic payment as well as give the drivers a new solution which help them in the parking process without bother themselves with parking place, payment method. The system could be controlled by the user through a web application that is connected to a cloud server. The whole system is considered as an IOT-based system. The proposed methodology for this system is that: by using the IR sensor to detect either there is a free slot or not, (this information will appear to the user on the

web application) the user can login and choose the slot and based on his/her e-wallet, that connected to the same application, the user could pay the fees of the parking and then a QR code is generated, the user can this QR to enter and access the car park. The system has some constrains such as: not having a mobile application, and the system was designed only for parallel parking.

Researchers (Chandran et al., 2020) proposed an IOT smart parking system, in which the researcher designed a smart parking system to help the users to reserve parking slots by using Android application and this solution tried to help the drivers to find areas for parking in shorter time.

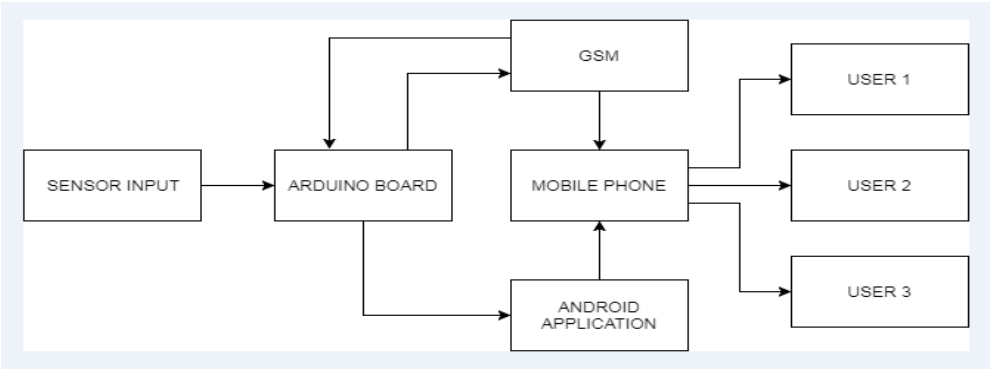


Figure 2.6 : Block Diagram for proposed IOT based Smart Car Park Sytem (Chandran et al., 2020)

As shown in Figure 2.6, the microcontroller (the Arduino board) will read the data from the sensor to check either there is a free slot or not and then from the mobile application the user could select the free slot. After that a code is generated to the user by the GSM module then once the car is parked the application start to calculate the duration to calculate the payment that the user need to pay. The limitation for this system is that it did not specify the type of parking design also only one sensor is implemented for checking either the slots are free or not, lack of helping equipments like front mirror, which help the driver in the parking process.

Researchers (Zeeshan et al., 2021) developed an IOT based system for smart car parking to solve the congestion problem and the less availability of free car parking slots. The aim of this system is to develop a mobile application to allow the user to check the availability of parking space and book it accordingly.

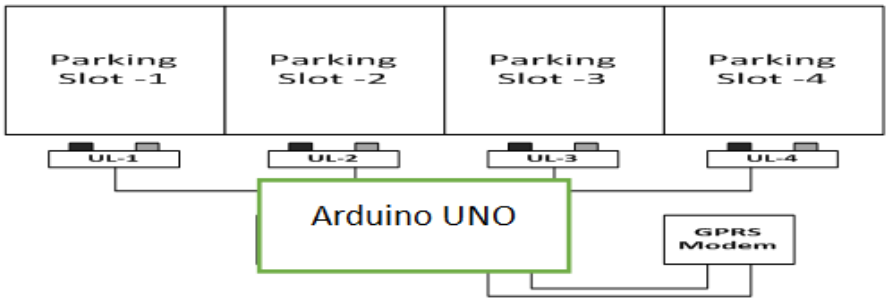


Fig.1. Block diagram of car parking

Figure 2.7 : Block Diagram for proposed IOT Smart Car Park

(Zeeshan Sheikh et al., 2021)

As per Figure 2.7, the free parking slots are detected by the ultrasonic sensor and the data sent to the Arduino microcontroller and the Arduino microcontroller will send the data to the online database, thus the user could check the free slots from the mobile application and select it, and when the user retrieve the car, he/she will be notified by the amount needed to be paid and the payment method by using the GSM module. Additionally, the system contains two IR sensors that had been used at the entry and exit gates to detect the presence of the car and automatically open or close the gates. The main drawbacks of the proposed system are that: The lack helping equipments like front mirror, that needed by the drivers to help them during the parking process, the system is designed for ordinary car parks designs not rotary car parks or vertical car parks that is more beneficial for the congestion and less parking slots problems.

Researchers (Dr.R.Gandhi et al., 2021) proposed a IOT based system for smart park, the aim is to identify available parking spaces using IOT and ultrasonic sensors. The main problem is the congestion of metropolises and to help in decreasing the pollution and provide safety to the drivers and save time in parking process.

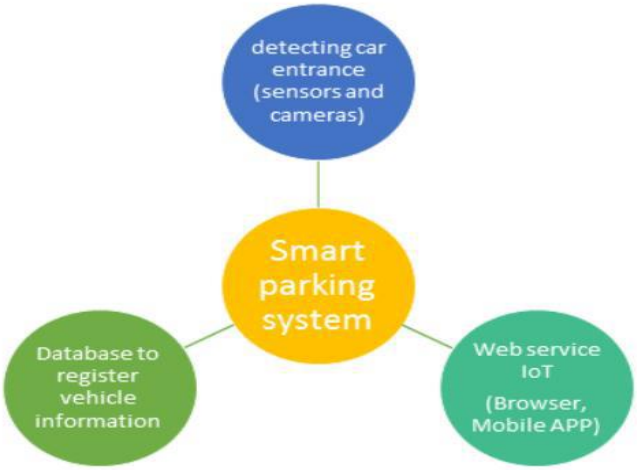


Figure 2.8 : Mian Architecture for the proposed IOT Smart Car Park

(Dr.R.Gandhi et al., 2021)

As shown in Figure 2.8, the system consists of three main components: (1) sensor, (2) camera to detect the car entrance and the availability of the slot and (3) IOT service through the web & mobile application and the database which responsible for recoding the data and the car information.

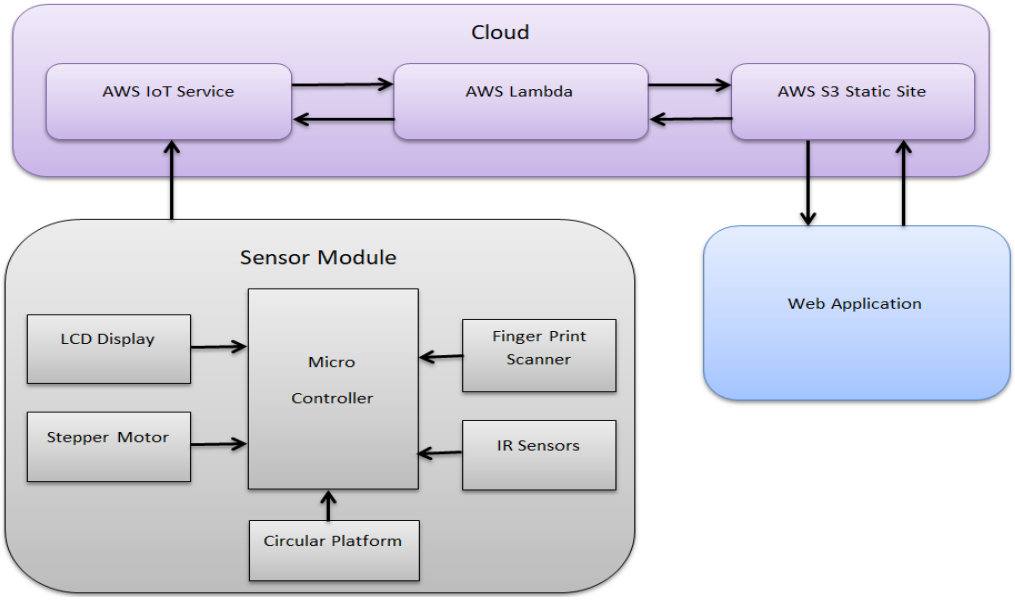


Figure 2.9 : Block Diagram for the proposed IOT Smart Car Park

(Dr.R.Gandhi et al., 2021)

As shown in Figure 2.9, the system will check from the user through the web application either the user needs to park or to retrieve the car and if the user chooses to park, he/she can check the free slot and take the fingerprint of the user and open the gate to him/her to park the car. If the user chooses to retrieve the car, the user needs to scan his/her fingerprint and if it matches with the data saved on the database, the gates are opened for the user to retrieve the car. The free slots

are checked by using the HC-SR04 ultrasonic sensor and the data are controlled by the ESP8266 which is the IOT microcontroller that send the data to the cloud database. The main limitation in this system is that the system is not fully automated as the user need to deal with the control system to scan the fingerprint, the system is not fully dependent on the IOT web application and the lack of helping equipments like front mirror, which help the driver in the parking and retrieving process.

2.2.3 Fully Implementation of RPS

Researchers (P.S.Shri Harish et al., 2018) had proposed an automated rotary car parking system where it depends on using chain drives with roller switches as well as the chain drive is driven by a DC motor which programmed and controlled by PLC though WPL software. The working principle is that the structure consist of carriages in which cars are parked as these carriages are rotated in a chain and sprocket mechanism. Moreover, when the car enters the parking area a senor will sense and an empty carriage will come down to take the car, a Human Machine Interface (HMI) (Numerical Keypad) is near the rotary car park so the user can enter their car numbers and how much time the car will be parked in. Not only that but also, a proximity sensor is kept at the column to detect the presence of a car inside the carriage, the motor will turn on only when the proximity sensor produces a high signal. The main limitation in this system is that the system is not fully automated as the user need to deal with the control system to enter is car number and select the car pallet. Also, the system is not dependent on the IOT and does not provide any innovative ideas that make the retrieving car process is more easier for the user like the rotational car discs.

Researchers (Alnakar & Catovic, 2021) had proposed rotary car parking system, where it had been built-up and developed a rotary car park which could hold 5 vehicles controlled by Arduino uno microcontroller as well as the rotary movement based on a chain and sprockets connected to a DC motor.

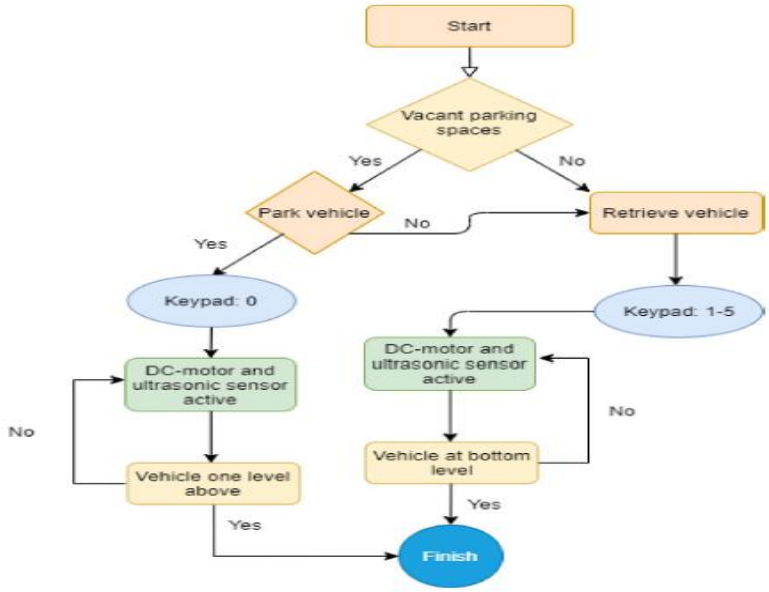


Figure 2.10 : Flow Chart for the proposed RPS

(Alnakar & Catovic, 2021)

As shown in Figure 2.10, the system will check either there is a vacant space or not, then will check from the user either he/she wants to park or retrieve his/her car and based on the number which will be entered through the keypad the DC-motor and the ultrasonic will be activated in order to bring the vehicle at the bottom or either rise the vehicle one level above. The main limitations in this system is that the system is not fully automated as the user need to deal with the control system and use the keypad in order to park or retrieve the does not provide any innovative ideas that make the retrieving process is more easier for the user like the rotational car discs. Not only that but also, the system does not have any safety procedures, like the DC-motor stop rotating is a user enters the parking area during the rotational process.

Researchers (Supratno et al., 2021) had proposed a vertical parking automatic control system controlled by Programmable Logic Control (PLC).

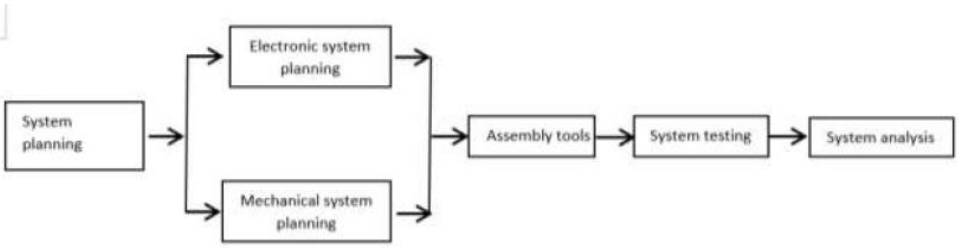


Figure 2.11 : Flow Chart for the proposed RPS

(Supratno et al., 2021)

As per Figure 2.11, it is shown the main flowchart and the procedure of the proposed system, as this protype is created to have a capacity of six cars which is developed and controlled by Mitsubishi FX3G PLC system. Furthermore, a position sensors is used to send pulse signals to the PLC in order to help in the rotary process of the system. The mechanism of rotation is done by using 2 sprockets and gear chains which is controlled by 3 phase induction motor. Furthermore, the PLC has serval function , including the CPU as the control section where tis input function come from a button press and the positions sensor. Therefore, the main limitations of this system that it is not fully automated and required a physical actions from the user to park or retrieve his/her car as well as there is no implementation of IOT system.

Researchers (M.Raghupathi et al., 2021) had proposed a design analysis of rotary car parking system, which is driven by a chain and sprocket mechanism and a wiper motor is used in order to drive the required power to the system, as well as these design could accommodate up to eight cars. The advantages of this proposed system is ensures quick parking and easy retrieval of vehicles , Most suitable for parking in offices, malls and similar places. And Low maintenance levels are required by the system. The main limitations of this system is no implementation of any automation or IOT system and does not provide any innovative ideas that make the retrieving process is more easier for the user like the rotational car discs.

Researchers (Agrawal et al., 2018) had proposed an RFID based rotational Car parking system, the system is developed based on RFID technology as the system is consist of a RFID read which is placed in front of the vehicle parking system. Furthermore, in order the user to park the car he/she needs to swipe the RFID card and now an empty car slot will gets down and the user could park the car. Moreover, for the retrieve process the need to swipe the RFID card, so his specific slot will come down in order to unpark the car as well as the whole process is mainly based on the (80328) micromolar which control the whole process of RFID reading s the motor rotations, as shown in Figure 2.12.

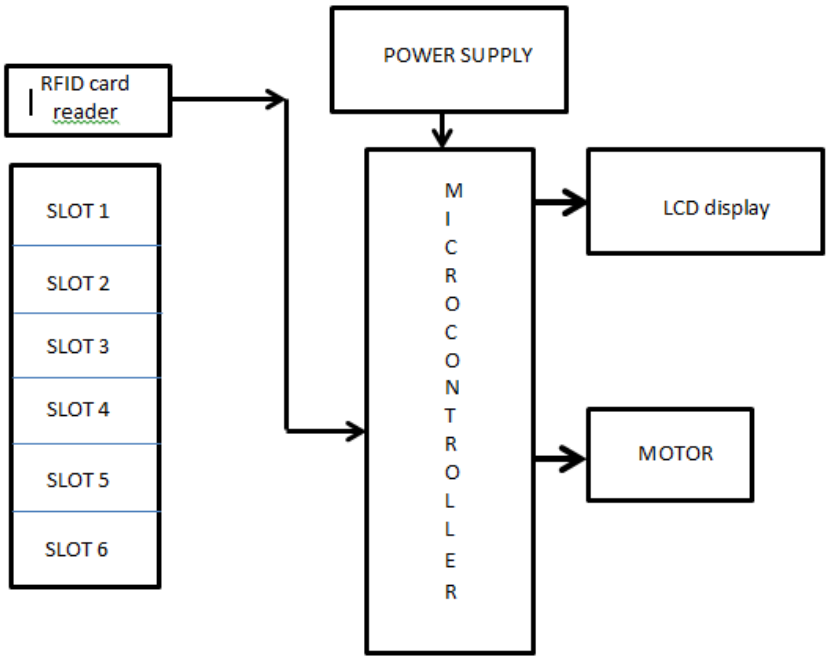


Figure 2.12 : Block Diagram for the proposed RPS
(Agrawal et al., 2018)

The main limitations of this system that the user need to park his/her car physically by swiping the RFID card, there is no any usage of IOT technology or mobile application the make the whole proceed more faster and easier. Furthermore, does not provide any innovative ideas that make the retrieving process is more easier for the user like the rotational car discs.

Table 2.1: Summary of Literature Review

No.	Year of Publication	Authors	Methodology & Results	Limitations
1	2017	M Sodiq	To design Rotary car park Model could hold 6 cars, developed system controlled by Arduino and the user control the system through Keypad.	lack of innovative technologies like IOT and the system is not fully Automated. lack of helping equipments like front mirror.
2	2017	Mohummad Shariful	Arduino Mega as the main microcontoller and 3*4 Matrix keypad is used, so by pressing a specfic number the required sheet pallet that hold the car will rotate by a DC gear motor and according to the number of the keypad the motor will rotate.	lack of smart, innovative solutions like IOT system, lack of presence of the option to rotate the car slot 180 degress for the drivers.
3	2018	Muhammad Asyraf Bin	Devloep a rotary car park system. The methodology is the input parameters that come from the sensors like encoder are connected to a PLC ssytem which control the rotating process.	User need to do a procces and deal with the control panel. (Not Fully Automated Sytem)
4	2018	Ravi Kishore Kodali	A smart parking system by using IOT through ultrasonic ditance sensor to detect either the car park slot stauts and by using ESP-32 Loara module which send data IBM Watson.	Lack of options for the car parking proceess

5	2018	S.Poornimakkani1	A cloud based smart parking system using the IR infrared sensor to detect wither there is a car space slot or not and from web application the user could do the payment and parking process is done by a QR code.	Not Fully Automated process for parking and retriving Car.
6	2019	Vishal Tayade	an automatic rotary car park system . The methodology is to check the free slots by using the IR sensor and send the data to a microcontroller and then give the user a sepfic RFID tag for the slot that chosen and this RFID tag is used in the retriving process	lack of using of IOT mobile or web application, not fully automated and no implementation for the option of rotating the car slot.
7	2020	Mehala Chandran	An IOT based smart parking system, that use Arduino microcontroller to recive data from sensors and check the aviabalitiy of free slots and send notifcation by GSM module	No any other sensors or mirror that help the driver in the parking process.
8	2020	Hugeng Hugeng	A rotary parking system that based on a mobile application as user log in to it to check the free slots based on the data recived from IR sensor and sent to the microcontoller and based on the chosen slot it will rotate and in retriving the user will enter a code sent to him to get his car.	Dealing the user with the control panel of the system to confirm his parking and to retrive his car. lack of presence of the option to rotate the car slot itself for the drivers.

9	2021	Zeeshan Sheikh	IOT based system for smart car parking, the methodology is IOT application that user from it, can check the free slots and all of the data are controlled by an arduino microcontoller by the help of IR and ultrasonic sensors	lack of helping equipments like front mirror.
10	2021	Dr.R.Gandhi	IOT based system for smart park as the methodology, the user through the web application will contoll the system and the user need to scan his fingr print to park or retreive the car and that done by conncting to a cloud database that save the data of the registered finger prints and the main IOT microcontoller is the ESP8266.	Not a fully automated as the user need to deal with the control panel system and scan his finger print to park or retrieve.
11	2018	P.S.Shri Harish et al.	Automated rotary car parking system where it depends on using chain drives with roller switches as well as the chain drive is driven by a DC motor which programmed and controlled by PLC though WPL software	The system is not dependent on the IOT and does not provide any innovative ideas. Like: the system lacks the option of rotating the car pallet
12	2021	Alnakar & Catovic	Built-up and developed a rotary car park which could hold 5 vehicles controlled by Arduino uno microcontroller as well as the rotary movement based on a chain and sprockets connected to a DC motor.	The system is not fully automated as the user need to deal with the control system and use the keypad in order to park or retrieve.

13	2020	Supratno et al.	A vertical parking automatic control system controlled by Programmable Logic Control (PLC).	system is not fully automated & required a physical actions from the user as well as there is no implementation of IOT system.
14	2021	M.Raghupathi et al.	Design analysis of rotary car parking system, which is driven by a chain and sprocket mechanism and a wiper motor is used in order to drive the required power to the system.	No implementation of any automation or IOT system
15	2018	Agrawal et al.	An RFID based rotational Car parking system; the system is developed based on RFID technology as the system is consist of a RFID read which is placed in front of the vehicle parking system.	Physically Process for park or retrieve the car by swiping the RFID card, No usage of IOT technology or mobile application.

2.3 Summary

In this chapter literature review had been done for the 15 journals, five journals focused on the designing as well as developing of the rotary car park. However, the other five had focused on the developing the IOT software application for smart parking system. Furthermore, the last 5 which had been added in phase 2 are mainly focus on the fully implementation of the RPS . Throughout the chapter the aims, outcomes and proposed methodology for each paper had been illustrated. The gaps had been identified for each paper which will be improved in this current proposed project to enhance the user experience.

CHAPTER 3

CONCEPT DESIGN AND RESEARCH METHODOLOGY

3.1 Introduction

Chapter 3 will illustrate the detailed procedure, investigation on tools and the proposed methodology of the automated RPS project, the detailed 2D and 3D sketches of the rotary car park model that could hold 5-cars. Also, the developed IOT GUI system is explained. Along with the standard rules, laws of safety and legal responsibilities of professional engineering practices is mentioned. Therefore, chapter 3 gives a detail justification of the project as well as the management of the timeline of the project with the aid of Gannt chart. Not only that but also the entrepreneurship 1 of the system alongside with the estimated cost analysis.

3.2 Investigation of tools and techniques

The tools as well as software which are implemented to achieve the mentioned aim and objectives of automated rotary car park are investigated. Justification of choices had been explained with aid of comparison tables to ensure the achievement of the system.

3.2.1 Microcontrollers

Microcontrollers are main components of any embedded or control system. Moreover, microcontroller is the Integrated Circuit (IC) which is part of the electric circuit that developed (programmed) to give instructions and specific tasks to the actuators in the system. Besides, some microcontrollers have the ability to connect actuators and sensor with the internet connectivity which lead to an IOT automated systems.

Arduino Uno is a microcontroller board that based on the ATmega3289. It has 14 digital input and output pins, 6 Pulse Width Modulation PWM pin and 6 analogue pins. Moreover, it consists of a USB connection, power jack and reset button. It could be connected to the computer by USB cable.

Arduino Nano 33 IOT is a microcontroller board which based on Arm Cortex 32-bit. It has the ability of Wi-Fi and Bluetooth which lead it to be an IOT microcontroller. It consists of 14 digital/output pins, 11 PWM pins and 8 analogue input pins and 1 analogue output pin.

ESP32 is a low-cost, low-power system chip microcontroller that implanted with Wi-Fi and Bluetooth options. ESP32 is a dual core CPU that operate from 160MHz to 240MHZ. Not only that but also, it is considered a 32-bit microcontroller with 16 PWM pins and 34 General Purpose Input/Output (GPIO) pins. The ESP32 is mainly used for IOT projects.

ESP8266 is a low-cost system chip microcontroller which consist of single core process that operate at 80MHZ. Also, it is the ability of Wi-Fi and Bluetooth connection. Furthermore, it consists of 8 PWM pins and 11 GPIO pins. Moreover, both ESP32 and ESP8266 has only 1 or 2 analogue pins.

Table 3.1: Comparison of Microcontrollers

Specifications	**Arduino Uno**	**Arduino Nano 33 IOT**	**ESP32**	**ESP8266**
Chip	Atmega 3289	Arm Cortex 32-bit	Xtensa Single-core 32-bit	Xtensa Dual-Core 32-bit
Operating voltage	5 Volt	5 Volt	3.3 Volt	3.3 Volt
Current rating per I/O pin	20 mA	7 mA	15 mA	15 mA
Digital I/O pins	14	14 (6 – PWM)	36	11
PWM	6	11	36	8
Analogue pins	6	8	1	2
Flash memory	32 KB	32 KB	4 MB	4MB
Bluetooth	No	Yes	YES	YES
Wi-Fi	No	YES	YES	YES
Clock speed	16 MHz	48 MHz	52MHZ – 160MHZ	80 MHZ
Temperature sensor	No	No	YES	NO

Based on the comparison that had been done the ESP32 microcontroller had been chosen to be the main microcontroller of the rotary car park system. Because it consists of the needed specification to achieve the objectives of the project, as the main specification is the Wi-Fi connectivity.

3.2.2 Software

There are 2 main developing software will be used for the developing process. Arduino Integrated development environment (IDE) is a cross-platform that developed by C programming language which used to write programs to microcontroller boards. Furthermore, it is the chosen developing software, to connect between the ESP32 microcontroller and the IOT cloud. Moreover, the Arduino IDE had chosen because the ESP32 board is compatible to Arduino IDE.

For the IOT cloud application software there are different IOT platforms which could be used. The IOT platform is used to connect between GUI and the rotary park system's sensors and actuators. The following table shows a comparison between different IOT platforms:

Table 3.2: Comparison of IOT Platforms

Specifications	**MIT APP Inventor**	**Arduino IOT Cloud**	**Blynk**
Programming language	Blocks Programming Language	Text Code Compatible with Arduino IDE	Text Code Compatible with Arduino IDE
GUI developing	Availability of GUI Widgets & Customizability of front-end interface	Very limited Widgets & customization options for end-user interface	Limited Widgets & customization of end-user interface
Compatible boards	Support for cloud Arduino & ESP32 boards	Support for Cloud Arduino &ESP32 boards	Support for cloud Arduino & ESP32 boards

Connectivity with Arduino IDE	Could be connected to Arduino IDE by specific Libraires	Direct, Easy connection	Could be connected to Arduino IDE by specific Libraires
Cloud Remote – Mobile App	Only for Android users	Applicable for IOS & Android user	Applicable for IOS & Android user
Pricing	Free	Low	Very Expensive

Based on the above comparison, the MIT APP Inventor IOT cloud platform is chosen to be the main IOT platform for the system to develop the GUI application and connect the user inputs with the rotary car park system's sensors and actuators.

For the Database, (ThingSpeak and Google Firebase) databases are chosen to be implemented in this project as it gives the option to connect between the ESP32 and the sensors readings as well as takes instruction from the GUI then send it to the ESP32 to control the actuators.

3.2.3 Sensors, Actuators & Miscellaneous Components

IR proximity sensor play an important role to achieve the project's aim. After investigation different sensor features and the literature reviews. The following table represent the main sensors that will be used for the project:

Table 3.3: Specifications of Proposed System Sensors

Specifications	**E18-D80NK IR Infrared Sensor**	**IR Infrared Sensor**
Mian Chip/ Module Name	E18-D80NK	LM393
Operating Voltage	5V	3.6V – 5V
Current Consumption	100mA	0.06A
Distance Range (CM)	3-80	2 – 30
Detection Angle	15º	35º

The table above is an overview of the sensors which will be used for the project to achieve the aim and objectives. Each sensor was chosen to do specific task. Therefore, IR sensor had been chosen to detect the parking status of each slot from the 5 main slots either the slot is free or occupied. Besides, it helps the driver in the parking process. Not only that but also the IR sensor is used for the rotating process as once it detects an occupied slot it will let the motor to rotate to provide another free slot. E18-D80NK IR sensor is mainly will used for the safety purpose of the system. In which the sensor will be used to detect either there is a person in the rotating parking area and in such case the system will stop for the safety of the user.

For the actuators there are two main motors will be used in this project. The following table represent the main specification of the proposed motors:

Table 3.4: Specifications of Proposed System's Actuators (Motors)

Specifications	**DC Gear Motor**	**Servo Motor**
Torque	12kg.cm	2.5kg.cm
Operating Voltage	6V	5V
Rotation Angle	0^o -360^o	0^o -180^o
Weight	154 g	9 g
Operating Speed	10 RPM	0.1s/60°

The above table shows the main proposed motors which will be used for the RPS. DC gear motor will be used to control the gear chain and the sprocket for the rotary process of the 5 car slots. In addition to that, DC gear motor will be connected to the ESP32 board so based on the specific sensors reading it will rotate with a specific angle to provide the free car slot. Furthermore, the servo motor will be responsible of the rotation of the circle disc which will be placed on each car slot. Because, in this proposed system each user will have the option to rotate the circular disc during the retrieving process to make it easier while exiting the parking area. In order to be able to control the DC gear motor speed and movement, a motor driver should be implemented. The following table shows different types of motor drivers:

Table 3.5: Comparison of Motor Drivers

Specifications	L293D	L298N	TB6612GNG
Driver Type	Transistor	Transistor	MOSFET
Channel output	2	2	2
PWM Support	YES	YES	YES
Motor Voltage	4.5V to 36V	4.5V to 46V	2.5V to 13.5V
Peak Current	1.2A	3A	3.2A
Continuous Current	600mA	3A	3.2A
Cost	5RM	6RM	10RM

Based on the above table the chosen motor driver is L298N as based on the choose DC motor and the project need it is most suitable and also cost effective The following table shows the main miscellaneous components and their usage in the project:

Table 3.6: Miscellaneous Components

Component	Application
LEDs (RED & Green)	To represent the status of each slot either occupied or not. Besides, the red alarm light indication for safety situations.
LCD (16*2 Display Board)	To display information for diver such as: Slot number, Instruction & Guides for parking process on the pallet.
Front Mirror	Placed to help the driver during the parking process on the slots

3.2.4 Mechanical components

There are more than one mechanical component needed for this project.

Table 3.7: Implemented System Mechanical Components

Component	Quantity	Application
Sprocket	4	To transmit rotation motion generated from motor to a Gear chain
Gear Chain	2	It mainly attached and connected between two sprockets to transmit its rotary motion between them.
Rectangle Plate	5	It is the rectangular structure that the cars will be places on it
Circular Discs	5	It is the Circular structure which will be placed on the plates to help the car to rotate by 180^{o}-degree for easier retrieving process.
Frame	2	They considered the main structure body for the rotary park system model, where the components of the system will be installed on it.

3.3 Proposed methodology

3.3.1 Block Diagram

The project methodology is proposed based on the reviewing of the past related projects mentioned in chapter 2. The proposed system could be divided in two main sections. First section is the designing and build up the rotary car park prototype which could hold 5-cars. Second section is the IOT based software for the automatic RPS, it consists of the GUI mobile application, microcontroller ESP32, ThingSpeak IOT Database and the Sensors & actuators.

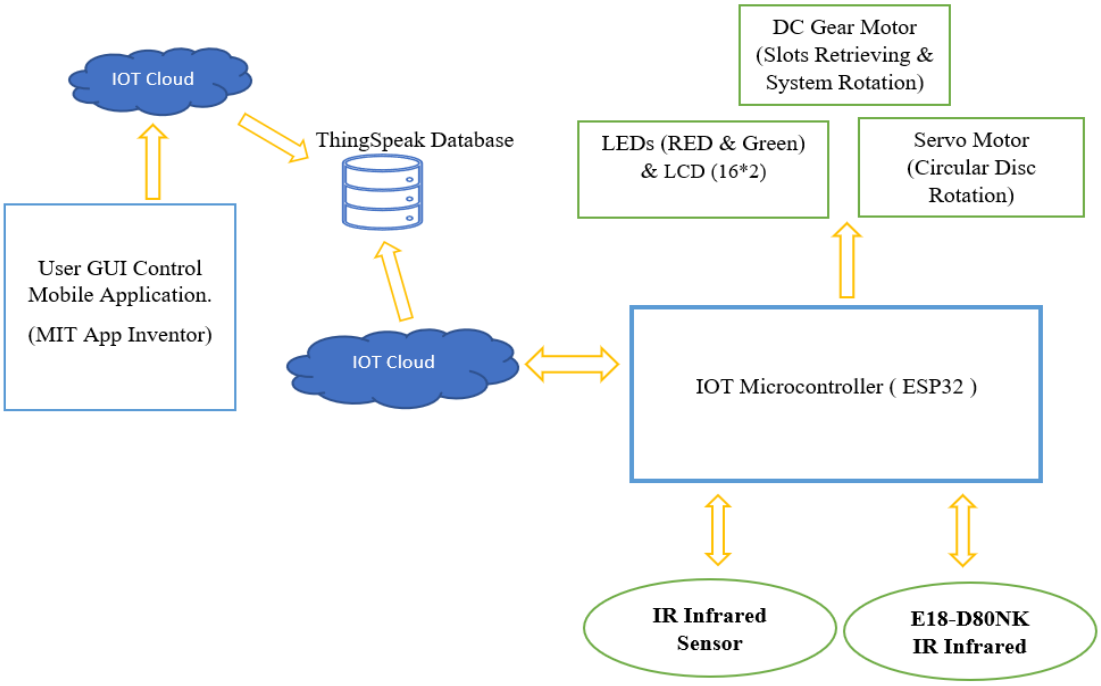


Figure 3.1: Block Diagram of Proposed Automatic Rotary Car Park System

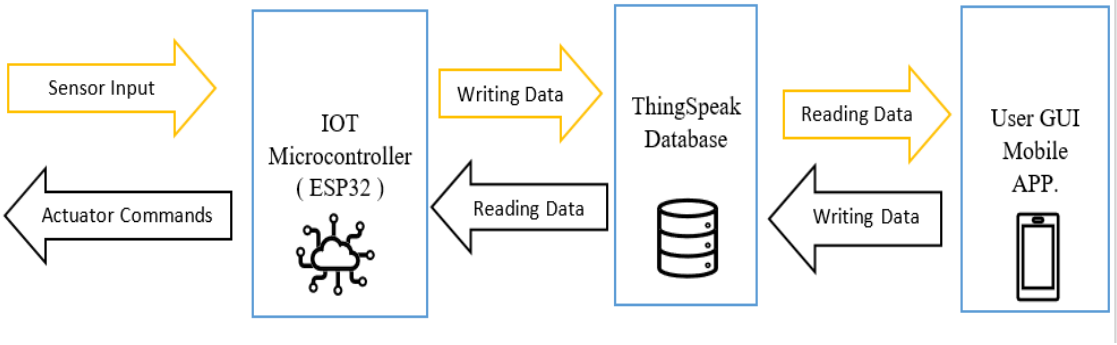


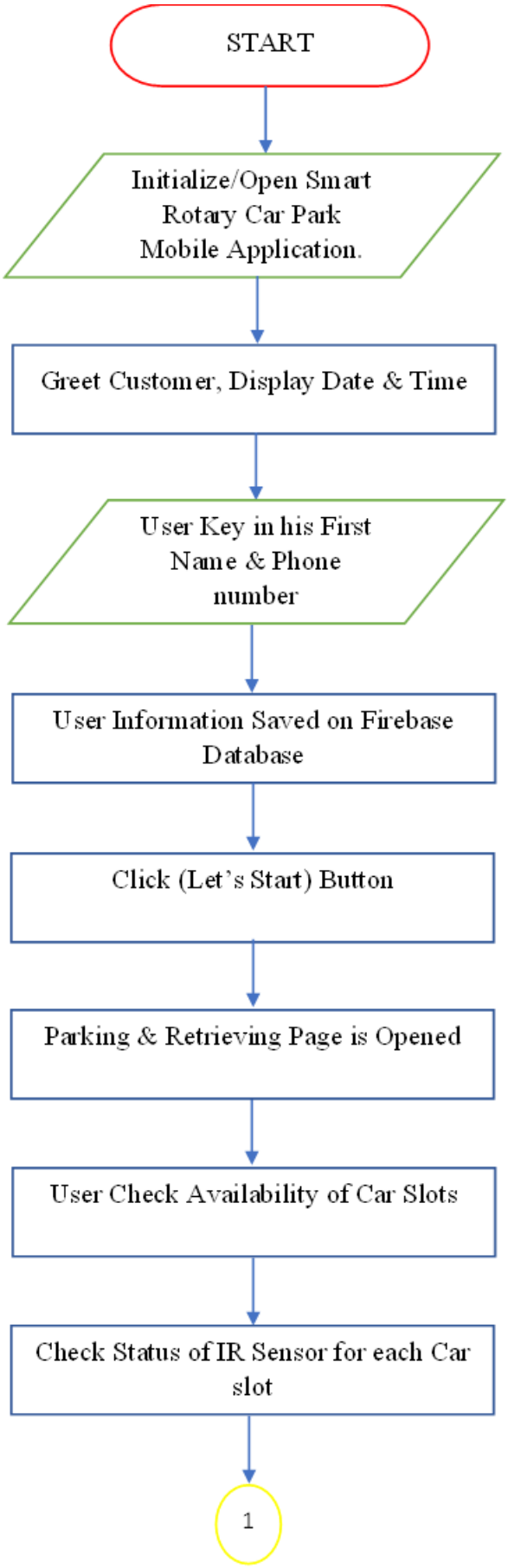
Figure 3.2 : Proposed Overall Block Diagram of the System

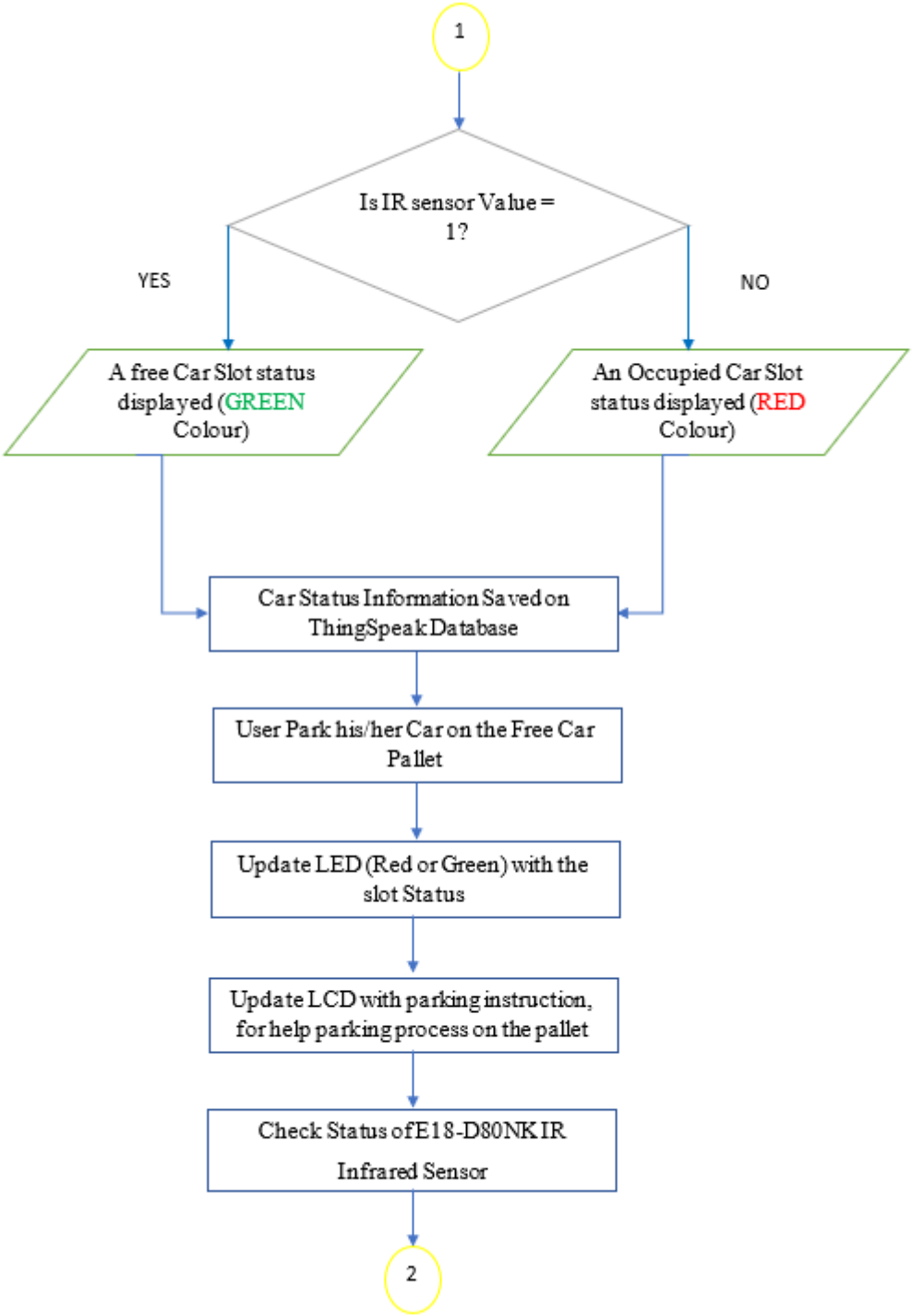
Figure 3.1 and figure 3.2 shows and explain the proposed block diagram of the IOT based automatic rotary car park system. Furthermore, the system is mainly based on the IOT microcontroller ESP32. Where the ESP32 is responsible to get the information from the 2 main sensors and control the 2 main actuators. The IR sensor that placed on each car slot from the 5 main slots and also placed at the bottom of the system in order to decide the availability of car slots, help the drivers in the parking process and help in the rotation process of the car slots. The E18-D80NK IR sensor is responsible for the safety of the system, as it will check if there is any person within the parking area.

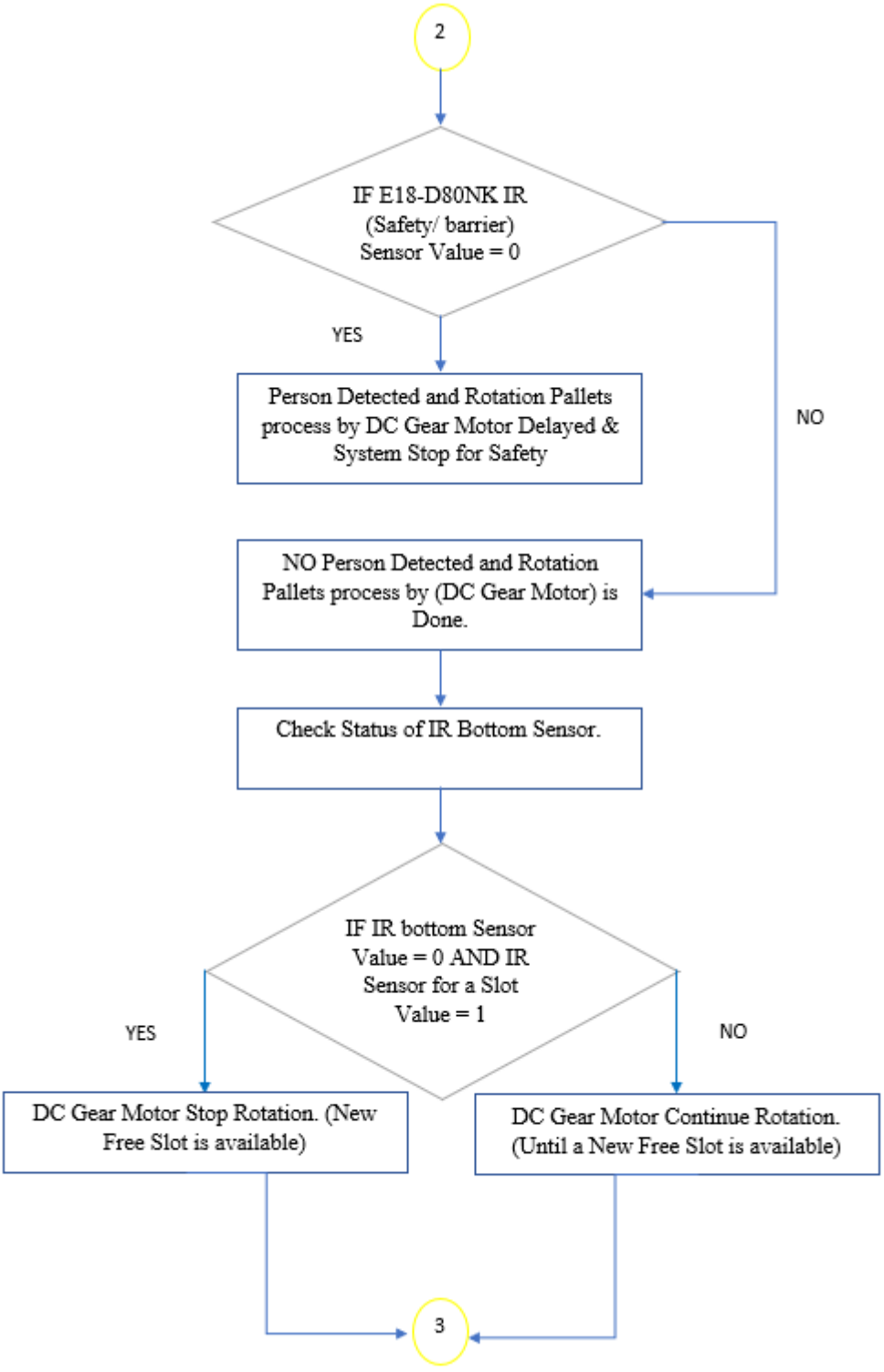
In Addition to that, the ESP32 microcontroller will send and save all the sensors and actuators information on the ThingSpeak database. ThingSpeak database will be the connection between the ESP32 and the sensors and the GUI which had been developed by MIT App Inventor. The GUI is responsible for registration of the user to the application. Besides it will display to the user the availability car slots. Not only that but also, through the GUI the user will have fully control on the system.

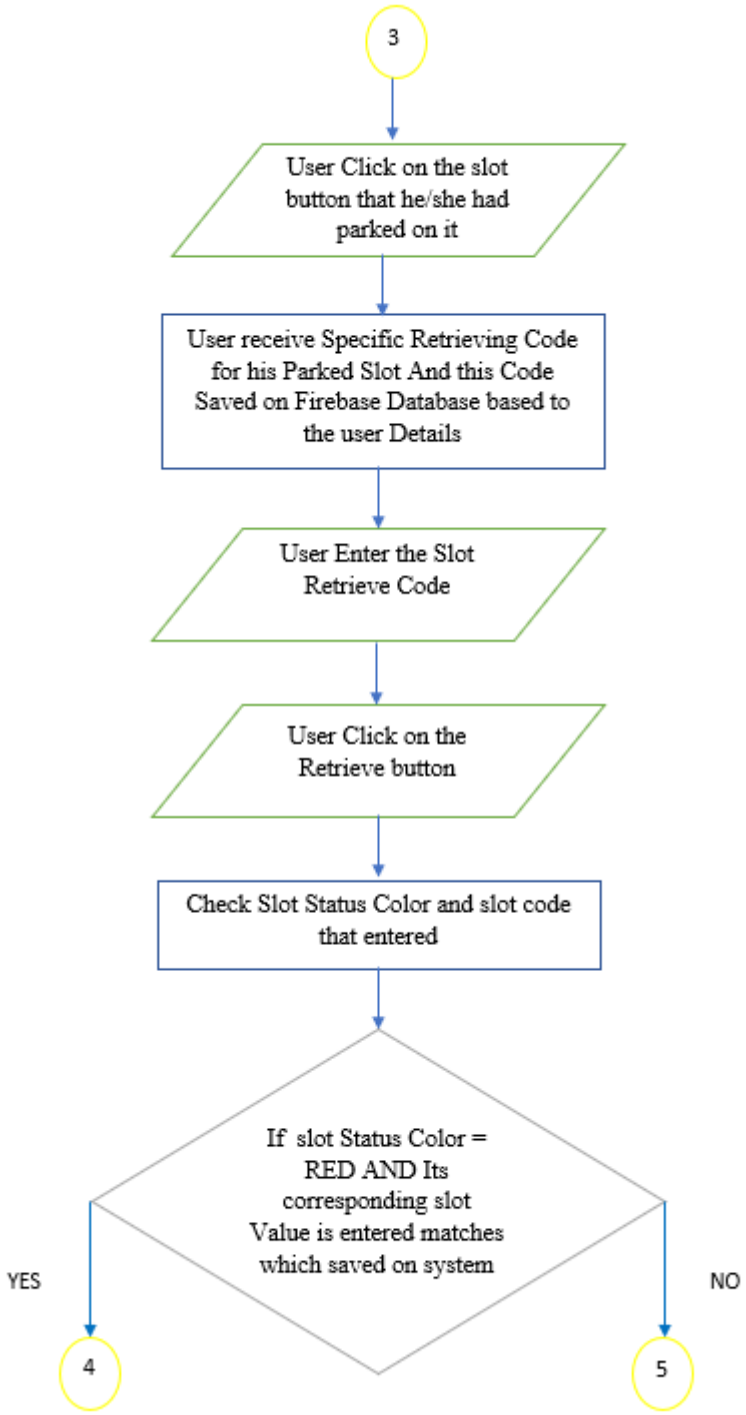
Moreover, the 2 main actuators (the DC gear motor and servo motor) are responsible for the rotation of the car slots and rotate the circular disc of car plate respectively, are also controlled by the user through the GUI as the information are sent to the database then to the ESP32 microcontroller.

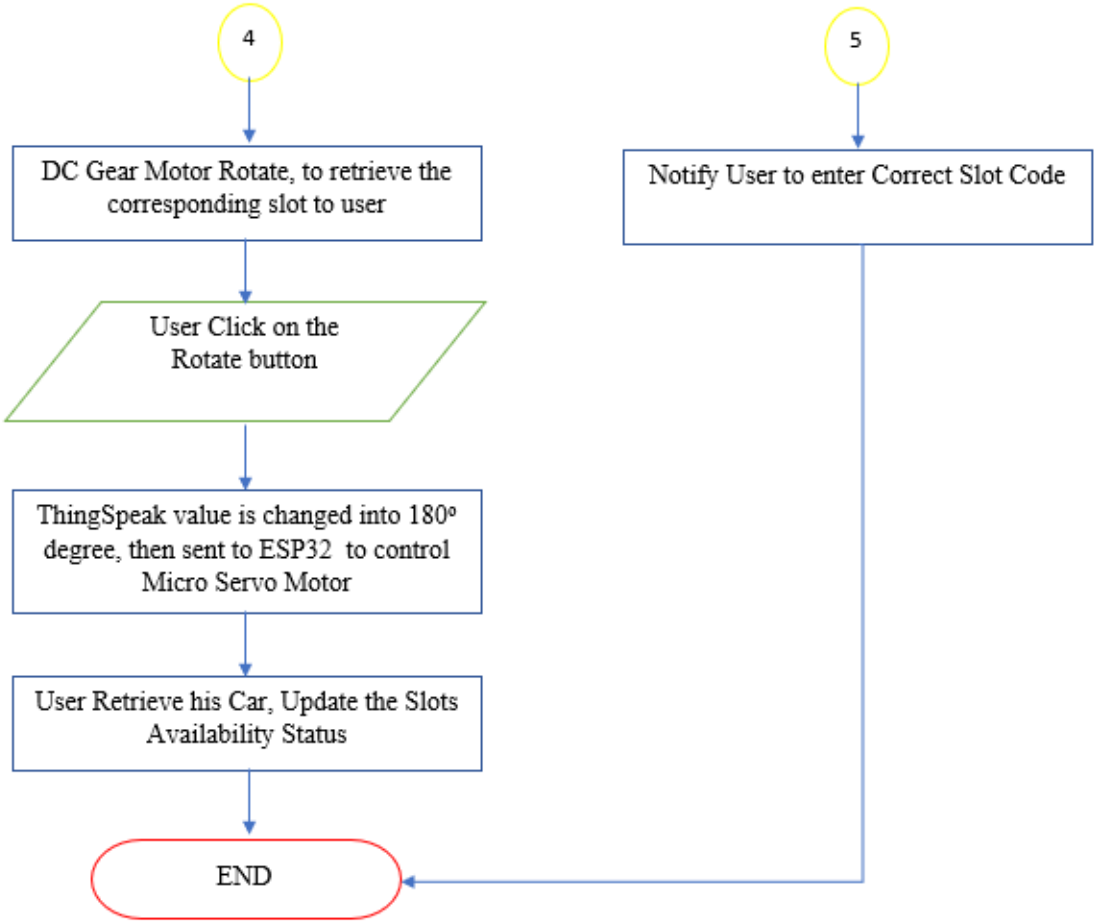
3.3.2 Flow Chart




1
Is IR sensor Value = 1?
YES
NO
A free Car Slot status displayed (GREEN Colour)
An Occupied Car Slot status displayed (RED Colour)
Car Status Information Saved on ThingSpeak Database
User Park his/her Car on the Free Car Pallet
Update LED (Red or Green) with the slot Status
Update LCD with parking instruction, for help parking process on the pallet
Check Status of E18-D80NK IR Infrared Sensor
2


2
IF E18-D80NK IR (Safety/ barrier) Sensor Value = 0
YES
NO
Person Detected and Rotation Pallets process by DC Gear Motor Delayed & System Stop for Safety
NO Person Detected and Rotation Pallets process by (DC Gear Motor) is Done.
Check Status of IR Bottom Sensor.
IF IR bottom Sensor Value = 0 AND IR Sensor for a Slot Value = 1
YES
NO
DC Gear Motor Stop Rotation. (New Free Slot is available)
DC Gear Motor Continue Rotation. (Until a New Free Slot is available)
3


3
User Click on the slot button that he/she had parked on it
User receive Specific Retrieving Code for his Parked Slot And this Code Saved on Firebase Database based to the user Details
User Enter the Slot Retrieve Code
User Click on the Retrieve button
Check Slot Status Color and slot code that entered
If slot Status Color = RED AND Its corresponding slot Value is entered matches which saved on system
YES
NO
4
5


4
5
DC Gear Motor Rotate, to retrieve the corresponding slot to user
Notify User to enter Correct Slot Code
User Click on the Rotate button
ThingSpeak value is changed into 180º degree, then sent to ESP32 to control Micro Servo Motor
User Retrieve his Car, Update the Slots Availability Status
END

The above is the proposed flowchart for the system, firstly, the user will open the mobile application and register his/her name and phone number which will be saved on Firebase database. Then he/she will check the availability of car slots. The availability of car slots is based on the IR sensor reading that attached on each car pallet, so if the car is parked the IR sensor value will be zero and indicates that on the GUI by display a red color for the corresponding slot, while if the pallet is free IR sensor value will be one and shows a green colour on the GUI. Besides, all the slots status information that gained from sensor are saved on ThingSpeak Database to be sent to MIT app inventor and appear the status on the GUI. The next step will be that the user will park the car on the pallet as the implemented LCD will instruct him/her to park the car as well as the front mirror which will help the drivers in the parking process.

Furthermore, E18-D80NK IR Infrared Sensor will be implemented to work as safety sensor, which means that the DC gear motor will not rotate until the user goes out from the parking area. Moreover, the rotation of the DC gear motor will depend also on the IR sensor (placed on the bottom of the plates), thus the DC gear motor will rotate the pallets until the IR sensor detects a free slot, at this moment the DC gear motor will stop to provide a new available slot for a new user. From the GUI application the user will have to select his/her slot to receive a notification or SMS message with the slot code where he/she will use it in the retrieving process. When the user needs to retrieve the car, he/she just need to enter the slot code and click on the (Retrieve) button through the GUI. After that, the system will compare the code that the user entered with the specific code for each slot that saved on the Firebase database to operate the DC gear motor and rotate the system.

Lastly, the user has the option to click on the (rotate) button to rotate the circular disc which will be placed on each pallet, once the user clicks on rotate button a signal will be sent to ThingSpeak database to change the value of corresponding servo motor from 0 to 180, then ThingSpeak database sends this signal value to the ESP32 microcontroller to control the servo motor and let it rotate by 180^{o} degree.

3.4 Concept design derived from fundamental engineering principles

This section will illustrate the design of mechanical components which will be used in the implementation phase, the proposed GUI and the developed programming code.

3.4.1 GUI

Through MIT App Inventor IOT platform the GUI of the system had been designed and developed. The following figures shows the proposed GUI design for the system:

Figure 3.3: First page for GUI of the proposed System

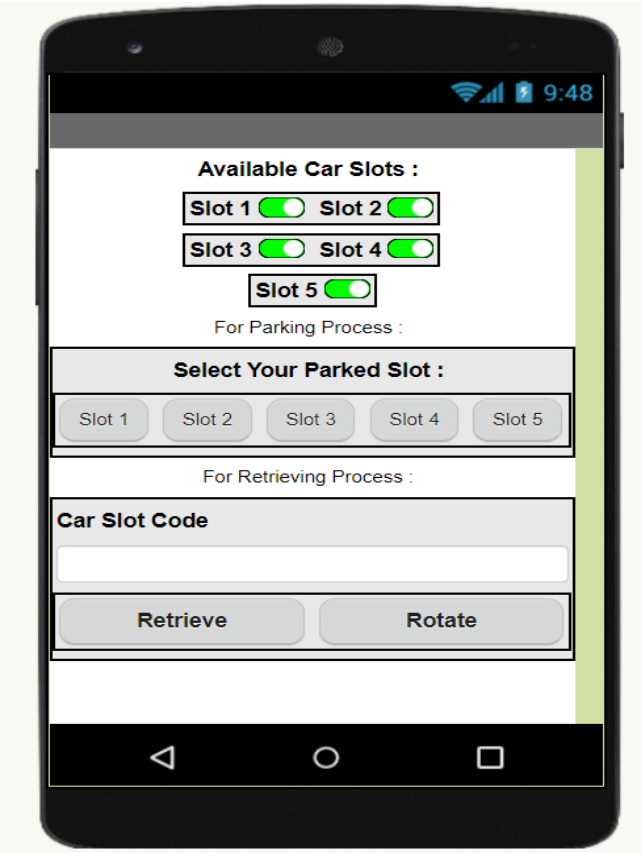


Figure 3.4: Second page for GUI of the proposed System

As per Figure 3.3 & Figure 3.4, The first page is a welcome page for the user, where the date and time will be displayed, as well as a definition sentence is shown to explain the main usage of this mobile app. Not only that but also, the user in this first page will enter his/her first name and phone number as this information will be saved on the database to be used later in the parking and retrieving process.

In the second page the availability of the slots is shown based on the IR sensor reading, thus, the green colour indicates free slot, while red colour indicates occupied. Furthermore, the user will push the slot's number to receive a specific code for this slot to use it later for retrieving the car. For the retrieving process, the user will enter the code and click on the retrieving button, if it match what had been sent to him/her the rotation process will begin. Additionally, the user can use the rotate button to rotate the circular disc of the pallet with 180^0 degree.

3.4.2 Programming Code

This section will illustrate and explain the initial code of IOT based automatic RPS, the developed code through MIT app inventor and Arduino IDE for the IOT mobile application.

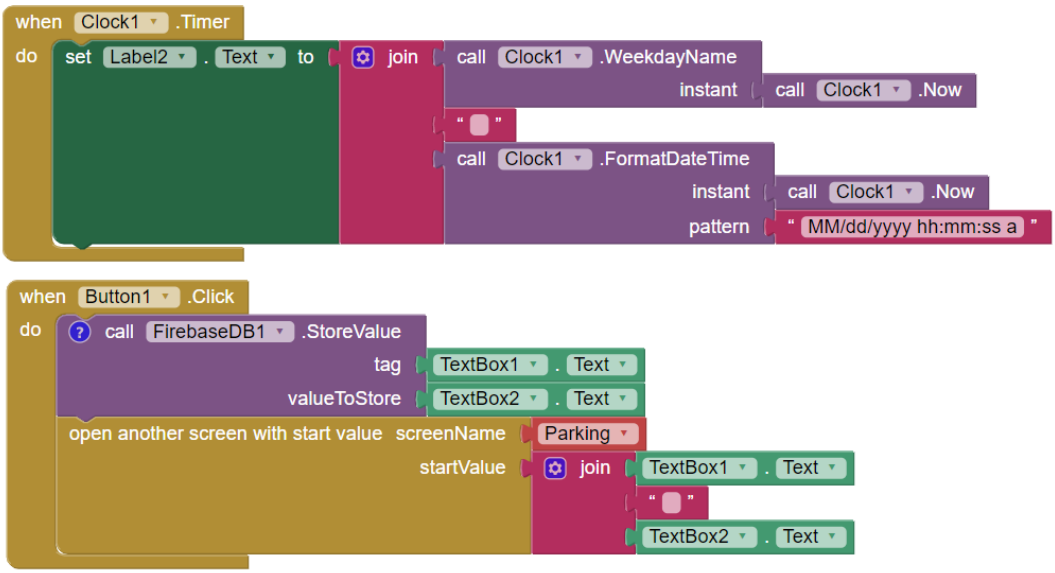


Figure 3.5: MIT app Inventor GUI First page Code

As per Figure 3.5, the developed code for the first page of the mobile application, it will display to the user current date & time. Additionally, it allows the user to push the button to open the second screen as well as it will save his/her name and phone number which had written in the textboxes to be used in the database process.

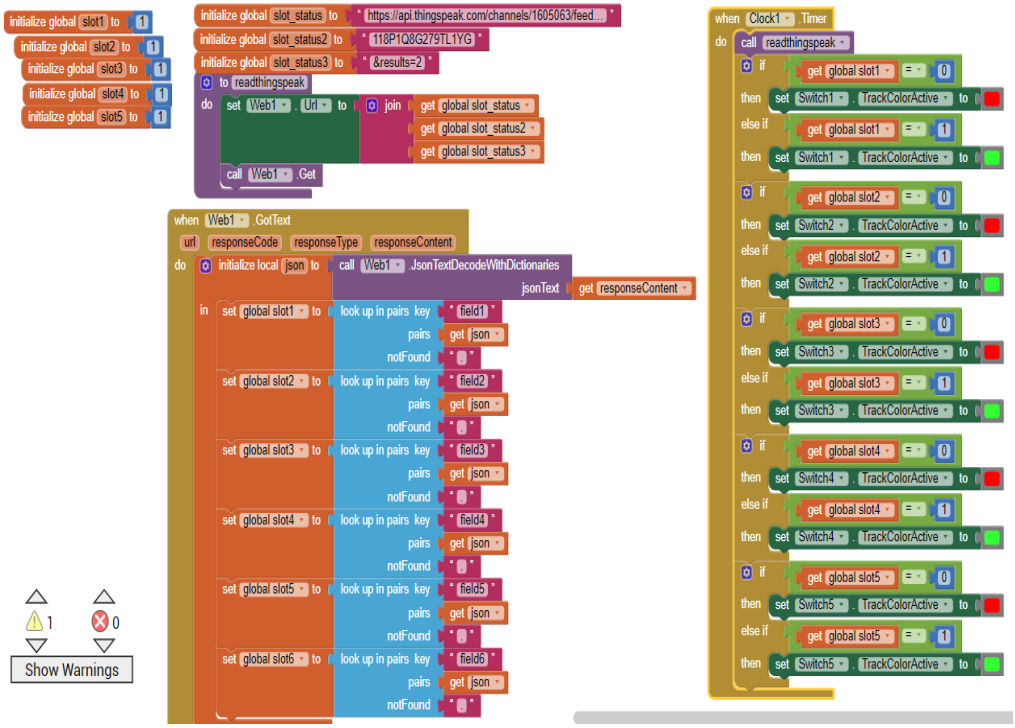


Figure 3.6 : MIT & ThingSpeak Initializing Connection Code

```
#include <ThingSpeak.h>
#include <WiFi.h>
WiFiClient client;
//#include <Servo.h>
#include <Servo_ESP32.h>
#include "Arduino.h"

#define channel_ID 1605063
#define apiKey  "PXOTY9930LETMTA0"

#define ssid  "ziad-TIME2.4Ghz"
#define pass  "2zea200299"

void connectToWifi(){
  Serial.print("Connecting to Wifi");
  //WiFi.mode(WIFI_STA);
  WiFi.begin(ssid,pass);
  Serial.print("Connecting");
  while (WiFi.status() != WL_CONNECTED)
  {
    delay(500);
    Serial.print(".");
  }
  Serial.println();
  Serial.print("Connected, IP address: ");
  Serial.println(WiFi.localIP());
}

void setup()
{
  Serial.begin(115200);
  connectToWifi();
  ThingSpeak.begin(client);
  pinMode(IRsensor1, INPUT);
  pinMode(IRsensor2, INPUT);

void loop()
{

 int slot1_status = digitalRead (IRsensor1);  ThingSpeak.setField(1,slot1_status);
 int slot2_status = digitalRead (IRsensor2);  ThingSpeak.setField(2,slot2_status);

 ThingSpeak.writeFields(channel_ID,apiKey);
```

Figure 3.7: Arduino IDE Code for IR sensor & Database Connection

Figure 3.6 and Figure 3.7, show the code that establish the connection between mobile application (MIT app inventor), IR sensor and ThingSpeak database. Through Arduino IDE firstly, ThingSpeak Library is identified and then the ThingSpeak's Channel ID and API key is declared. Secondly, connection of Wi-Fi is stabilized to connect the IOT ESP32 to the Wi-Fi Finally all the sensor readings is written in ThingSpeak Database by using (setField & writeFildes) functions.

Furthermore, the IR sensor send the data about the slot status either it occupied or not to ESP32 microcontroller. After that, ESP32 send data to ThingSpeak database and finally to MIT which responsible to display the result on the GUI. So, based on the reading the MIT receive from ThingSpeak it will display green color for a free slot indication or a red for an occupied slot. It should be noted that, this is considered the main process that will done for all the sensors through this project.

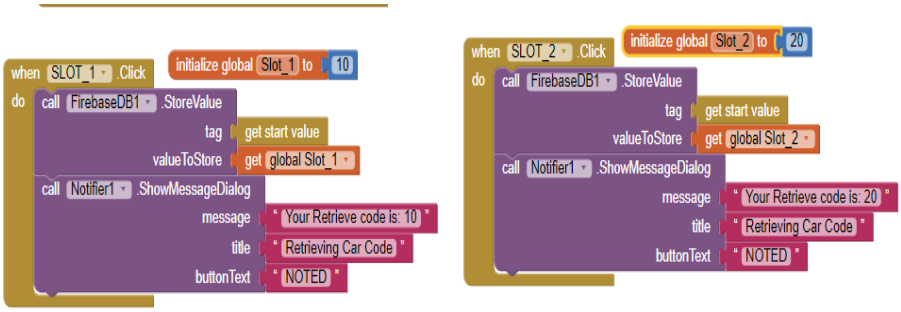


Figure 3.8: MIT app Code for Parking Process

Figure 3.8 shows the code of the process when the user parked the car and then the user can use the mobile application to select the parked slot, so once it is selected the user will receive a notification with his specific car slot code, where this code will be used later for the retrieving process. Furthermore, once the button of the slot is selected the user information with the specified code will be saved in Firebase database, as the database will be used in comparing between the data the user entered and the data which saved in it during the retrieving process.

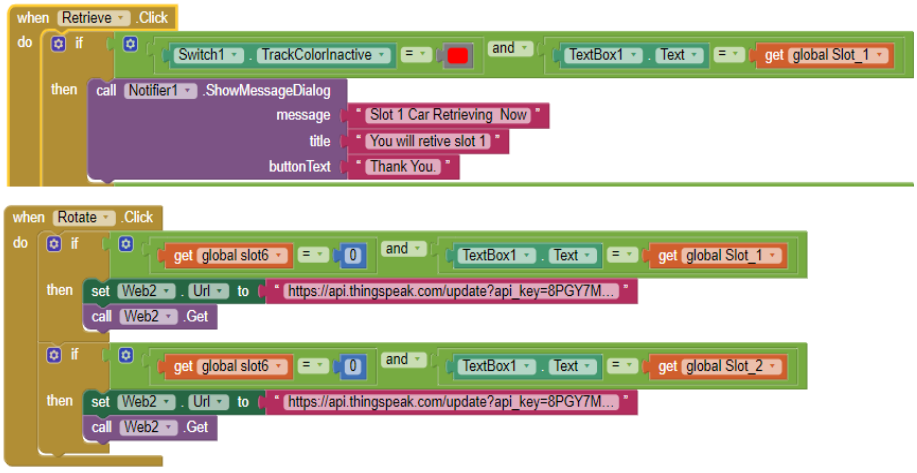


Figure 3.9: MIT app Code for Retrieving Process

```
Servo_ESP32 servo1;
int servoPin1 = 23;

Servo_ESP32 servo2;
//int servoPin2 =
```

```
pinMode(servoPin1,OUTPUT);
servo1.attach(servoPin1);

int A = ThingSpeak.readLongField(canalID1,1,readapikey);
Serial.println(A);
servo1.write(A);
```

Figure 3.10: Arduino IDE Code for Retrieving (Servo motor) Process

Figure 3.9 & Figure 3.10, show the developed code for the retrieving process, where it deals with the DC gear motor and Micro servo motor. Moreover, the process of retrieving is processed as follows: firstly, the user presses the retrieving button, so MIT app inventor send the signal to ThingSpeak database, then from database to ESP32 and lastly to the actuator to control its movement and rotation. For example, the following line of instruction:

[https://api.thingspeak.com/update?api_key=8PGY7MYRHBVBV2C4&field1=180]

is sent from IOT mobile application (MIT) once the user clicks the (Rotate) button through (set web.url) function to the ThingSpeak database, as well as it is saved on the database a value of (180), Then sent to the microcontroller to make the servo motor rotate by (180^{o} degree). Same process for (Retrieving) button information will be sent to DC gear motor from database and a specific slot will rotate if the user enters the correct code for it.

3.4.3 RPS Model Design

This section will illustrate the proposed initial 2D and 3D design for the RPS. So, the mechanical design had been designed by using SolidWorks software. The following figures represent the design of the mechanical parts:

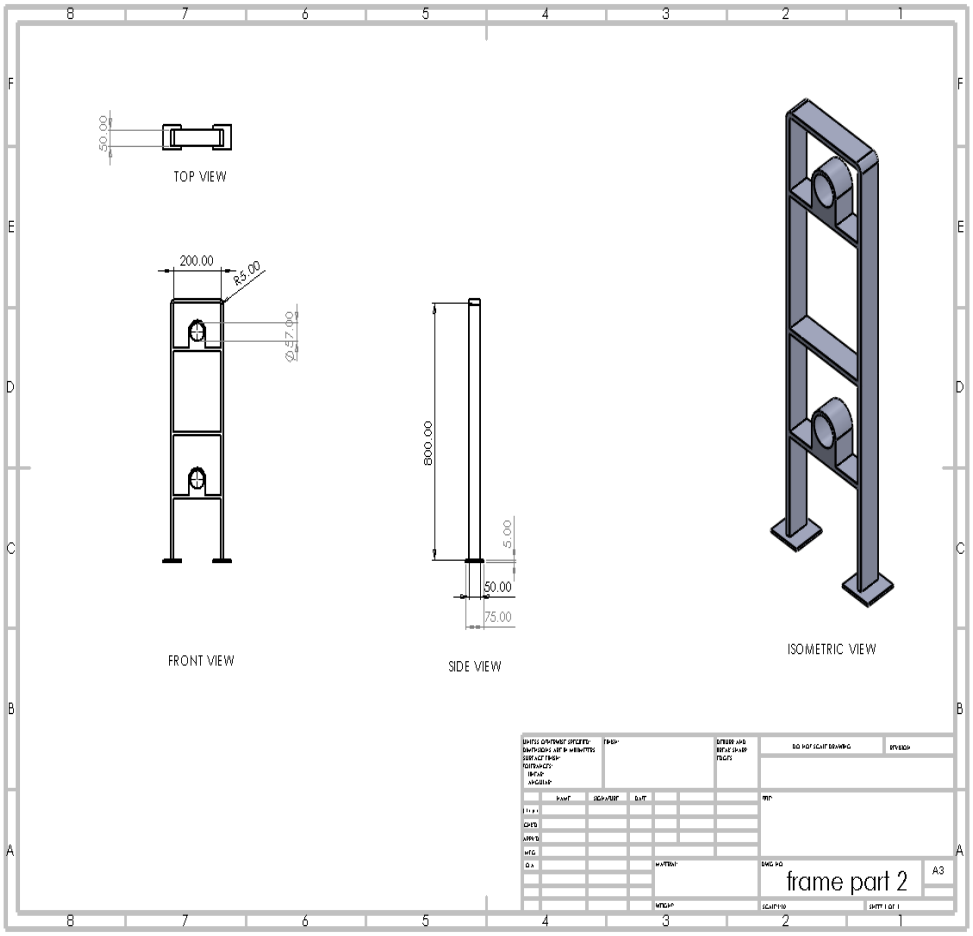


Figure 3.11: Design for RPS Frame

Figure 3.11 represents the main frame of the RPS with its dimensions. The frame is considered the main component for the system as on it, all the other components will be attached. The frame came with height of 800mm and width 50mm.

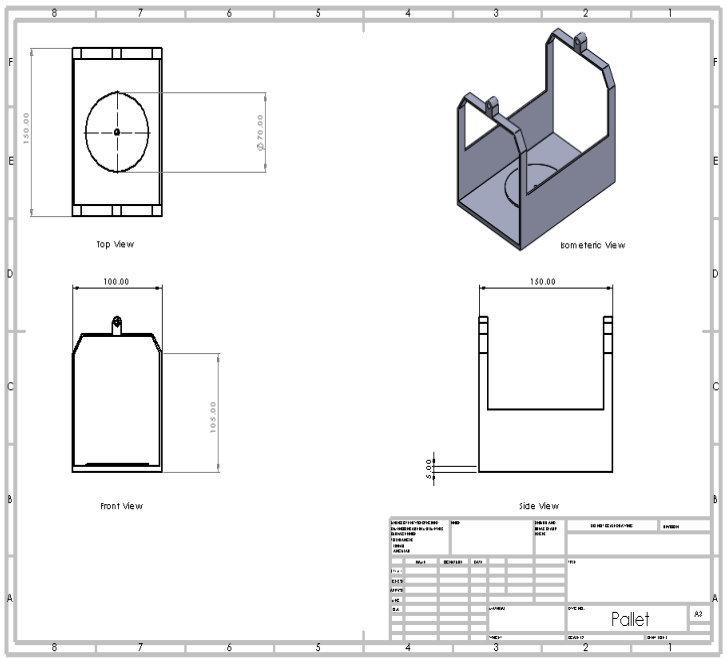


Figure 3.12: Design for RPS Car Pallets (Slots)

Figure 3.12 is shows the car pallets with its circular disc, where it is the slot which the car will parked on it as well as the circular disc give the car the option to rotate 180 degrees. The pallet with length and width 150mm and 100mm respectively. While the diameter of the circular disc is 70mm.

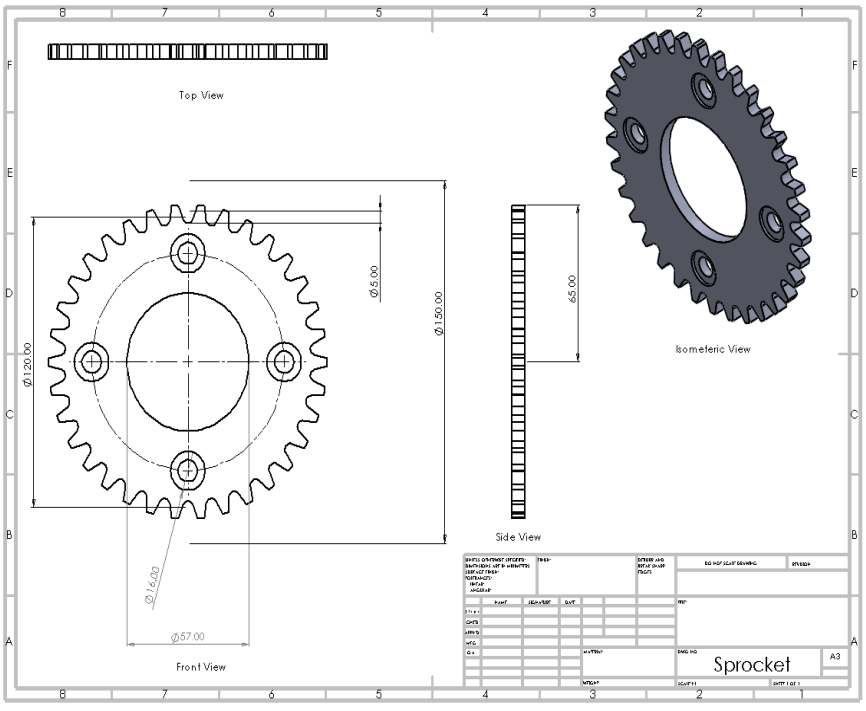


Figure 3.13 : Design for RPS Sprocket

Figure 3.13 shows the sprocket, which the gear chain will be attached to it and be responsible for the transfer rotary motion from the motor to the pallets. The diameter of the sprocket is 150mm and the inside circle come with diameter of 57mm.

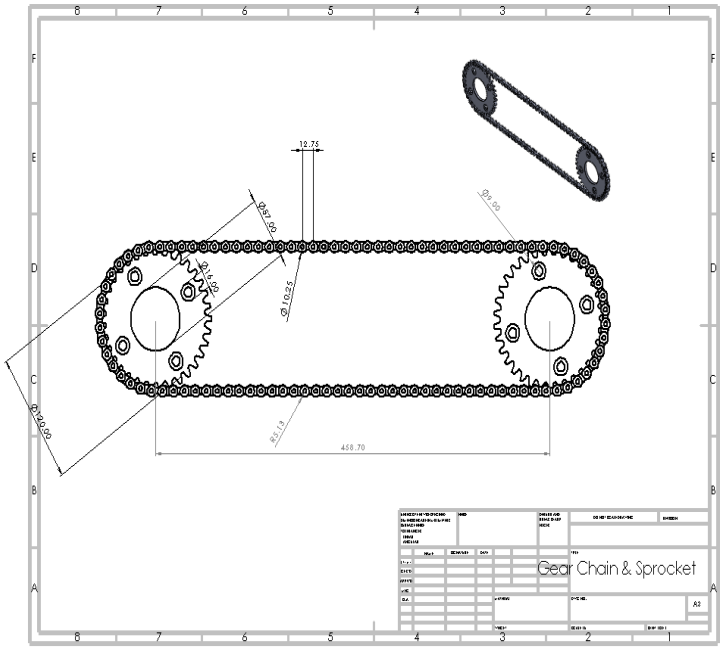


Figure 3.14: Design for RPS Gear Chain

As per Figure 3.14, the Gear Chain attached with the sprocket, where the Gear chain will be responsible for the transfer rotary motion as the 5-car slot will be attached on it the distance between the Center of the 2 sprockets (chain length) is 458.7mm and the inside circle come with diameter of 57mm.

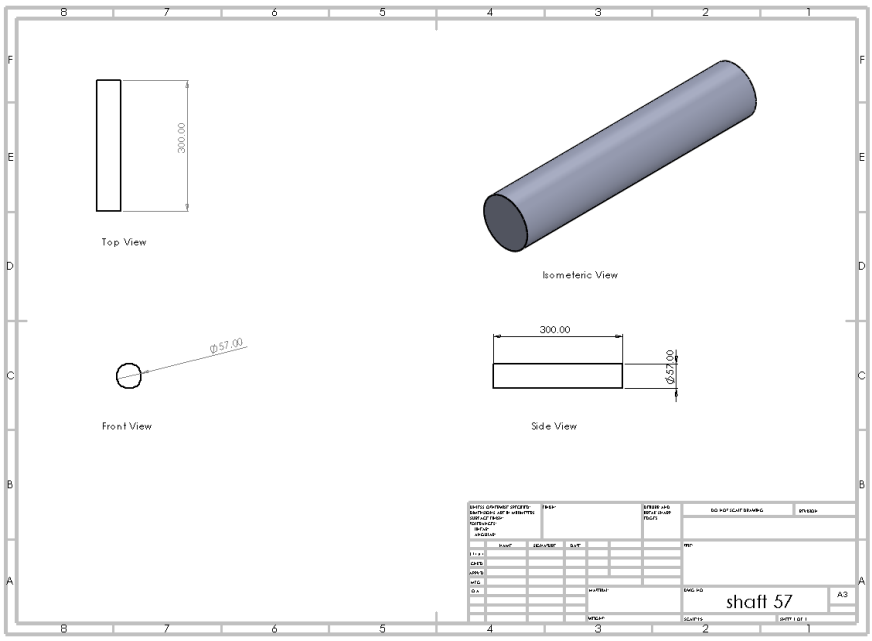


Figure 3.15: Design for RPS Sprocket Shafts

Figure 3.15 represents the shaft that will connect the 2 sprockets with each other. Moreover, this shaft will be connected to the DC gear motor, so it is main motion transfer as once it rotated the whole system (gear chain, sprocket and Slots) will rotate. The diameter of this shaft is 57mm, while its length is 300mm.

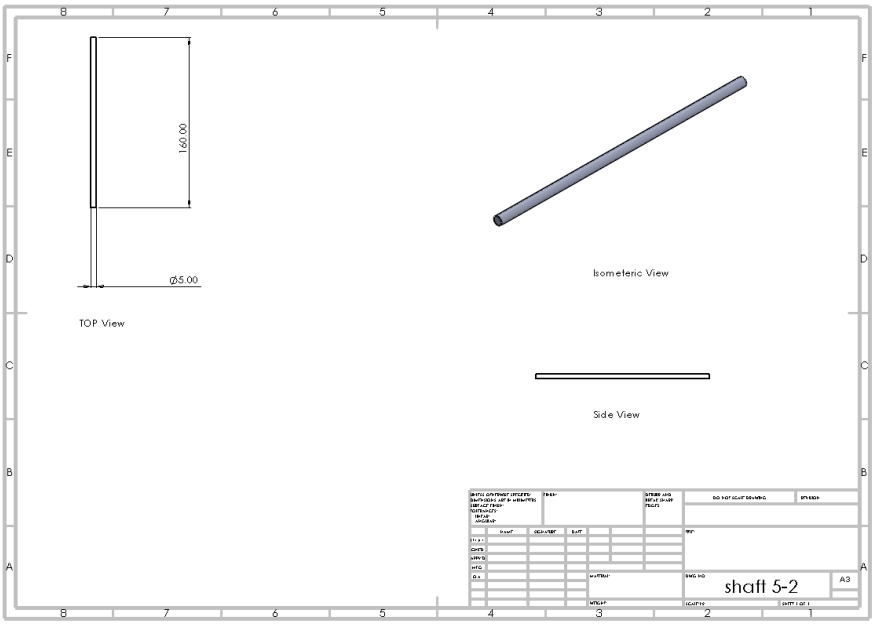


Figure 3.16: Design for RPS pallets Shafts

Figure 3.16 represents the shaft that will connect plates with the 2 gear chains. The diameter of this shaft is 5mm, while its length is 160mm.

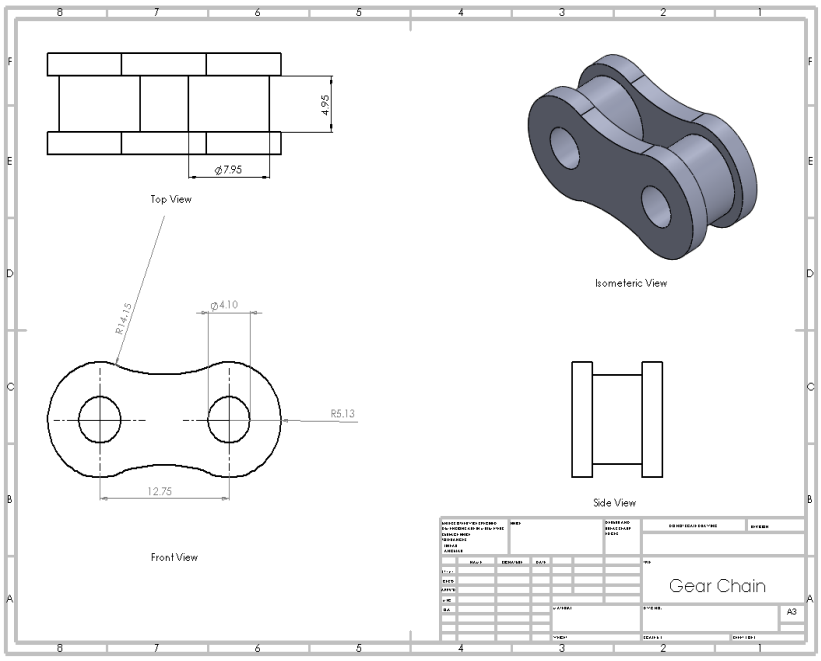


Figure 3.17 : Design for RPS Gear Chain

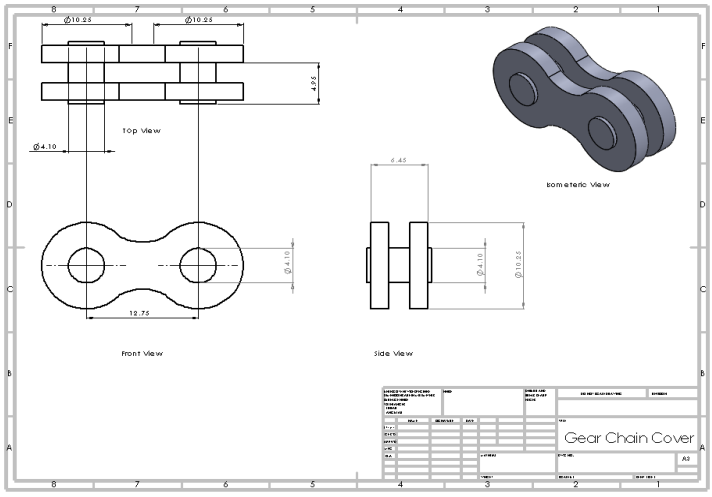


Figure 3.18: Design for RPS Gear Chain Cover

Figure 3.17 & Figure 3.18, shows the design of Gear chain and its cover, where once both parts are combined together, they give the assembled gear chain as shown in figure 3.11.

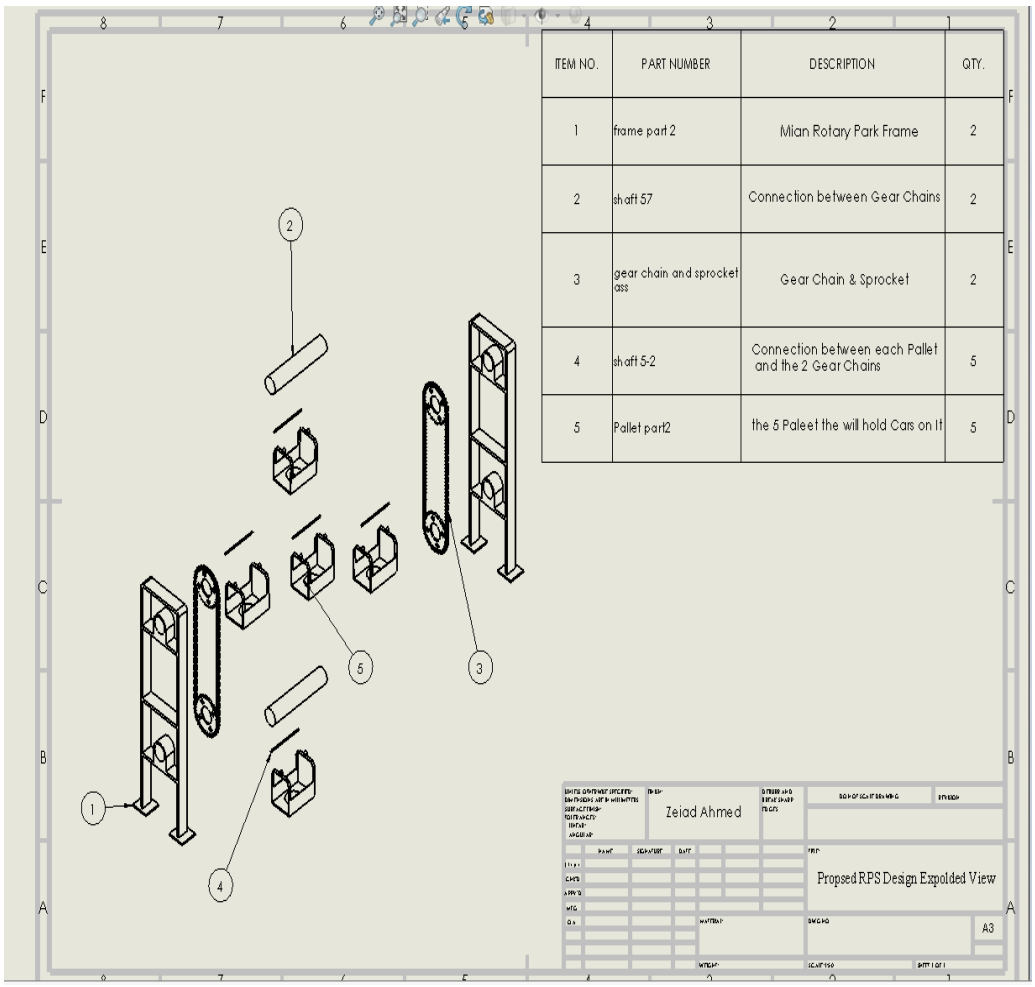


Figure 3.19: Overall Propsed Design for RPS

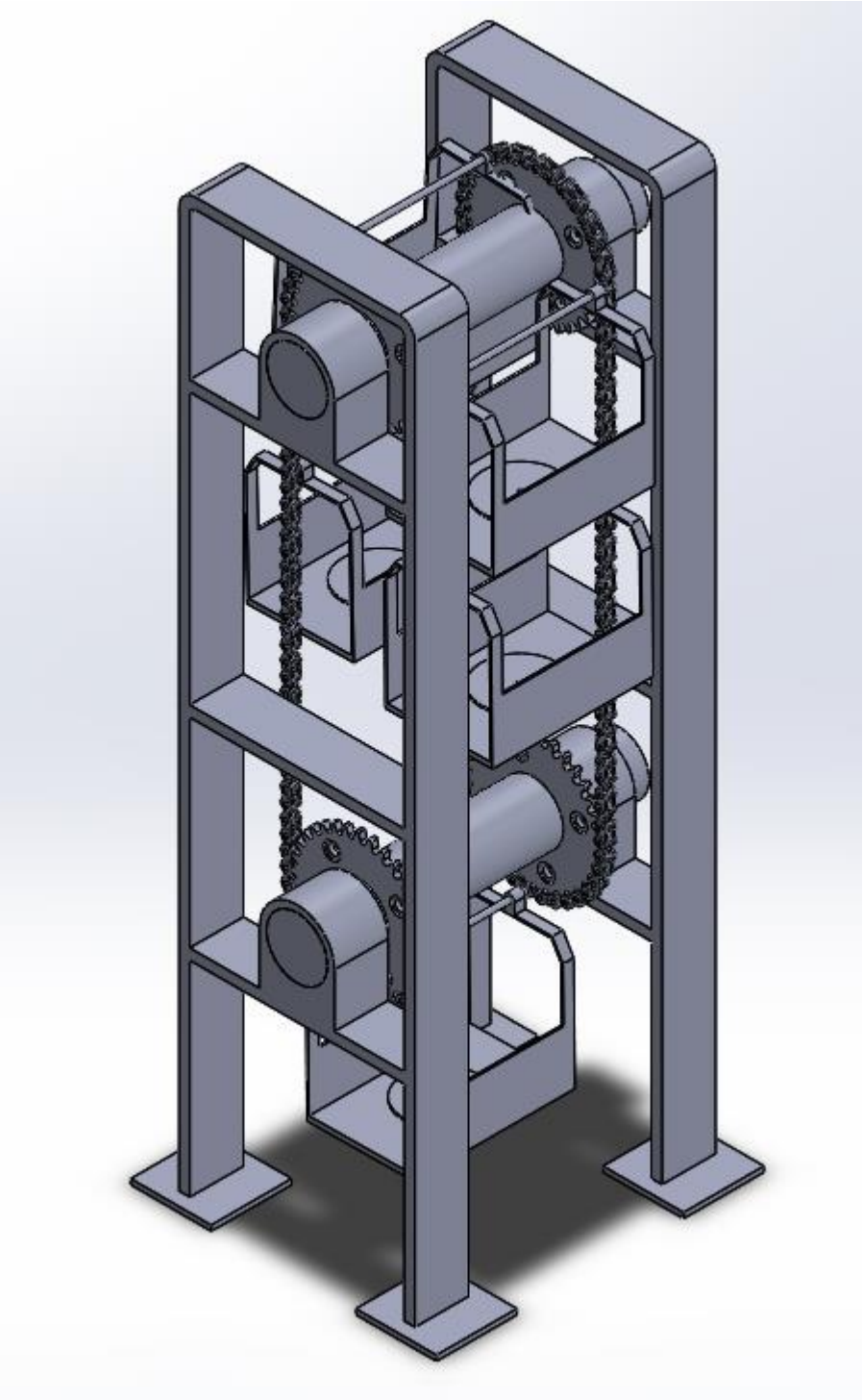


Figure 3.20: Overall Propsed 3D Design for RPS

Figure 3.19 & Figure 3.20, illustrate the overall and combined proposed 2D and 3D design for the rotary car park system. The following table specify the design specification for the RPS:

Table 3.8: Mechanical Components Design Specifications

NO	ITEMS	QUANTITY	DIMENSIONS SPECIFICATION			
			Length	**Width**	**Height**	**Diameter**
1	Sprocket	4				150mm
2	Platte	5	150mm	100mm	105mm	
3	Circular discs	5				70mm
4	Frame	2	50mm	5mm	800mm	
5	Sprocket Shaft	2	160mm			57mm
6	Platte Shaft	5	300mm			5mm

Table 3.9: Gear Chain Design Specification

NO	ITEMS	QUANTITY	GEAR CHAIN DESIGN SPECIFICATION						
			Pitch (from Center to Center of the chain)	**Roller Width**	**Roller Diameter**	**Chain Height**	**Thickness**	**Pin length (Cover)**	**Pin Diameter (Cover)**
7	Gear Chain	52	12.75mm	4.95mm	7.95mm	10.25mm	2mm	15mm	4.1mm

Table 3.8 and Table 3.9, show each gear chain design specification, there are 52 chains (as shown in Figures 3.13 & 3.14). So, when they connected together with the help of the chain cover, they form the gear chain, which in the system there are 2 gear chains attached to each frame for the rotary motion of the car park system.

3.5 Professional engineering practices

For professional engineering there are some standards and laws need to be obeyed to reach project objectives. These standards are related to safety, health, social, culture, and legal responsibilities.

Firstly, the safety of the project, through the proposed methodology of this project it had been mentioned that IR sensor will be implemented which will work as a safety sensor for the whole system to ensure user safety. So, the IR sensor will make sure that the system will not operate if there is any person within the parking area.

In terms of social, this project is considered an IOT based and fully automated controlled project. So, the IOT and the wireless communication is an essential thing for the social as long as that will make the dealing with the system easer, flexible and take less time. All these aspects are enhancing the social life of users and making it more relaxing, specially like parking and retrieving the cars.

In terms of culture, the building of the RPS will take into consideration factors like: color traits the design shape which reflect the culture of the city or country in which the system will be built

Through this project, construing a protype for a rotary car park system does not have any negative effect on the human health. In real life situation when implementing the RPS it will help in decreasing the traffic jams and congestion in big cities, which lead to a great positive effect on big cities' people in terms of car pollution and congestions.

Finally, while conducting this project all the legal issues had been noted and followed. As all the software that had been used with legal licenses such as ThingSpeak Database and SolidWorks Design software which are under APU University student account as well as all other software which are free to be used by all developers.

3.6 Project management, Finance and Entrepreneurship

3.6.1 Project management

This section will explain how the project had been organised and managed through project Management procedures. Project management is an important factor to ensure that the project could be accomplished on time. There will be 2 Gantt charts, one for phase 1 (investigation phase), the other one is for phase 2 (implementation phase)

Table 3.10: FYP Phase 1 Gantt Chart

					Final Year Project Phase 1 (Investigation) Gannt Chart													
					MONTH													
NO	**Tasks**	**Progress**	**Start**	**End**	**October**				**November**				**December**			**January**		
					W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Selection of FYP	100%	10/4/21	10/8/21														
2	Approval for FYP Selection	100%	10/7/21	10/7/21														
3	Supervisor Clinic	100%	10/11/21	10/17/21														
4	Confirm Project Title and Develop Project Aim & Objectives	100%	10/11/21	10/17/21														
5	Mandatory Meeting 1	100%	10/15/21	10/15/21														
6	Chapter 1 & 2 Writing	100%	10/15/21	11/18/21														
7	Mandatory Meeting 2	100%	11/1/21	11/1/21														
8	PSF Form Completion	100%	11/1/21	11/1/21														
9	Chapter 3 Writing	100%	11/18/21	12/30/21														
10	Mandatory Meeting 3	100%	12/5/21	12/5/21														
11	Mandatory Meeting 4	100%	12/20/21	12/20/21														
12	Final Check for Phase 1 Report content & the Report Format	100%	12/31/21	1/9/22														
13	FYP report Phase 1 Submission	100%	1/10/22	1/10/22														
14	Oral Presentation (mid-project presentation)	Planned	1/17/22	1/24/22														

Table 3.11: FYP Phase 2 Gantt Chart

					Final Year Project Phase 2 (Implementation) Gannt Chart													
					MONTH													
NO	**TASKS**	**PROGRESS**	**START**	**END**	**February**				**March**					**April**			**May**	
					W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Buy all necessary implementation components	Planned	28/2/2022	7/3/2022														
2	Start in Build-up Prototype	Planned	7/3/2022	18/3/2021														
3	Mandatory Meeting 7	Planned	7/3/2022	11/3/2022														
4	Mandatory Meeting 8	Planned	21/3/2022	25/3/2022														
5	In progress Presentation	Planned	28/3/2022	1/4/2022														
6	Combine & attach all component together and Start in Testing the system	Planned	28/3/2022	25/4/2022														
7	Enhance more in GUI & IOT system	Planned	18/4/2022	29/4/2022														
8	Chapter 4 & 5 Writing	Planned	18/4/2022	9/5/2022														
9	Mandatory Meeting 9 & Submit First FYP report Draft	Planned	4/4/2022	8/4/2022														
10	Mandatory Meeting 10	Planned	18/4/2022	22/4/2022														
11	In progress Presentation-2 & chapter 6 writing	Planned	25/4/2022	29/4/2022														
12	Mandatory Meeting 11	Planned	9/5/2022	13/5/2022														
13	Mandatory Meeting 12	Planned	16/5/2022	20/5/2022														
14	Final FYP Report submission	Planned	25/5/2022	25/5/2022														
15	FYP presentations	Planned	30/5/2022	10/6/2022														

3.6.2 Finance

One of the important elements of any project that should be handled carefully is the process of cost estimation. Cost estimation is the estimating of the type and quantity of the resource needed to conduct and complete the project. Cost estimation process helps to achieve the project objectives within the agreed budget. Table 3.12 shows the estimated cost of the project components.

Table 3.12: FYP Project Components Estimated Cost

NO.	SPECIFICATION	ITEMS	QUANTITY	COST PER UNIT (RM)	TOTAL COST (RM)
1	Sensors	IR Sensor	6	1.28	7.68
2		E18-IR Sensor	1	13.90	13.90
3		ESP32	1	30	30
4	Actuators	16RPM DC Gear Motor	1	36.90	36.90
5		Micro Servo Motor	5	11.30	56.5
6		L298N Motor Driver	1	6.90	6.90
7	Mechanical Components	Sprocket	4	7.5	30
8		Gear Chain	2	15	30
9		Pallet	5	10	50
10		Pallet's Circular Disc	5	10	50
11		Frame	2	15	30
12	Software	Arduino IDE	1	Free	Free
13		MIT App Inventor	1	Free	Free
14		Google FireBase Database	1	Free	Free
15		ThingSpeak Database	1	Free (Registered by APU Student Account)	Free (Registered by APU Student Account)

16	Miscellaneous Components	LCD (16*2 Display Board)	1	10	10
17		LEDs (Red & Green)	10	0.5	5
18		Front Mirror	1	10	10
Total Cost (RM)					**366.88**

3.6.3 Entrepreneurship

This IOT based automated rotary car park project could be marketable and spread among many users with different methods. Firstly, the project could be marketed to the population in larger cities as a good, recommended solution for the congestion and traffic jams, since it consumes less building area, save time in searching for parking slot and allocate many parking slots in the smallest area possible. All of these factors will attract more people to use the RPS rather than the ordinary car parks. Furthermore, by adding payment methods to the RPS the whole project could be more profitable.

Another method that could be implemented is: To use the rotary park as an adverting area for any company or product. So, the companies could invest to put their advertising, logos, posters on the rotary car park. Furthermore, also the theme or the colour of the rotary car park could have the same theme of a specific company or a product and that will attract more user and be profitable for both the company and the RPS owners.

3.7 Summary

Through Chapter 3, the proposed methodology had been discussed. Furthermore, the main tools and techniques had been illustrated, these tools are divided into software, sensors, actuators and mechanical components. Then the project block diagram and detailed flow chart had been explained. Moreover, the proposed IOT system, GUI, prototype design and design specification with fully dimensions had been discussed. After that all the engineering standards for safety, health, social, culture and legal had been stated. Finally, it had been shown how phase 1 for this project had been managed within the timeline with help of Gantt charts and all the estimated costs and how this project could be marketable are explained.

CHAPTER 4

FINAL DESIGN & SYSTEM IMPLEMENTATION

4.1 Introduction

Chapter 4 illustrates the final design, system implementation of the automated RPS project as well as the changes & modification which had been done comparing to what had been proposed in chapter 3. The main difference which had been done through the implementation phase was the usage of another cloud database (Google Firebase) instead of (ThingSpeak Database).

Furthermore, some of the miscellaneous components that had been removed like : (LCD and Slot LEDs status indicator), as the main aim is to make the user fully depend on the IOT (mobile application) system. All the modifications are stated in the new block diagram as well as the new flowchart which could be checked through Figures (4.16, 4.20, 4.22, 4.24 and 4.26) as well as they will be illustrated in more details throughout this chapter.

4.2 System Implementation

4.2.1 Overall Block Diagram

The system had been divided in two main sections. First section is the designing and build up the rotary car park prototype which could hold 5-cars. Second section is the IOT based mobile application. The following are the figures of the overall block diagram of the developed RPS.

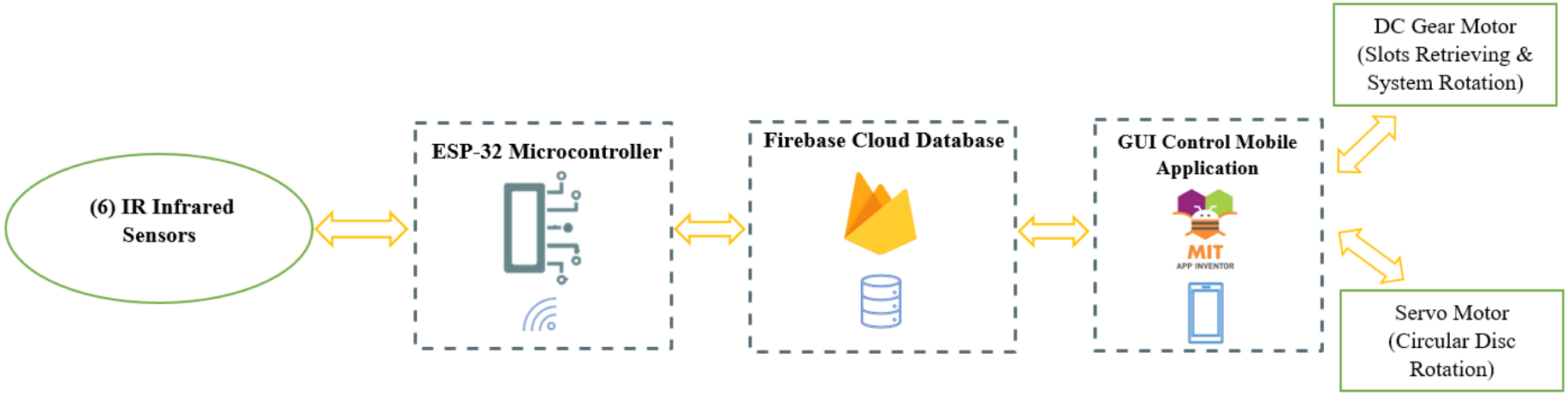


Figure 4.1: Final Block Diagram of RPS

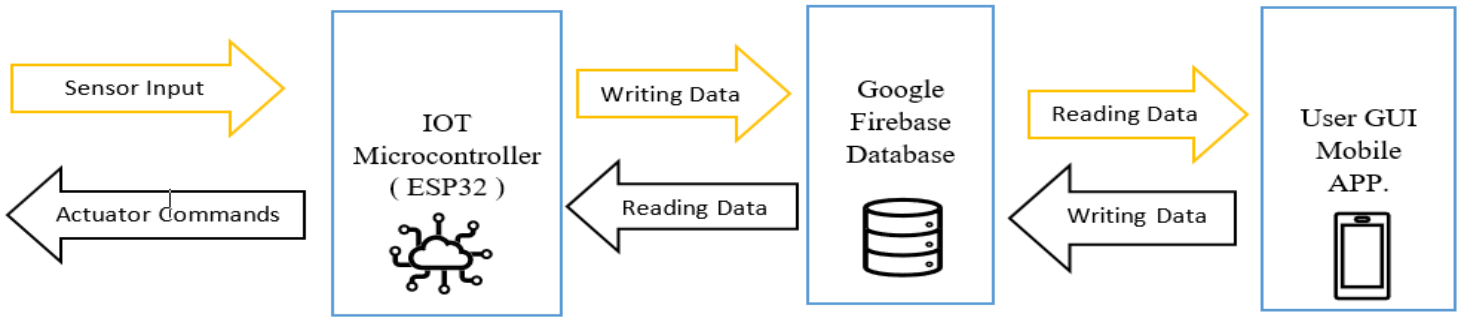


Figure 4.2: Final Overall Block Diagram of RPS

Figure 4.1 and figure 4.2 explain the final block diagram of the IOT based automated RPS. Furthermore, the system is mainly based on the IOT microcontroller ESP32. Where the ESP32 is responsible to get the information from the 2 main sensors and control the 2 main actuators.

In Addition to that, the ESP32 microcontroller will send and save all the sensors and actuators information on Google Firebase database. Firebase database will be the main & only database for the system, as well as it is considered the main change that had been done compared to what had been proposed in phase 1, that's because firebase is considered more faster in terms of receiving and sending to & from the ESP32 over the Wi-Fi connection than the ThingSpeak database.

The IOT mobile application (GUI) which developed by the MIT app Inventor IOT platform is responsible for the whole process of registration, parking and retrieving the car.

Moreover, the 2 main actuators (the DC gear motor and servo motor) are responsible for the rotation of the car slots and rotate the circular disc of car plate respectively.

4.2.2 Programming

This section will illustrate and explain the main final developed code for IOT based automated RPS, as well as how the microcontroller had been connected with the firebase and the GUI, so based on the shown block diagram the IOT system is consist of 3 main stages, which are (ESP32 microcontroller, Firebase Database and the Mobile application GUI). Where ESP32 programming code had been developed through Arduino IDE and the GUI is through MIT app Inventor.

Figure 4.3: Main Libraires Used for the ESP32 Programming Code

```
void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  WiFi.begin (WIFI_SSID, WIFI_PASSWORD);
  Serial.print("Connecting...");
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(300);
  }
  Serial.println();
  Serial.print("IP Address: ");
  Serial.println(WiFi.localIP());
  Serial.println();
  Firebase.begin(FIREBASE_HOST, FIREBASE_Authorization_key);
  Firebase.reconnectWiFi(true);
```

Figure 4.4: Developed Code for Wi-Fi connection of the ESP32

As per Shown in Figures 4.3 & 4.4, the developed code where the essential libraries had been identified and declared such as Firebase , Servo motors as well as the Wi-Fi declaration in order to connect the ESP32 microcontroller with the Wi-Fi-connection.

```
// Code For Set Data Into Firebase from the (5) IR Sensors (Slot-Status):
Firebase.setFloat(firebaseData, "/Slot_Status/slot-1", slot1_status);
Firebase.setFloat(firebaseData, "/Slot_Status/slot-2", slot2_status);
Firebase.setFloat(firebaseData, "/Slot_Status/slot-3", slot3_status);
Firebase.setFloat(firebaseData, "/Slot_Status/slot-4", slot4_status);
Firebase.setFloat(firebaseData, "/Slot_Status/slot-5", slot5_status);
```

Figure 4.5: Developed Code for Set Data from Sensor into Database

As per what mentioned before and shown in Figure 4.2, the process flow is that the ESP32 microcontroller send the data to the database and then finally it is displayed on the GUI. Furthermore, here in Figure 4.5 it is considered the first step (Sensor Input). Where, the 5 IR Sensors send their readings to ESP32, then the ESP32 write these data (Firebase.setFloat) on the Firebase Database in order to be able to read by the GUI.

```
// Code For Read Data From Firebase for the DC-Gear-Motor:

int Rspeed = 120;
if (Firebase.getString(DCGearMotor, "/Slot_Status/DCMotor"))
{
  String GearMotor = DCGearMotor.stringData();

  if (GearMotor.substring(1, 2) == "1")
  {
    analogWrite(enable1Pin, Rspeed);
    digitalWrite(motor1Pin1, LOW); // control the motor's direction in clockwise
    digitalWrite(motor1Pin2, HIGH);  // control the motor's direction in clockwise
    delay (4000);                   // keep rotating for 4 Second.
    digitalWrite(motor1Pin1, LOW); // DC Motor Stop
    digitalWrite(motor1Pin2, LOW);  // DC Motor Stop
    Firebase.setFloat(firebaseData, "/Slot_Status/DCMotor",0);

  }
```

Figure 4.6: Developed Code for Read Data from Database to (DC-Motor)

```
  else if (GearMotor.substring(1, 2) == "2")
  {
    digitalWrite(motor1Pin1, LOW); // control the motor's direction in clockwise
    digitalWrite(motor1Pin2, HIGH);  // control the motor's direction in clockwise
    delay (4000*2);                   // keep rotating for 8 Second.
    digitalWrite(motor1Pin1, LOW); // DC Motor Stop
    digitalWrite(motor1Pin2, LOW);  // DC Motor Stop
    Firebase.setFloat(firebaseData, "/Slot_Status/DCMotor",0);
  }
```

Figure 4.7(a): Developed Code for Read Data from Database to (DC-Motor)

```
// Code For Read Data From Firebase of the (5) Micro Servo Motors:

if (Firebase.getString(CicularDisc, "/Slot_Status/Slot-Disc-1"))
{
  String CicularDisc1 = CicularDisc.stringData();
  if (CicularDisc1.substring(1, 2) == "1")
  {
    servo1.write(180);

  }
  else if (CicularDisc1.substring(1, 2) == "0")
  {
    servo1.write(0);
  }

}
```

Figure 4.8: Developed Code for Read Data from Database to (Servo-Motor)

While, in Figure 4.6 & 4.7, it is shown the reverse process of the IOT system, where the command come from the GUI and written on the Firebase Database and this developed code is responsible for making ESP32 read the data value from database and then do a specific actuator command.

For example, the (Firebase.getString) function get the data, if it is (1) that means to run the DC motor, while if it is (0) the DC motor stops. Furthermore, the (delay) function is for keep the motor running for a specific time as it is considered the period that needed to bring a slot (pallet) instead of another one. Therefore, this delay period depend on the number that ESP32 get from database So, if it (1) the motor will run for (4 seconds) to rotate one rotation and bring a one pallet instead of another one (for example pallet 3 instead of pallet 2), while for example if it is (2), the motor will run for (4 seconds Multiped by 2) in order to rotate two periods of the specified time (4 seconds) and bring pallet 5 instead of 3 and so on as per Figure 4.7.

Furthermore, in figure 4.8, the same situation is done for the micro-servo motor, the ESP32 read the data and based on this date the servo more rotate to 180 degree or rotate to the zero degree.

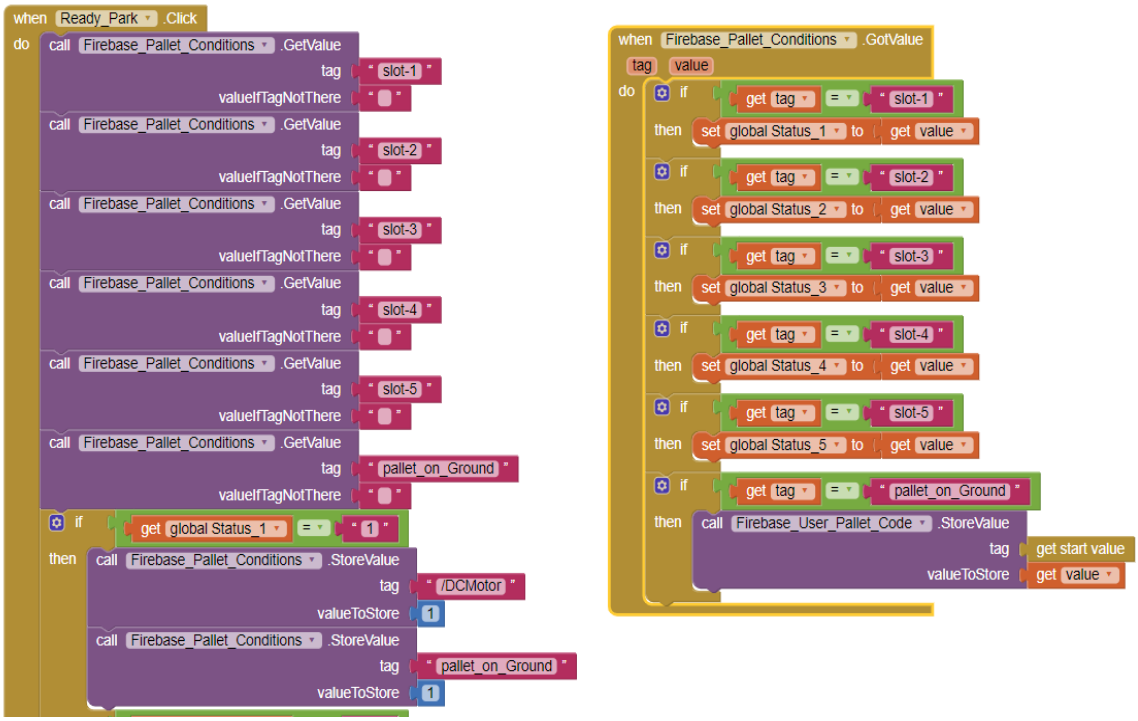


Figure 4.9: MIT Code (Parking Process)

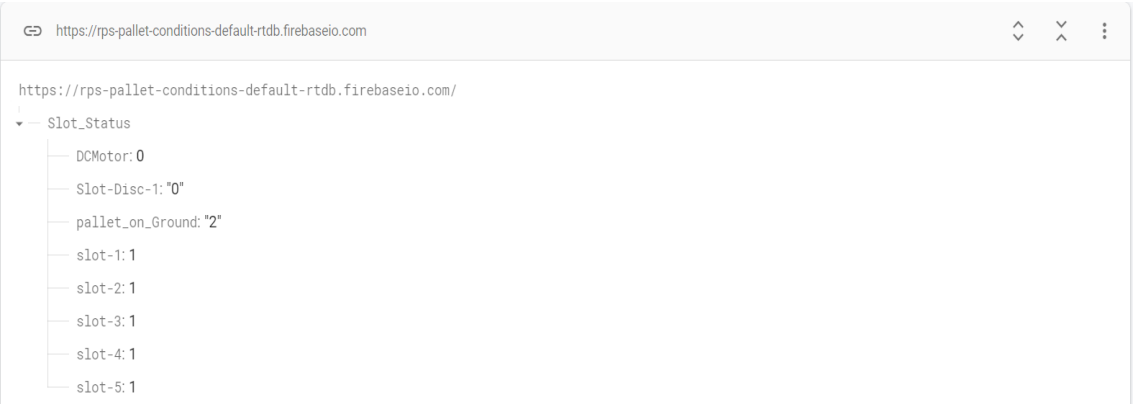


Figure 4.10: Saved Data Firebase Database

As per Figures 4.9 & 4 .10, it is shown the Reverse process of the IOT system, where the user from the mobile application (GUI) sends specific commands to the system. Moreover, here it shows the parking process as once the (Park Your Car) button is pressed and a free slot is available the MIT send the value of (1) to be saved with a name tag (DC Motor), then it could be read by the ESP32 as shown in Figure 4.6.

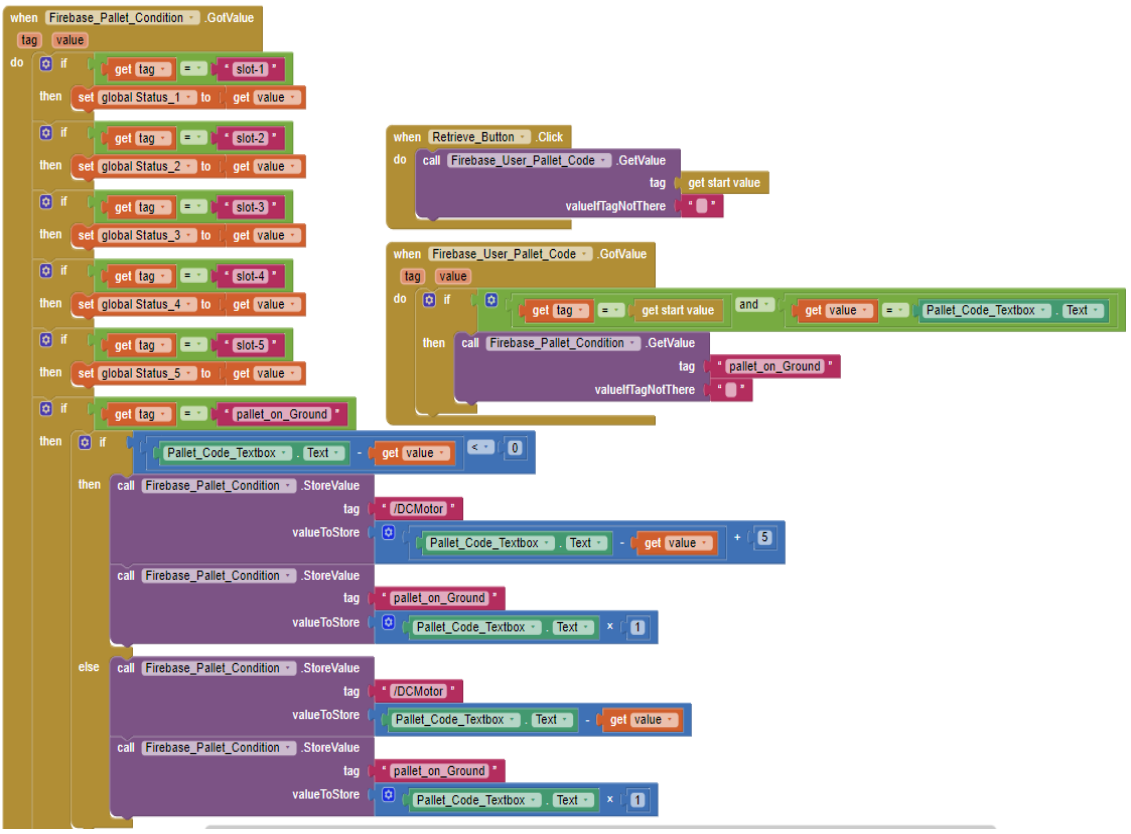


Figure 4.11: MIT Code (Retrieve Process)

While, here in Figure 4.11 it shows the retrieve process as once the (Retrieve) button is pressed the system checks the pallet code number which written by the user and if it is correct as per what saved in the database, the system could start the retrieving process. Furthermore, in the retrieving process the system subtract the (palate code number) from the value of (Pallet on ground) which represent the number of pallet that is currently on the ground. That's mean the main retrieve process equation is: ((Number of Wanted Pallet – Number of pallet on ground) * 4seconds).

For example, if the pallet on the ground is (pallet number 2) and the user wants to retrieve his/her car from pallet (number 5), so the system will subtract 2 from 5 and store on the Database to the (DC Motor) value of (3). Then the ESP32 could read this value and based on this value the DC motor will run for (12 seconds) in order to bring pallet (number 5) as per shown and explained in Figures 4.6 & 4.7.

In addition to that, another example, if the user want to retrieve his/her car from pallet (number 1) and now on the ground pallet (number 2). Therefore, in this case since the result of the subtraction will be negative value (-1). So, value of (5) will be added, so in this example it will be stored in the database value of (4), which mean the ESP32 will read (4) and that's make the DC motor will rotate for (16 seconds), in order to make a full rotation and retrieve (bring) back pallet number (1) to the user.

That is how the algorithm of retrieve process is developed and how the GUI, microcontroller, Firebase and the actuator (DC Motor) is communicated together to do the process.

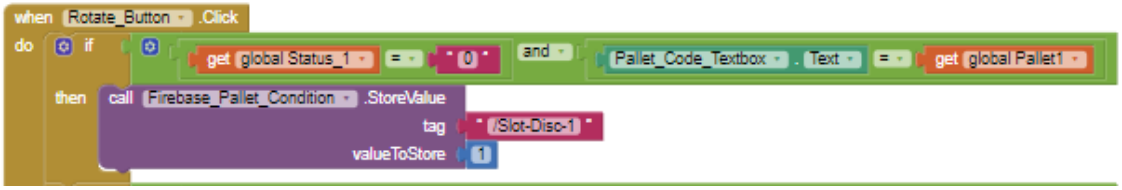


Figure 4.12: MIT Code (Rotating Process)

As per Figure 4.12, it shows the process of rotating as once the user click the button and the system checks that the car is placed on the pallet as well as the user enter the correct pallet code, it will send the value of (1) to be saved on the firebase under the name of (Slot-Disc), in order to be read by the ESP32 and rotate the servo motor as per developed code in Figure 4.8.

4.2.3 Construction Details

This section will illustrate and explain the main steps which had been taken in order to build up the prototype of the RPS which could hold up 5 vehicles slots. This section illustrates the main components (Frame, Chains, Sprocket & pallets) while combined together as in the next section (4.3), it will be shown the whole mechanical system (prototype) along with the electronic components combined and working together.

As per what had been proposed in section (3.4.3) in the first phase for the RPS prototype design as well as the mentioned mechanical components in Table 3.7, all of them had been combined and implemented together during phase 2. Furthermore, the final prototype is almost the same as the proposed 3D design in phase 1.

Figure 4.13: First Prototype of RPS

As per Figure 4.13, it considered the first step which had been taken, where it had been used a 5mm PVC board sheet as the main martial for both frames as well as the 5 pallets. Furthermore, the PVC board had designed and cut to design the frames as shown in the figure.

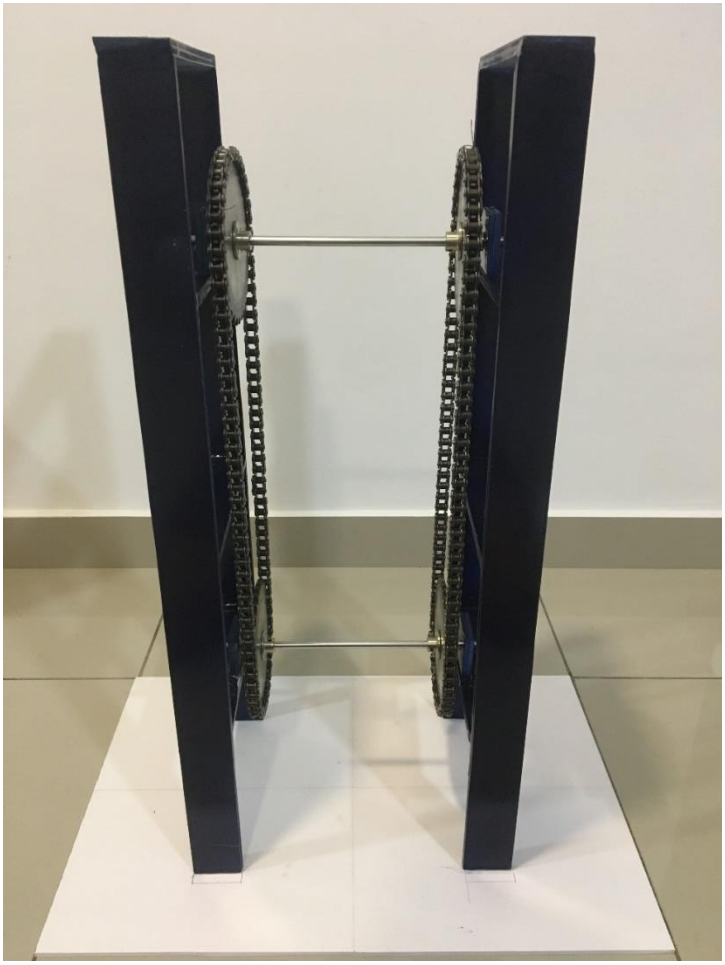


Figure 4.14: Second Prototype of RPS

Moreover, the 2 gear chains with the 4 sprockets had been implemented on the 2 frames and connect by 2 shafts as per Figure 4.14. These 2 shafts (30cm long & 8mm diameter) are used in order to connects the 2 frames with each other as well as the down shaft will be connected with, the DC-Motor in order to be responsible for the gear chain & sprockets rotation. Furthermore, a blue spray had been used to give a color for the white frames for better design view. Not only that but also, another PVC board had been used to be the main ground and attach the 2 frames on it , so the whole system be more stable.

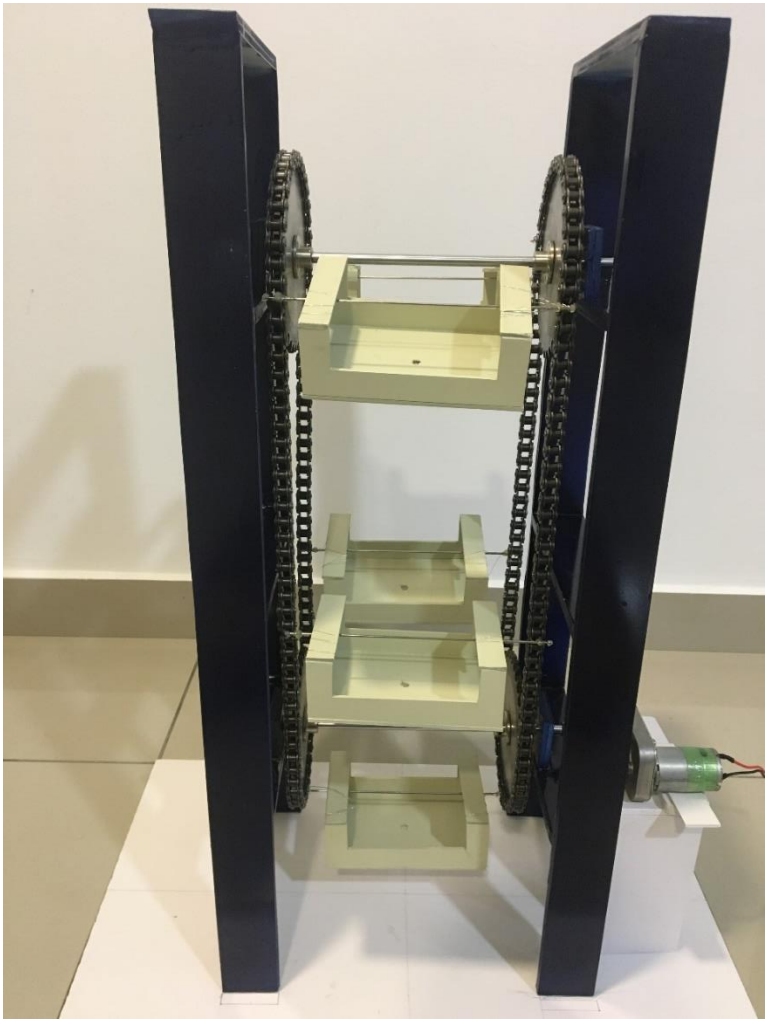


Figure 4.15: Third Prototype of RPS with 5 Pallets

As per Figure 4.15, it considered the third step which the 5 pallets had been attached between the 2 gear chains. The 5 pallets had been manufactured by a 3mm PVC board and it had given a green color. Like that all the main components for the RPS had been combined together. Furthermore, later in section 4.3, it will be shown the whole final prototype design and the whole system along with the electronic components as well as how they are working with the IOT mobile application.

4.2.4 Flowchart & Working Principle

This section will illustrated the working principle for the IOT RPS system along with final designs of the IOT mobile application (GUI) as well as the detailed flowchart, which had been updated and modified comparing to the proposed flowchart in chapter 3.

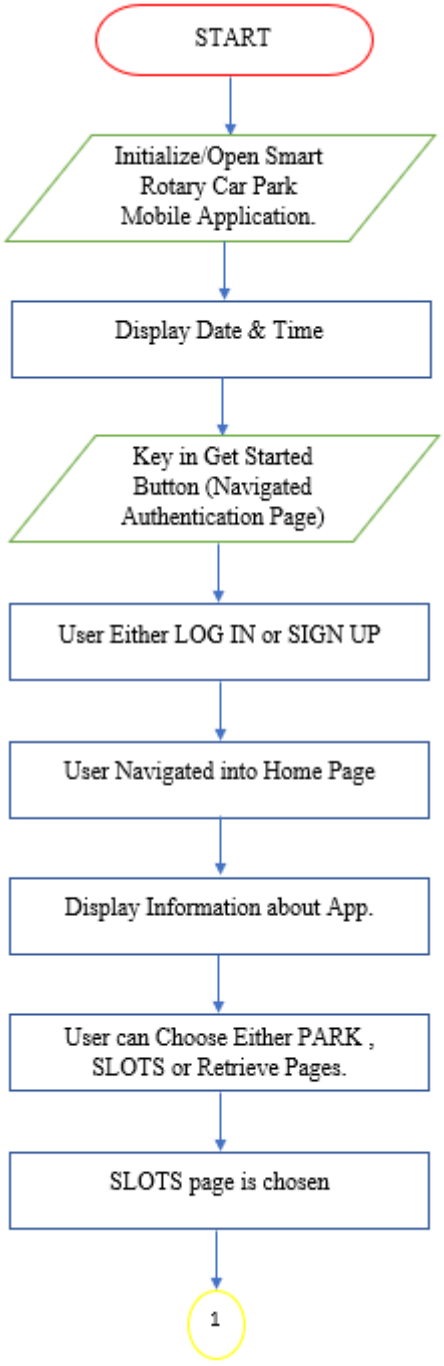


Figure 4.16: First Flowchart IOT RPS

As per Figure 4.16, it shows the final flowchart for the system as it starts with explain the first pages for the IOT mobile application. The user firstly will navigate into the Authentication pages to either login or signup as well as all his information is saved on the firebase database, then after a successful registration button the user will navigated to the home page.

Figure 4.17: Get Started page of IOT GUI

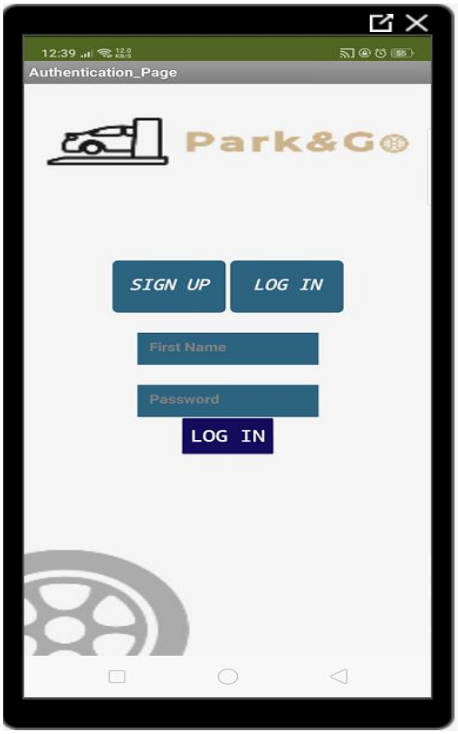


Figure 4.18: Authentication page of IOT GUI

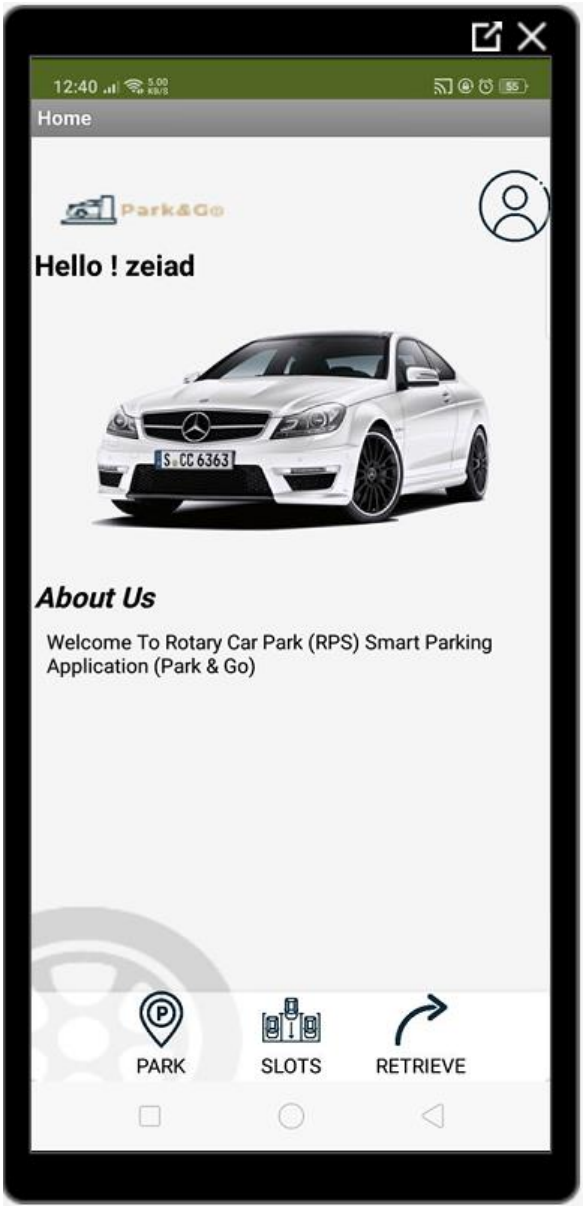


Figure 4.19: Main Home page of IOT GUI

As per Figures 4.17, 4.18 & 4.19, they show the final design of the user IOT mobile application as they represent the gest started page as well as the authentication pages and the (Home Page), where the user from the home page could navigate through the application wither to park, retrieve, check the slots availability or check his profile page.

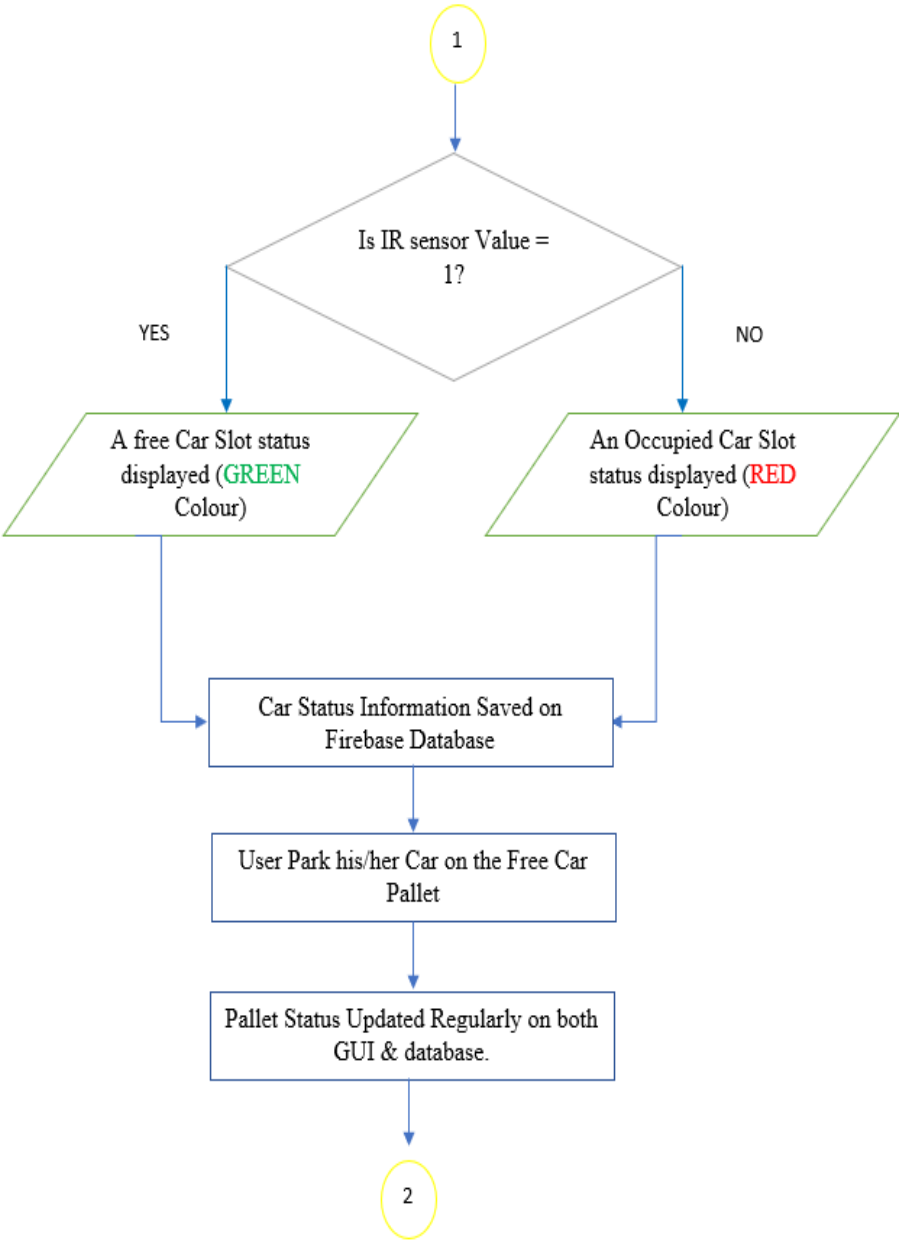


Figure 4.20: Second Flowchart IOT RPS (Slots) Page

Figure 4.21: Slot page of IOT GUI

As per Figure 4.20 & 4.21, it shows the flowchart as well as the GUI of slots pages. Moreover, it explains the relation between the IR sensors and the mobile application, the status of each pallet will be stored in the database (either its empty or occupied), and these values will appear to the user on the GUI to be regularly updated him/her with the slots status.

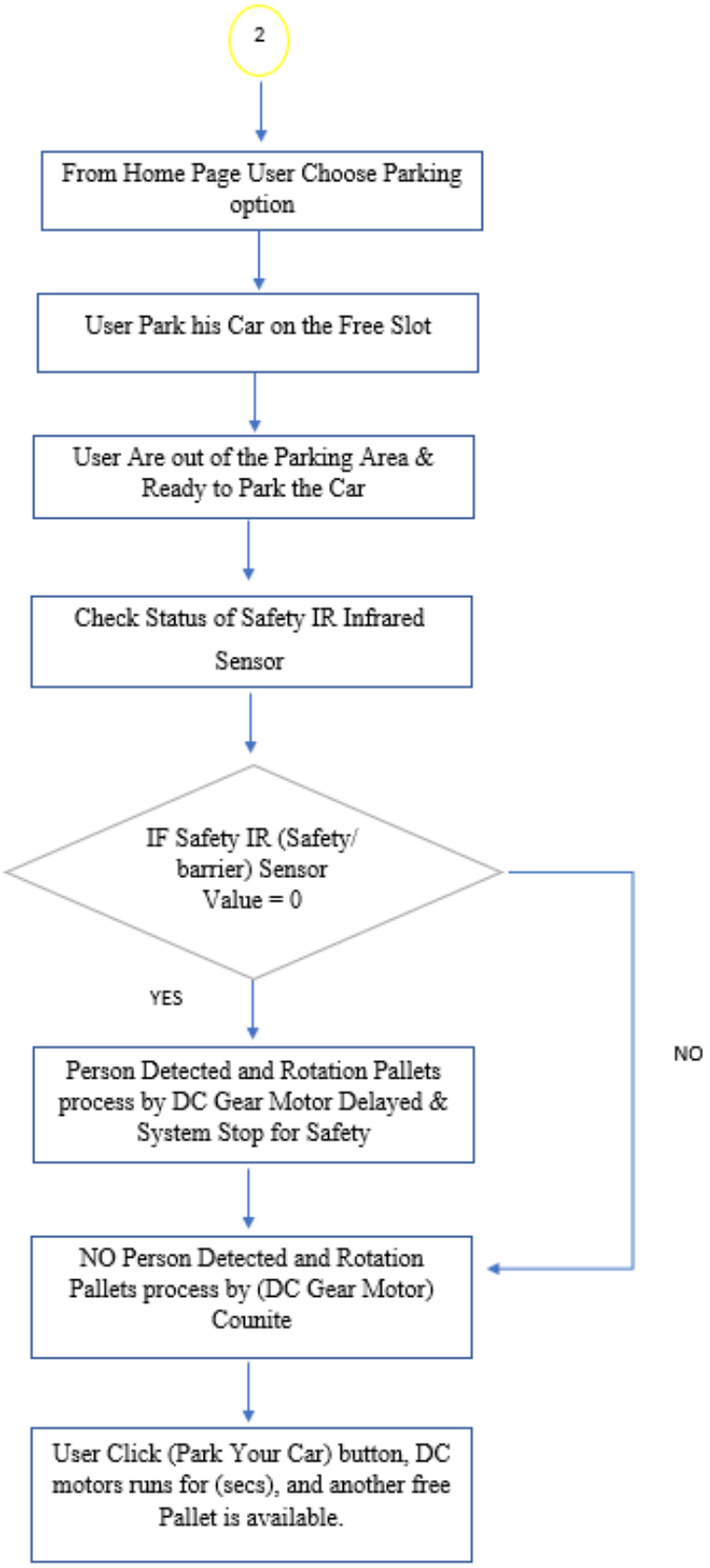


Figure 4.22: Third Flowchart IOT RPS (Parking)

Figure 4.23: Parking page of IOT GUI

As per Figure 4.22 & 4.23, they represent the parking process. After the user parks the car on the pallet and get out the parking area and the system checks that there is no one for the safety reason, the user could click (Park Your Car) button, the rotary process is done with help of DC motor, in order to park the car and another free slots will come to be ready for another user.

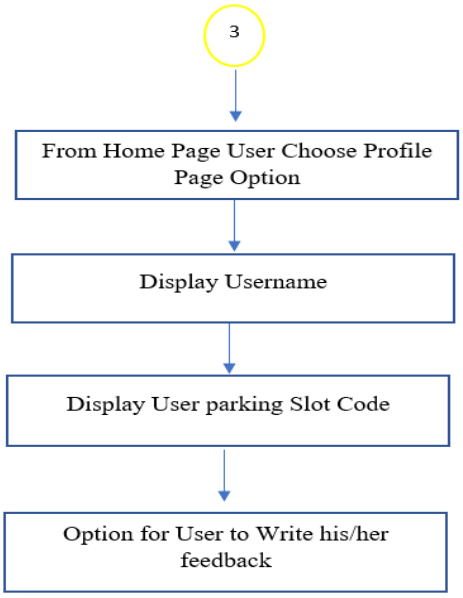


Figure 4.24: Fourth Flowchart IOT RPS (Profile) Page

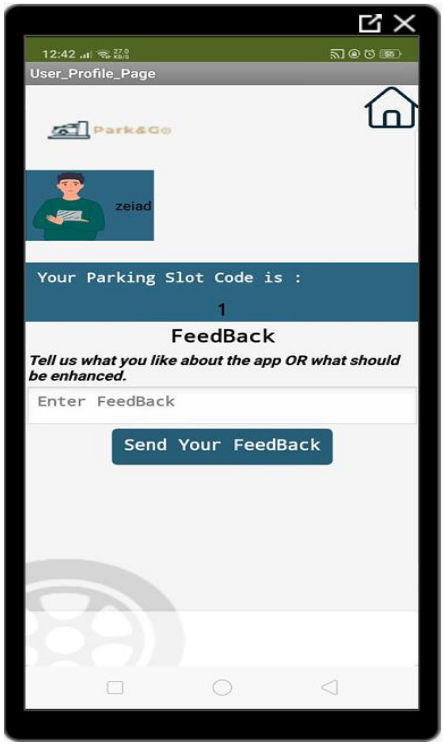


Figure 4.25: Profile page of IOT GUI

Figures 4.24 & 4.25, show the selection of the user of the profile page where he/she could check their parking slot code which will be used for the retrieving process as well as the user could write his/her own feedback for the system.

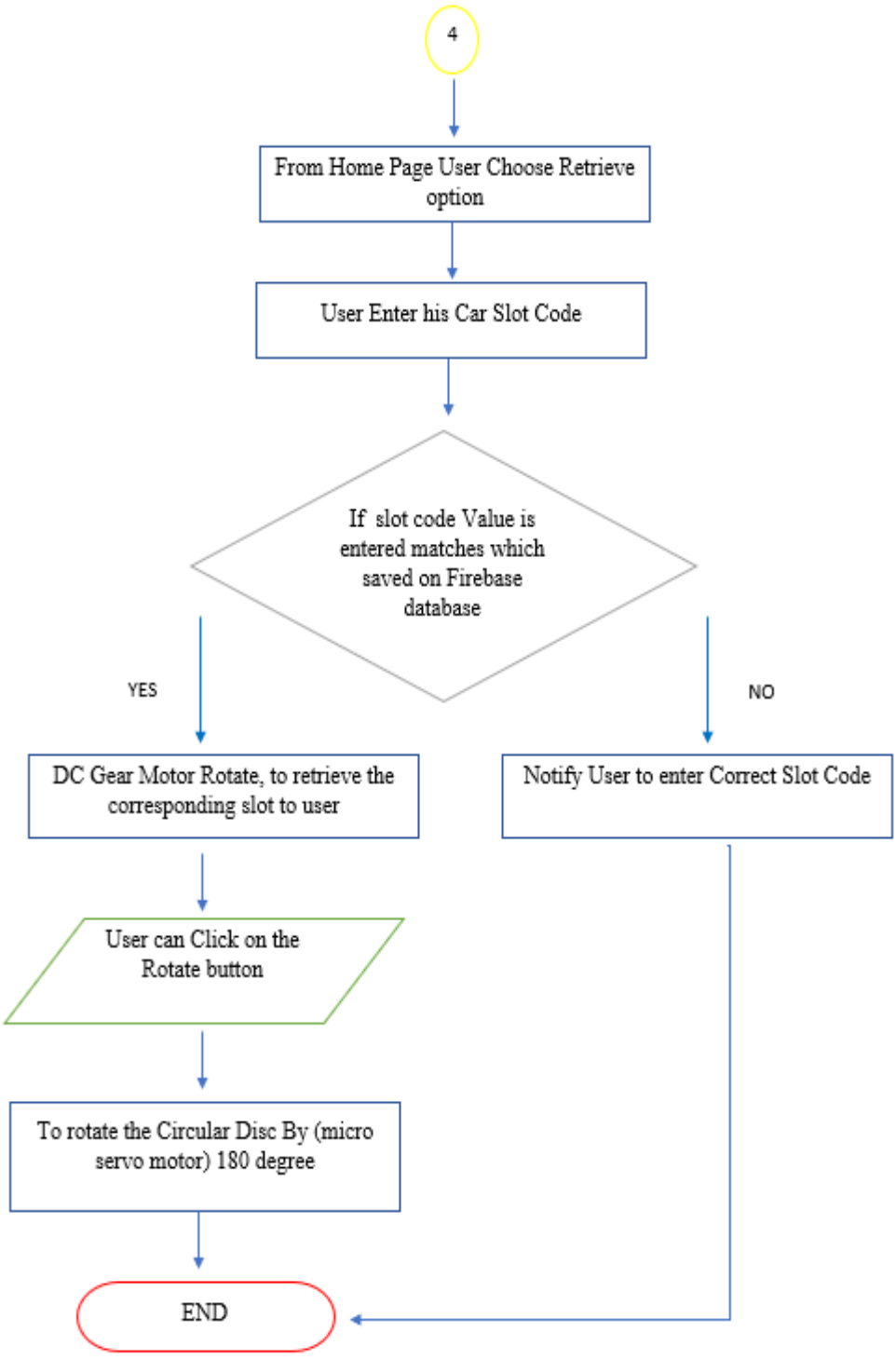


Figure 4.26: Fifth Flowchart IOT RPS (Retrieve)

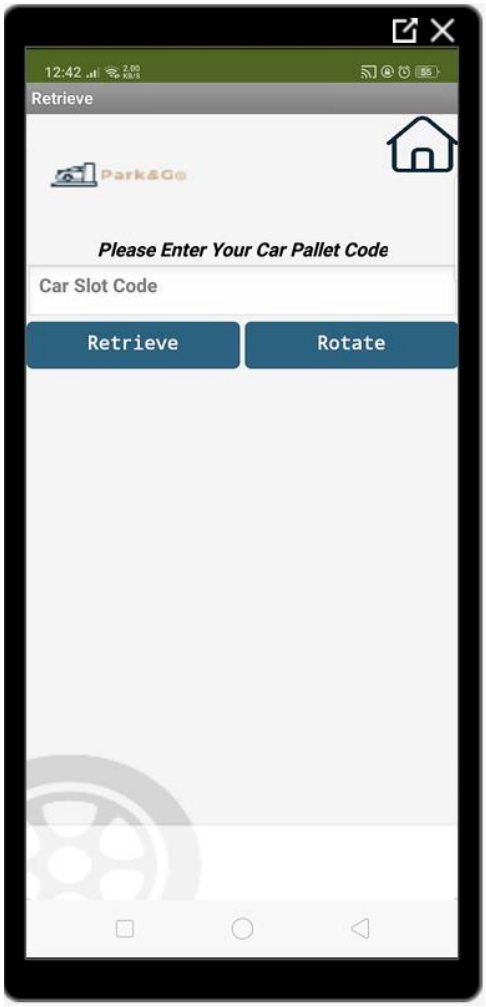


Figure 4.27: Retrieve page of IOT GUI

Figures 4.26 & 4.27, show the retrieve process, as once the user navigated to the retrieve page he/she will be asked to write down their car slot code and if it matches what is saved on the database, the car pallet will be retrieved, and the user can get the car. Furthermore, the user had the option to click on the (Rotate) button in order to rotate the circular disc of the pallet which the car is placed on it, thus the car will rotate 180 degree for easier retrieving and exiting process.

4.3 Hardware & Simulation Results

4.3.1 Prototype (Hardware) Results

Through this section the figures of the final RPS prototype, hardware results along with the software (IOT GUI) results will be shown and explained. As per what mentioned before, the developed system is consist of 2 main section which are the IOT software and the hardware porotype. Therefore, this section will show the main figures of the main results of the RPS (when both software & hardware are integrated), which demonstrate the main functions of the system (Parking, Retrieving, Circular disc rotation).

Figure 4.28: RPS Prototype Final Design (a)

Figure 4.29: RPS Prototype Final Design (b)

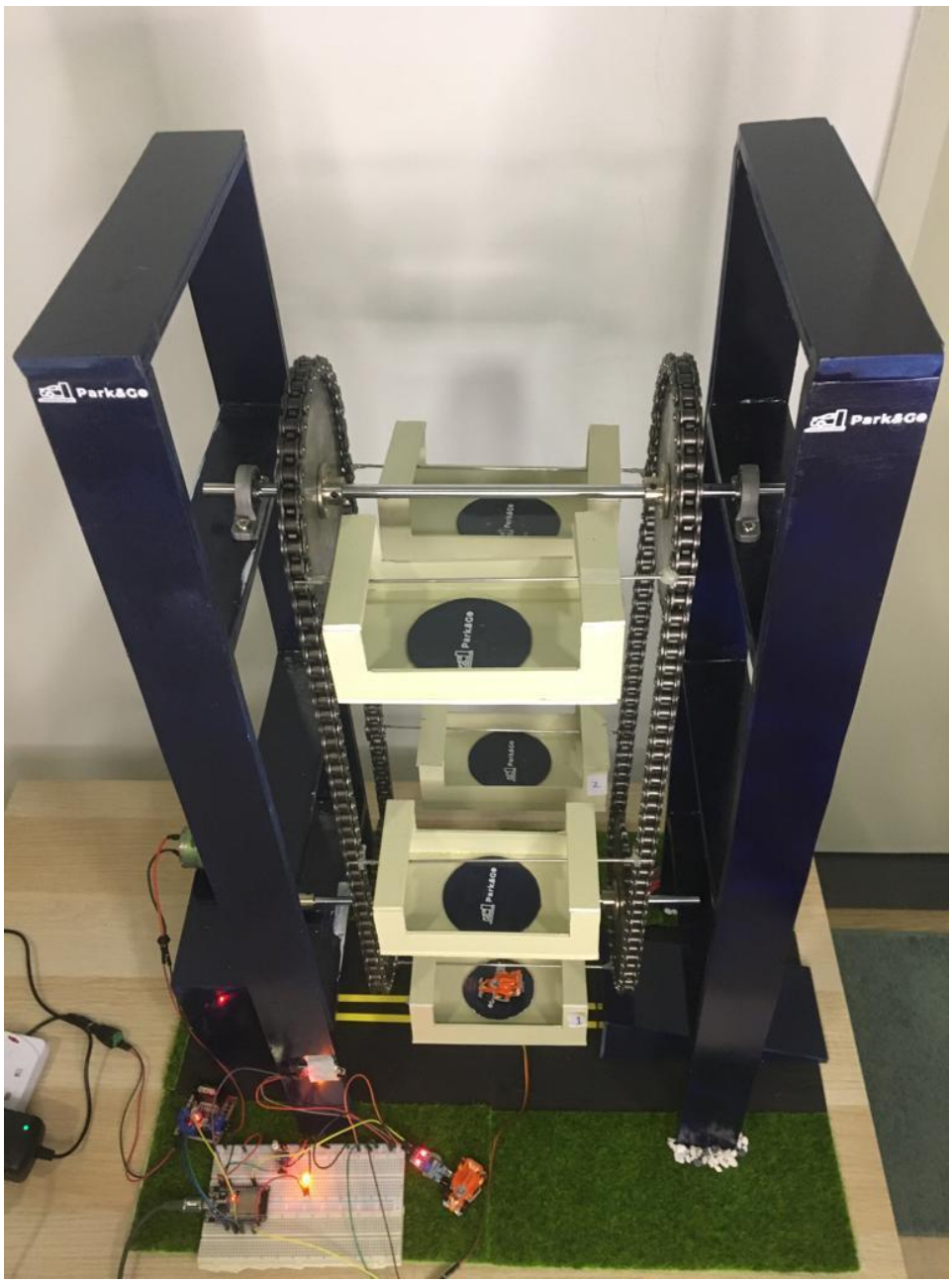


Figure 4.30 : RPS Prototype Final Design (c)

As per figures 4.28,4.29 & 4.30, they represent the final RPS prototype design which had been built-up as well as it is noticed that a special logo and a title for the RPS project (Park & Go) had been designed for the project, which indicate the easy and faster process of parking and retrieving process while using the project.

4.3.2 RPS IOT System (Slots page) Result

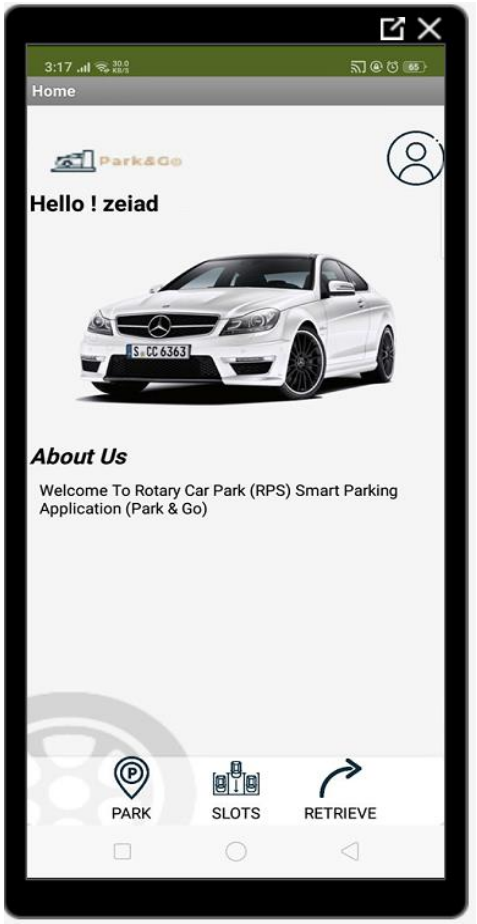


Figure 4.31 : RPS IOT GUI Software Result (1)

Figure 4.31. shows the main results after a successful registration by the user (zeiad) and a successfully navigation in the (Home) page. Where the user could choose the Park, Check Slots, Retrieve or Check the profile.

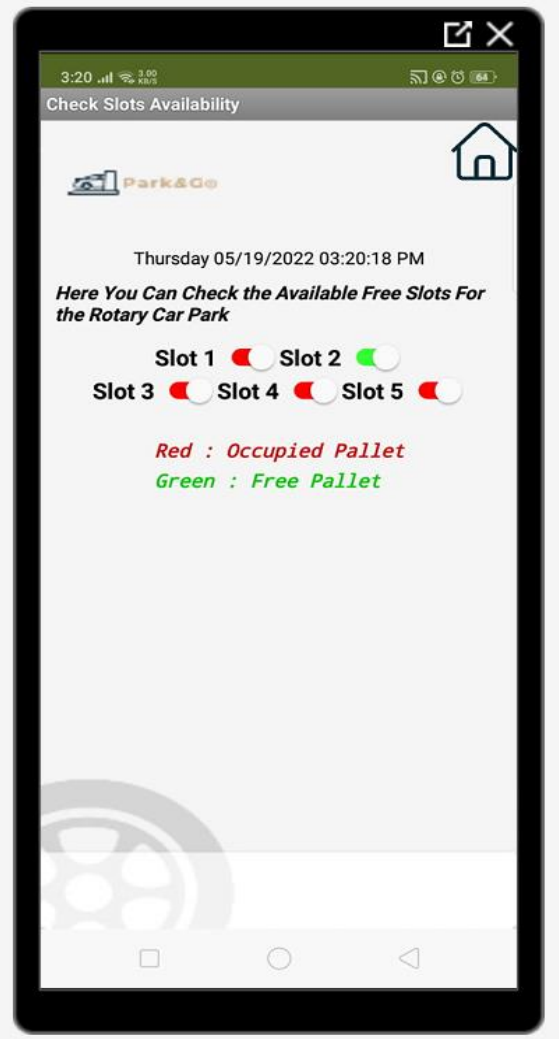


Figure 4.32 : RPS IOT GUI Software Result (Slots Page)

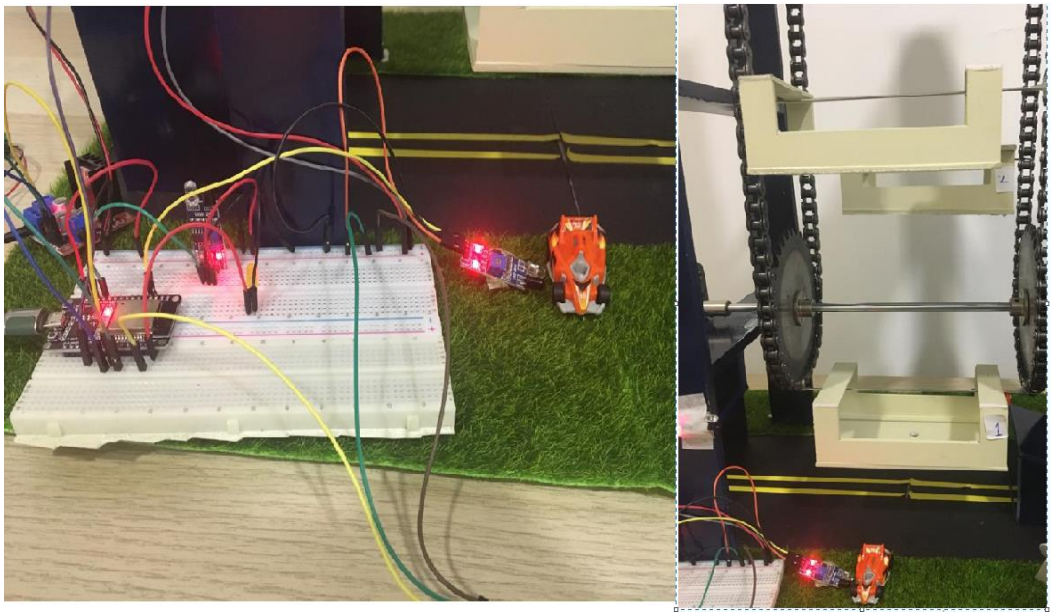


Figure 4.33 : RPS Hardware Result (Slots Page)

Figures 4.32 & 4.33 are showing the relation between both hardware (sensors) and the IOT GUI, where once the car is put in front of the first sensor the GUI show red color (occupied) for slot 1 in the GUI, while the second sensor which is placed on the breadboard, since there is no car in front of it, so the GUI show green color (free) for slot 2.

It could be noticed that the IR sensor is not placed in the correct way on the pallets, that's unfortunately from the limitation of the wiring tension problem, which delays the DC motor rotation, that's why the IR sensor is located in this position. This limitation will be explained in more details in section (6.2).

4.3.3 RPS IOT System (Parking process) Results

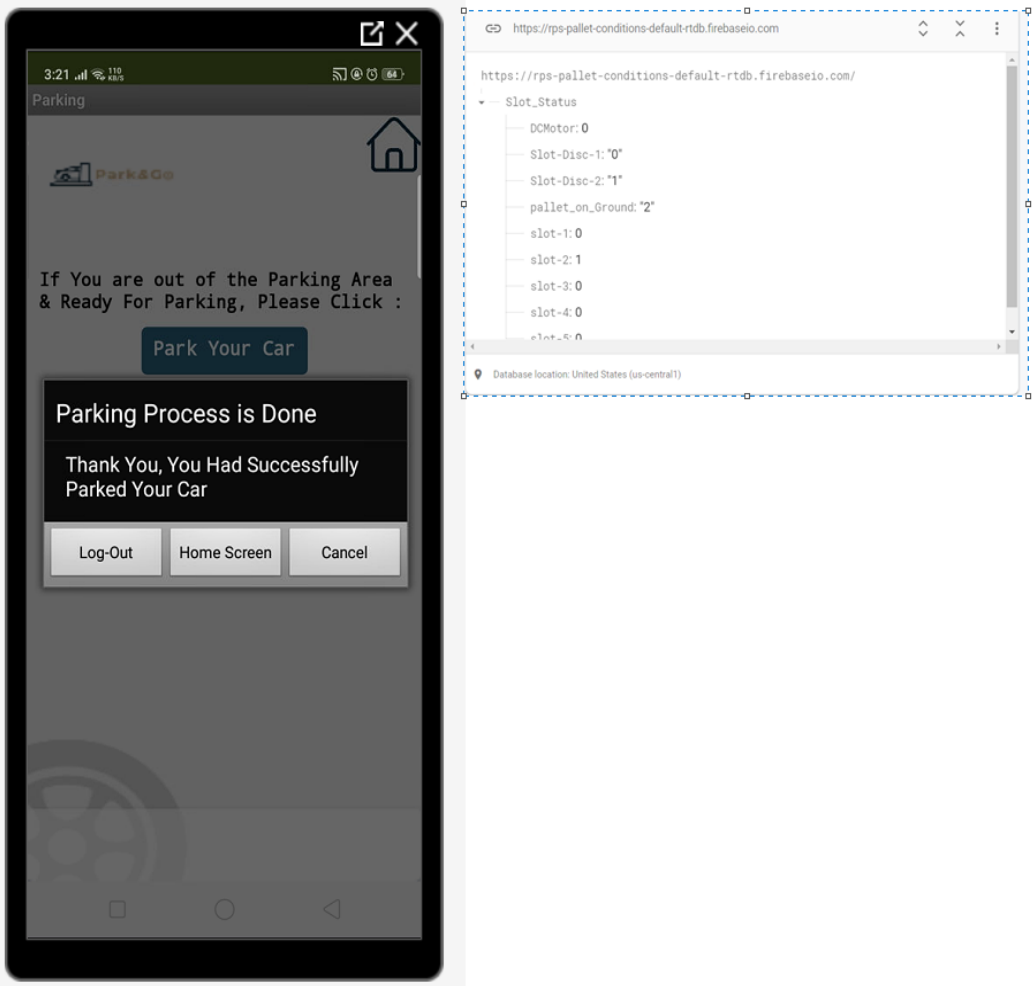


Figure 4.34 : RPS IOT GUI Software Result (Parking Page)

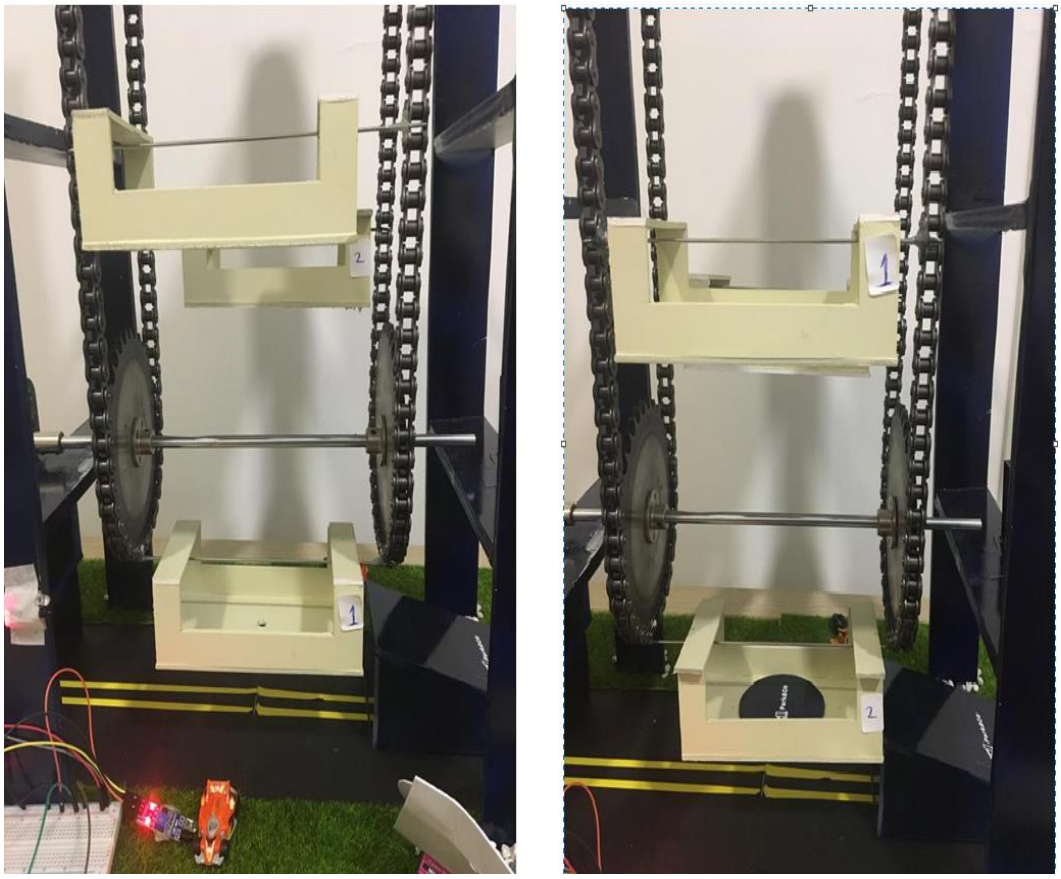


Figure 4.35 : RPS Hardware Result (Parking process)

As per Figure 4.34, it shows the result of the parking page, after the user parks his/her car and he/she is ready to do the parking process, so as shown the value of the database of the (pallet-on-ground) is change to (2), which indicate that the rotary process is done and now pallet number (2) is come instead of pallet number (1). Furthermore, In Figure 4.35, it shows this integration and the result for the RPS as once the button (Park Your Car) is pressed, the Dc motor rotate, and parking process is done.

4.3.4 RPS IOT System (Profile & Feedback) Results

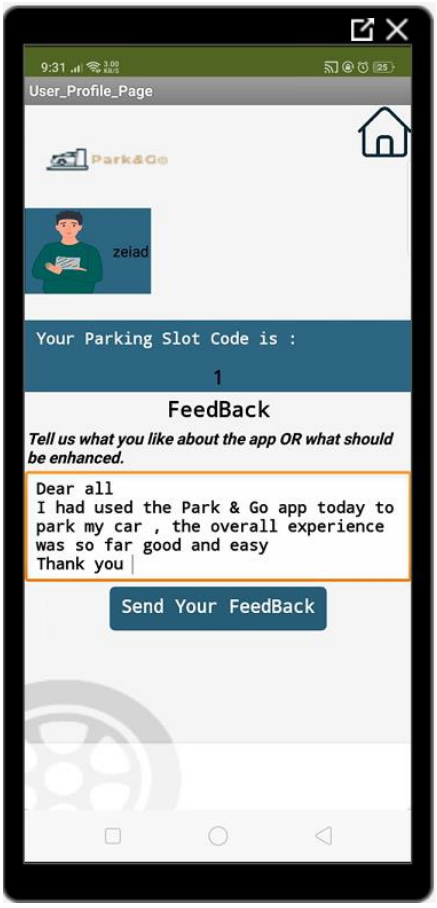


Figure 4.36 : RPS IOT GUI Software Result (Profile Page)

In Figure 4.36, it shows the profile page of the user after the parking process, where it shows his/her name as well as the parking code where he will use it to retrieve back the car as well as the feedback option. Not only that but also, the following figure 4.37, shows an example for the result of the (Received email), once the user write his own feedback and send it to the system.

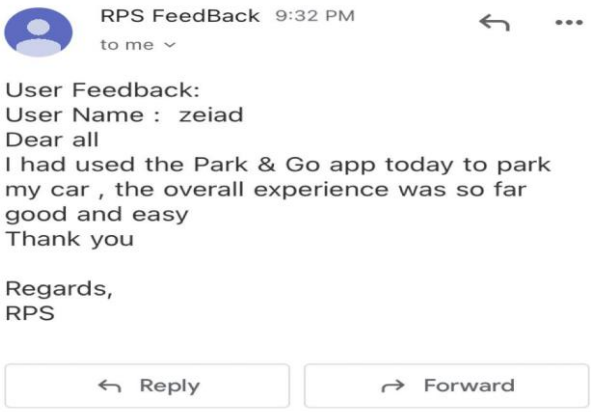


Figure 4.37 : RPS IOT GUI Received Feedback Email Result

4.3.5 RPS IOT System (Retrieving & Rotating Process) Results

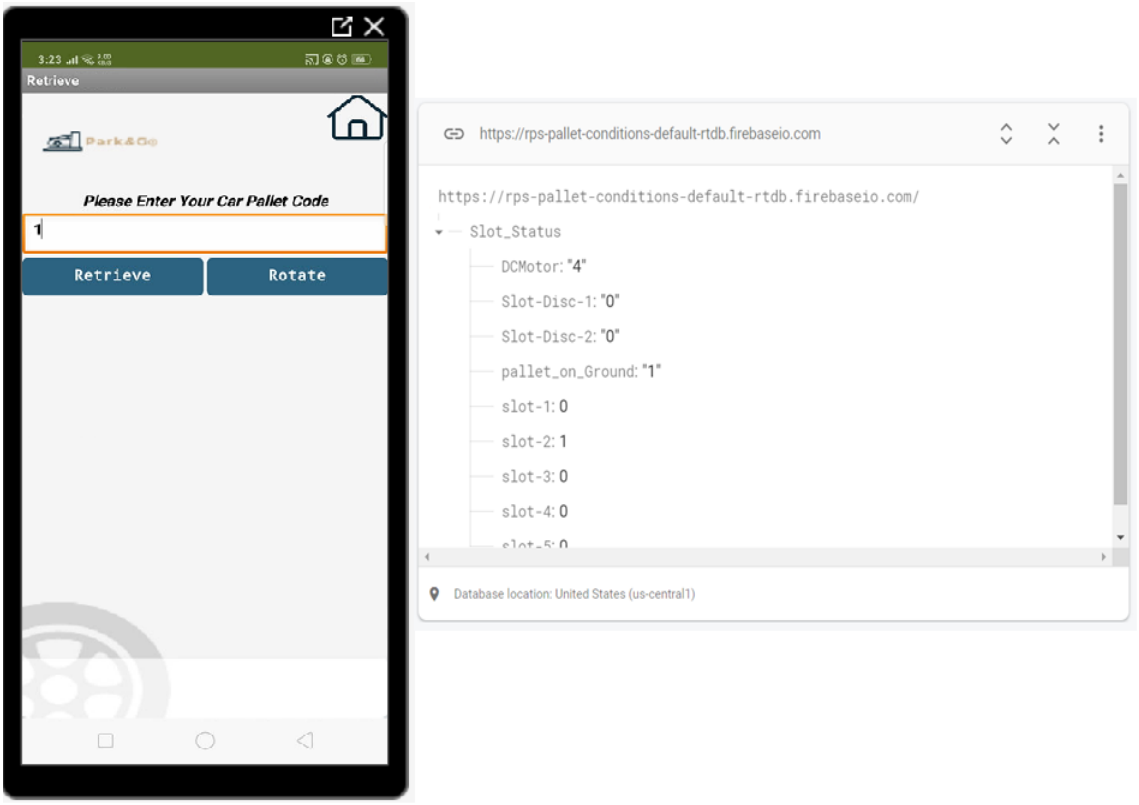


Figure 4.38 : RPS IOT GUI Software Result (Retrieve Page)

In Figure 4.38, it shows the retrieve process, as once the user write down the correct car slot code and click (Retrieve) button, the DC motor rotate and slot 1 is bring backed to the user as well as the DC motor value on database is stored with (4) in order to rotate and bring the slot back as per the algorithm which explained in section (4.2.2) per Figures 4.7 & 4.11.

Figure 4.39 : RPS IOT GUI Software Result (Rotate Process)

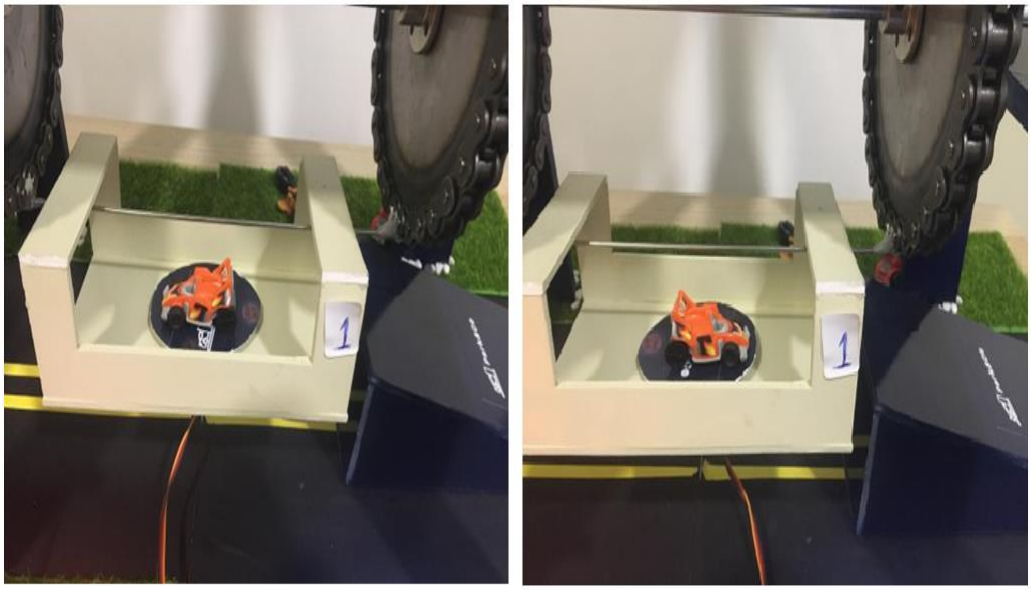


Figure 4.40 : RPS Hardware Result (Rotate process)

As well as in Figure 4.40, it shows the rotate process of the circular disc, which done by the micro-servo motor. Furthermore, in Figure 4.39, the value of the (Slot-Disc-1) is stored by (1). Since the user clicked the (Rotate) button after retrieving the car in order to rotate the car 180 degree for easier exiting process from the car park.

4.4 Summary

Through Chapter 4, the final developed RPS had been shown and illustrated in detail as well as it had been mentioned the main changes and modification which had been done comparing to what had been proposed in chapter 3 (during project Phase 1). Moreover, all the hardware and IOT GUI results had been mentioned as well as all the essential and related figures is implemented though this chapter.

CHAPTER 5

DISCUSSION – PROJECT FINDINGS AND TESTING

5.1 Testing

Recalling the project objectives as per chapter 1, the third objective of this project is to evaluate the accuracy of the developed system. Therefore, this section will illustrate the testing which had been done to evaluate the objectives of the proposed project. Table 5.1 shows the Tests which had been done. Furthermore, there are 4 Testing aspects (Definition, Experimental Setup, Data collection and Data analysis), which are explained in this section based on each test type needs.

Table 5.1: Five Tests performed for RPS project

Testing	Testing type
5.1.1	RPS Prototype Efficiency
5.1.2	RPS IOT System Efficiency
5.1.3	RPS Actuator Efficiency
5.1.4	RPS Cloud Database Efficiency
5.1.5	RPS IOT GUI Features Efficiency

5.1.1 RPS Prototype Efficiency

- **Definition**

The first objective of the RPS project is to design & built-up a model for the rotary parking which could hold up 5 vehicles slots. Therefore, constructing the model and integrate all the mechanical components (2 Frames, 2 Gear chains 4 Sprockets, 2 Shafts, 5 pallets and 5 pallets Shafts) together are very essential and critical, so it was necessary to test all these components together, in order to be all to integrate them in the next stage with the electronic components as well as with the IOT system.

- **Experimental setup**

In order to conduct this test, a specific materials and specifications had been chosen in order setup the prototype in the most correct way. Furthermore, for the Frames the PVC board with (10mm) thickness had been chosen to be the main material for the frames, in order to give strength for the whole system.

Moreover, for the gear chain, it need to choose the correct type of the gear chain which is suitable for the project. Therefore, it had been chosen a (420 100L) gear chain, which mean that the number of the pins of the chain is (100) which gives (50 chains), based on the project requirement that need to have 5 vehicles slots, that was the most appropriate choice, so each pallet could be attached on the gear chain and have an equal space (10 chains) between each two pallet as well as this will help in the rotation process, since the rotation is based on timing and how the DC mor will rotate to bring a pallet instead of another, this equal distances had helped in determining the appropriate time for DC motor rotation process.

In addition to that, the choice of the 4 sprockets had been very critical, since the design of the sprocket should be suitable for the type of the gear chain in order to be able to attach them together correctly. As firstly the 4 sprockets had been manufactured by (3D printing) process as shown in Figure 5.1.

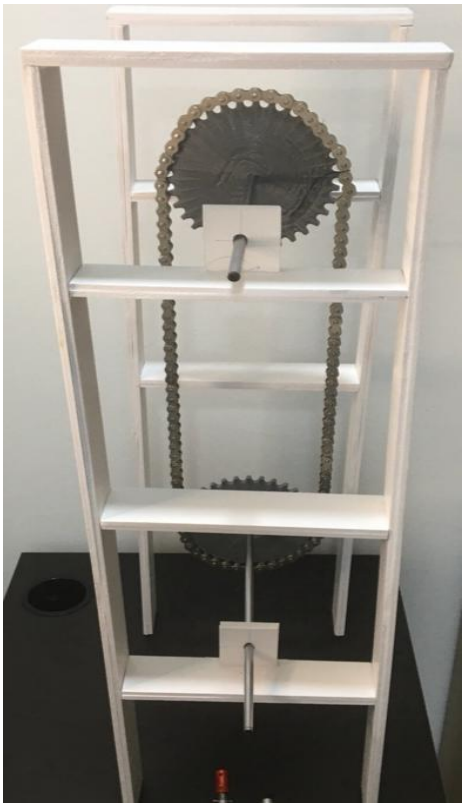


Figure 5.1 : Manufactured Sprockets by 3D Printing

As per Figure 5.1, it shows the first construction steps for the sprockets and RPS prototype as well as, it had been observed that the 3D printed sprockets are not fit properly with the gear chains. Therefore, it had been referred to an Industrial equipment supplier company (REKA Transmission Sdn. Bhd.) (rekatransmission, 2022), in order to manufacture the (Carbon Steel) sprockets based on the gear chain type, which had been used as the main sprockets for the RPS as shown in figures though chapter 4.

Not only that but also, from the main tests and trials which had been done while implementing the RPS prototype is the designing and manufacturing of the five pallets (Height). Furthermore, at the beginning of the implementation process the pallets had been designed to have a height of (10 cm), but that lead to a problem during the rotation process as the pallets during the rotation process touches with the main shafts (which connect the 2 Gear chain together) and that leads to stop the rotation. Therefore, it had been noticed that the best solution is that: the height of the pallets should be less than the half of the height of the sprockets (which is 14 cm) and based on that test, the pallets had been designed once again to be with height of (5 cm) and by that the pallets were able to pass over the upper shafts as well as pass under the lower shaft without touching them and without any problem. Furthermore, the 5 pallets had been deigned also by the PVC board with (5mm) thickness and they had been attached on the gear chain.

Furthermore, there are some essential components had been used for the prototype, such as the (2 mounted Ball Bearing), which are used to attach the shaft at the top of the frame as shown in Figure 4.30. Not only that but also, the (8 Rigid motor coupler) which had been attached on both sides of the sprockets, in order to attach the main shafts firmly with the sprocket, which lead to proper rotation when the DC motor operate. These components (ball bearing and rigid motor coupler) were used after many testing activities to have a smooth rotation for the shafts.

Therefore, by performing all these tests, the first objective had been achieved, as all mechanical and hardware parts had been tested and integrated together as well as they proof that they could sustain and bear the rotation process of the DC motor without any damage, so the choice of the martials of the prototype and testing it were very essential for the project progress.

5.1.2 RPS IOT System Efficiency

- **Definition**

The second objective of the RPS project is to develop an automated system by IOT technology in order to facilitate for the user the process of parking and retrieving, so the main aim of this testing processing to ensure the accuracy of the developed IOT system.

- **Experimental setup**

In order to conduct this test, the IOT GUI mobile application should be ready and initialized. The GUI has 3 main system (pages) needed to be checked & tested (Slot page, Parking page and Retrieve page). Because the Slot page is responsible for testing the efficiency of the IR sensors as they are able to detect an object (car) approach them, so they change their statues from free (value of 1) to occupied (value of 0).

Furthermore, the Parking page will test the rotation process as well as the responding of DC motor once the user click on (Park Your Car) button. Not only that but also, the Retrieving Page will test the rotation process and the efficiency of retrieving back the needed slot as well as it test the 180-degrees rotation of the circular disc by the micro servo motor.

- **Data Collection**

As this project is mainly depends on the IOT GUI and how the user deal and control the whole parking parameters through the mobile application. Therefore, it is very important to analyse the time taken once the user choose any command from the GUI until the real respond is happened on the RPS.

Moreover, in Table 5.2, which represent the data collection for the time taken once the user take an action from the IOT GUI until a response happened (5 Trials) for either the DC motor (parking & retrieving process) and the response of the micro servo motor (circular disc rotation process) as well as the response of the IR sensor once the user park the car and how long it is taken to show the result on the GUI (Slot Page).

Table 5.2: Data Collection for GUI Response

	SYSTEM	DELAY TIME TAKEN FOR THE RESPONSE (Seconds)					
		No. of trial					
Page Name		**1**	**2**	**3**	**4**	**5**	**Average**
IR Sensor (Slot Page)	IOT Mobile Application (GUI)	1.59	3.98	1.0	1.39	1.40	1.872
(Park Your Car) button Parking Page		1.39	1.22	0.50	1.13	1.07	1.062
(Retrieve) button Retrieving Page		1.54	1.50	1.20	1.45	1.50	1.438
(Rotate) button Retrieving Page		0.48	0.45	0.50	0.49	1.00	0.584

- **Data Analysis**

Figure 5.2 shows the Change of time taken (Delay) over different IOT GUI commands, so it is shown how every command like car parking, retrieving, status of slots and circular disc rotation are different from each other, as well as it is shown through 5 trials for each command how times are changed. Therefore, it is proven that the delay of commands is mainly depends on the ESP32 microcontroller and the speed Wi-Fi connectivity.

Furthermore, the faster the internet connection the faster the ESP32 could send the IR sensor data to the firebase database and to be shown on the GUI, as well as if the user send a command from GUI like (Park Your Car or Retrieve), the connectivity play an important role to send this command to the database and then to the microcontroller to control the actuators (DC-motor or micro servo motor)

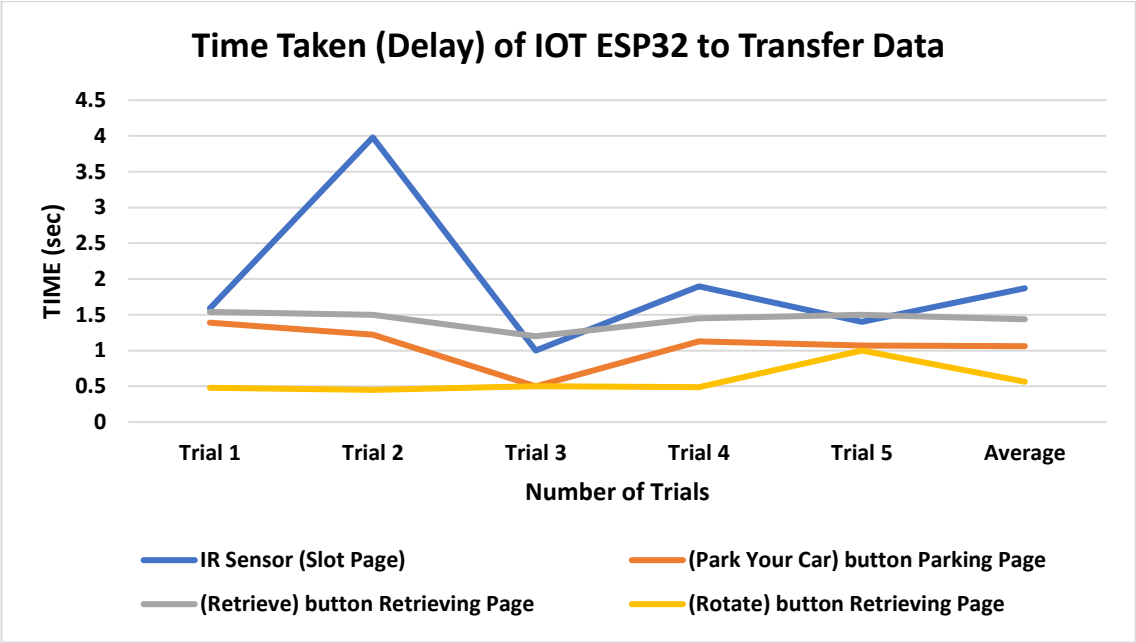


Figure 5.2: Change of Time Taken over different IOT GUI Commands

5.1.3 RPS Actuator Efficiency

- **Definition**

Through this test the actuators of the RPS (DC-motor) is tested, in order to make sure of the efficiency of the DC-motor and its ability to rotate the whole system, since it is considered the main actuator which responsible for the main rotation process for the whole RPS.

- **Experimental setup**

At the beginning of the RPS implementing process a (6 volts -16RPM) DC gear motor had been used, it had been observed that this motor is not applicable for the project as it was not able to perform the rotation process as well as it was not able to give them enough power to rotate the 2 gear chains which is attached to the 5 pallets. Therefore, it had been changed to the (24 volts – 80 RPM) Metal DC gear highly torque motor which had been implemented and used as the main motor for the RPS. Moreover, this motor had proven its efficiency for do the rotating process and sustain the weight of the 2 gear chains as well as the 5 pallets. Furthermore, through (5.1.2) test it had proof that efficiency of receiving the commands of (Parking and Retrieving) from the GUI as the average delay time for both process were (1.062 second) and (1.438 second) respectively.

5.1.4 RPS Cloud Database Efficiency

- **Definition**

Through this test it will be mentioned and analysed why the usage of cloud database had been changed. As through the investigation phase it had been proposed that the (ThingSpeak) database will be used along with the (Google Firebase) database, but while the implementation phase, Firebase database become the only main cloud IOT database for the whole RPS other than using the two databases.

- **Experimental setup**

At the beginning of the RPS investigation process ThingSpeak database had been proposed to be used as it had been proposed that it will be responsible for two main things (Car slots status and Rotation process of both DC and micro servo Motors) as the IR sensors data will be send to ESP32 then to the ThingSpeak and finally the database will send it to the IOT GUI as well as the same process for the actuator the data will be send from the GUI into ThingSpeak and then to the ESP32 microcontroller. While the Firebase database will be responsible, saving the user authentication information.

However, during the implementation phase for the RPS project, it had been noticed that there is delay sending the data From ESP32 to ThingSpeak Database and vice-versa. Therefore, it had decided the RPS will be mainly dependent on Google Firebase Database only, as it provides faster communication between the IOT ESP32 microcontroller and the database.

- **Data Collection**

Therefore, it is very important to analyse the time taken once any command is done from the GUI until it is respond on the cloud database as well as it will be compared between both ThingSpeak and Firebase in order to justify why it had been chosen the Firebase over the ThingSpeak.

Table 5.3: Data Collection for Cloud Database Response

	DELAY (TIME TAKEN) FOR THE RESPONSE (Seconds)					
	No. of trials					
IOT Cloud Database	**1**	**2**	**3**	**4**	**5**	**Average**
Google Firebase	0.48	0.45	0.40	0.49	1.00	0.564
ThingSpeak	1.59	3.98	2.0	1.39	4.40	2.672

- **Data Analysis**

Figure 5.3 shows the time taken (Delay) for both databases ThingSpeak and Google Firebase. Moreover, the data analysis justify why Firebase had been chosen over ThingSpeak. The data shows that Firebase is faster than ThingSpeak. As well as the speed of transferring the data and commands are very vital in the RPS project in order to display to the user the real data and status of the car slots right now as well as retrieve or park the car once the user click on the buttons from the GUI. Therefore, the speed and connectivity between the IOT systems is very important.

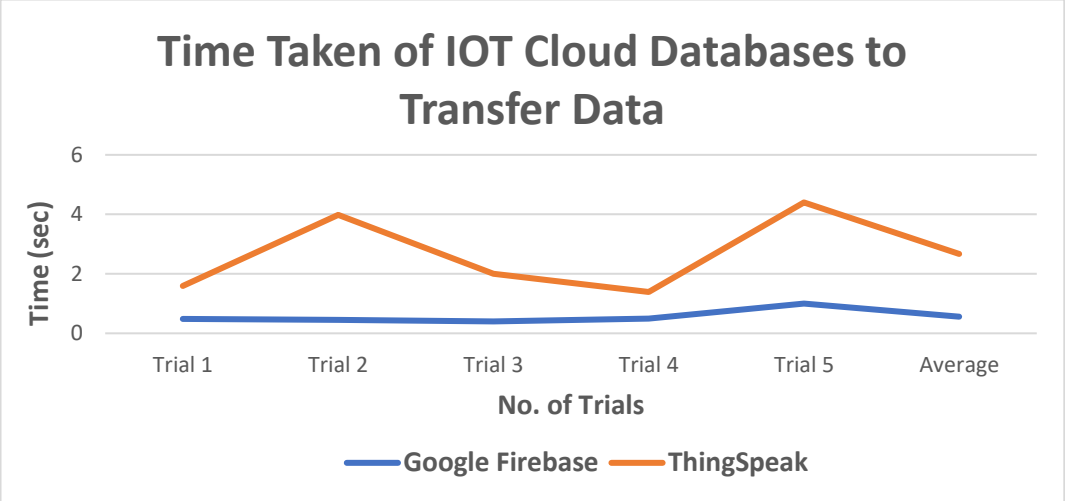


Figure 5.3: Change of Time Taken Firebase & ThingSpeak Databases

5.1.5 RPS IOT GUI Features Efficiency

- **Definition**

While designing and implementing the IOT GUI, there are many features had been developed liked the (Authentication) process which allow the user to have his/her own account as well as give privacy and security for the user while using the RPS.

- **Experimental setup**

Once the IOT GUI is opened and the user click (Get Started), the authentication page will be open for the user, through this testing process it is tested the operation of the IOT system to store the user information on the database successfully, as well as it will test the responding of the system in case the user enters wrong information.

- **Data Collection**

Therefore, Figure 5.4 shows the successful storing process of the user information on Firebase database once the user fill up his own information and click on (SIGN UP) button .

Figure 5.4: Testing of Authentication Process

While, Figure 5.5, represent when the user renter the wrong username and the system refuse to authenticate him and ask the user to (Try again) and enter the correct information.

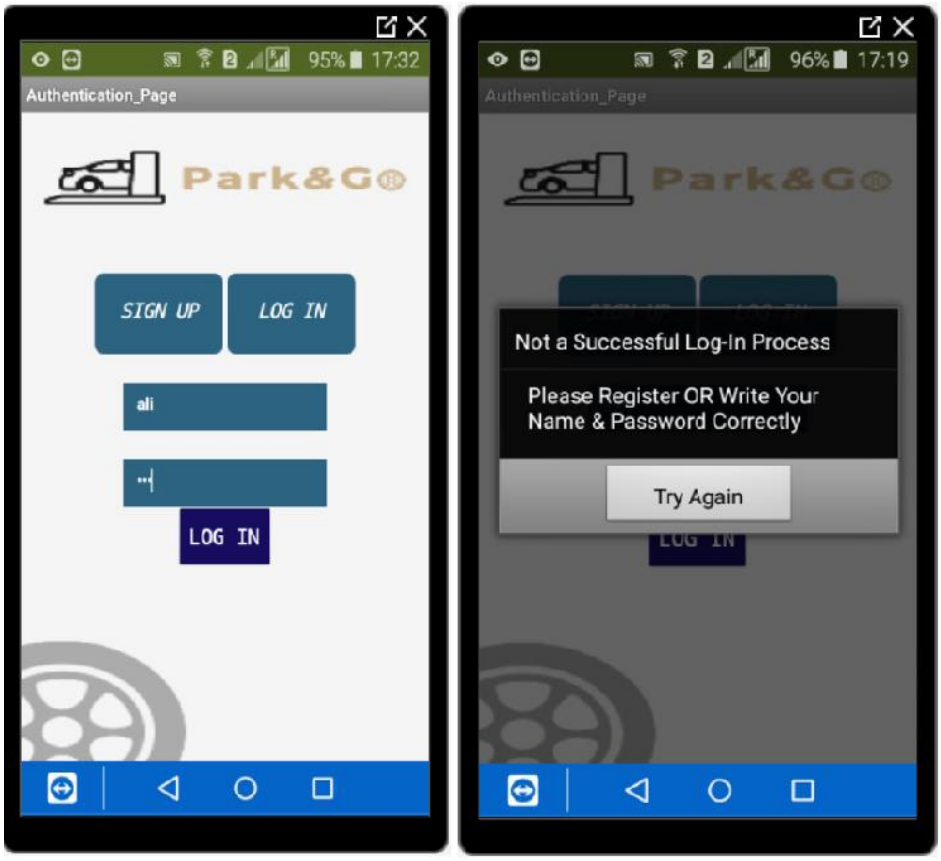


Figure 5.5: (a) Testing of Authentication Process

It is very critical to make sure that the authentication process is working correctly in order to make sure that the user information is secured and no one else other than the user could navigate through his account and know critical information like (Slot code) and that will consider a danger and non-safe for the original car owner as this stolen information could be used to steal the car.

5.2 Discrepancy between the theoretical and experimental results

This section illustrate the discrepancy between the theoretical (expected) results which had prosed in chapter 3 and the experimental (implemented) results. Firstly, during the implementation phase for the software part, there were some changes in IOT GUI as the design of the mobile application had been modified in order to become more user friendly. In chapter 4 it had been shown and explained the new design of the IOT GUI.

While for the prototype there is a difference between what had been proposed in the 3d design (section 3.4.3) and what had been implemented. Table 5.4 shows the difference between 3d design measurand values of the porotype and the real built-up prototype.

Table 5.4: Discrepancy between the theoretical and implemented measurements

Components	**Theoretical (Proposed 3D design)**	**Implemented prototype results**
Frame	Height : 80 cm Width : 20 cm Thickness: 7.5 cm	Height : 75 cm Width : 4.5 cm Thickness: 1 cm
Pallet	Length : 15 cm Width : 10 cm Height : 10 cm	Length : 15 cm Width : 9 cm Height : 5 cm
Circular Disc	Diameter : 7 cm	Diameter : 6 cm
Sprockets	Diameter : 15 cm	Diameter : 14 cm
Mian Shafts	Diameter : 5.7 cm Length : 30 cm	Diameter : 0.8 cm Length : 30 cm
Pallet Shafts	Diameter : 0.5 cm Length : 16 cm	Diameter : 0.1 cm Length : 21 cm

5.3 Explain the possible sources of error and troubleshooting methods

The possible sources of error which had been identified during the implementation of RPS project as well as the troubleshooting method that had been done to solve the error are explained and listed in Table 5.5.

Table 5.5: Possible sources of error and troubleshooting methods

No	Possible Source of Error	Error	Troubleshooting methods
1	Dis-Connecting of MIT-App Inventor Server Website.	Since the MIT APP inventor is the main IOT Platform for this project. Therefore, during the testing process of this project once the server of the website is disconnected, the GUI was not able to run up, which lead to non-functionality of the whole system.	An official email had been sent to the (help) department of MIT APP inventor website as well as Inquiry message had been sent on the community of the MIT, to understand either the error from my side or from the main server and the respond came and it is noticed that the error was from the main server, and it had been solved.
2	Error While uploading the Code to ESP32 microcontroller.	During uploading the code to the ESP32, the microcontroller ship itself was not in the (uploading mode), so it was giving an error and refused to upload the code.	There is an (Boot) button on the ESP32 ship, before upload you need to press and hold it, after start uploading you can release button, so like the ESP32 could receive and upload the code on it.
3	Slow Connectivity between ESP32 & cloud Database.	While testing the project sometimes selecting options from the IOT GUI or situation of IR sensor, the real time data and values is not updated on the spot in the real time on the firebase database, which lead to some delay in the actuators responding	Refreshing the firebase database website as well as disconnect and re-connect again the ESP32 from its power source and also reopen the IOT mobile application, these methods are helping in refreshing the whole system and faster the Wi-Fi-communication between the database and microcontroller.

5.4 Sustainable Development and Environmental considerations

Sustainable projects are the project which aimed to have environment and social benefits as well as positive impact on the environment, economics and social developments. Therefore, while conducting any engineering projects all the sustainable aspects should be considered in order to not harm the end-user or cause any damage on the environment or the people life. Hence, through is section the main objective is to explain and justify how sustainability is achieved for the Rotary car parking IOT based system project.

In terms of social development, this implemented project will help the society, government and big cities in solving a major problem which is congestion and traffic jams, as the rotary car parking is providing a parking car slots in such a small area. Furthermore, the implemented project is developed based on smart IOT system which let the whole system is automated and that lead to a much easier and comfort experience as well as it save time for the user. Not only that but also, it solve the problem of congestions car due to unorganised system for car parking areas.

In terms of environment development, this project have a positive sustainability effect in term of protecting the environment, since most of chosen components and parts are made from recycled materials, like connecting wires and breadboard as well as mentioned the automated rotary parking system is solving the problem of congestion of cars which lead to less traffic jams and less air pollution and all of that has a great positive effect on the environment.

In terms of economic development, as per tested and analysed data in section (5.1.2), this project is mainly dependent on the IOT GUI and how it is fast, dependent and reliable which let the user control the whole process of RPS in most easiest and flexible way. All of that are considered the main aspects of the economic development of this project since, these advantages will save time and effort for the user which lead to positive economic effect for the user.

5.5 Moral Professionalism and Ethical Consideration

As a Mechatronic Engineer conducting an automated rotary parking IOT based system, there should be a professionalism while conducting this project as well as some ethics code should be obeyed and followed. Furthermore, it could be said that the professional ethics is how the engineer will use his skills and knowledge which based on his/her moral and ethics in order to ensure high quality and safety when he/she provide the product to the end-users.

Moreover, the professionalism and ethical consideration is very important for any engineer, since his/her work has a massive effect on people's lives as well as if the ethics are not applied then significant events may happen which lead to massive expenses loss and negative influence on the environment and society and, most significantly, life loss. Therefore, through this section it will be demonstrated how the professionalism and ethics had been applied and considered while conducting this project as well as how Board of Engineering Malaysia (BEM) Code of Ethics had been implemented.

Firstly, while conducting this project and writing this report professionalism and ethics had been considered through preventing dishonesty and plagiarism by following the APA refencing system while referring to any information from any journal or articles or past related project.

Secondly, by following the BEM code 1.1.4 " A registered Professional Engineer with Practising Certificate shall undertake assignments only if he is qualified by education and experience in the specific technical fields of that assignment in which he is to be involved ". (BOARD OF ENGINEERS MALAYSIA, 2016). The implementing of this automated rotary car park IOT based system is done after specific skills and knowledge about the mechanical, electronic and IOT programming devloepding had been gained after 4 years of Mechatronic Engineering degree studying, so this project is considered the core of my studying in (Asia Pacific University). Which mean the BEM 1.1.4 code had been followed and obeyed.

Thirdly, by following BEM code 1.1.7 “A registered Professional Engineer with practicing Certificate shall be objective and truthful in making professional reports, statements and testimonies. He shall include all relevant and pertinent information in such reports, statements, or testimonies, which should bear the date indicating when the information was current” (BOARD OF ENGINEERS MALAYSIA, 2016). As while writing this report all the professional consideration had been applied as well as all the project results had been tested and evaluated. Not only that but also, all the data which related to this project which had been referred to it during the investigation phase had been stated, cited and mentioned with its date.

Lastly, BEM code of professional 1.0 has been followed which state that “A Registered Engineer shall at all times hold paramount the safety , health and welfare of the public”. (BEM, 2005). As the implementation of the project does not have any negative effect on the public or the environment. On other hand, this automated rotary car park IOT based system project help the people to find free parking slot for their car in much faster way as well as the process of parking or retrieving is much easier because of the implementation of the IOT mobile application system. Furthermore, this system ensure the safety of the users while dealing with it due to the implementation of safety sensors, which stop the process of motor and pallets rotation if any person enter parking area while the rotation process occurs.

5.6 Project Management, Finance and Entrepreneurship 2

This section will explain how the project had been organised with the help of Gannt chart as well as all the financial consideration and the final project cost is stated. Finally, it will be explained how this project could be marketable. furthermore, all these factors are aligned with what had been proposed in chapter 3 during phase 1.

5.6.1 Project management

Table 5.6 shows the Gantt chart for phase 2 to ensure that the project had been implemented within the time planned compared to what had been proposed in phase 1. The first week was dedicated to buy all the required components like PVC board for the frames, the gear chain and sprockets all other electronic components like IR sensors and Dc motor in order to start in building the prototype and implement everything together.

From week 2 until week 10 was dedicated to the IOT software enhancing and prototype implementations as well as during these weeks, mandatory meeting 5 and the first progress meeting with the supervisor and second marker had been done to check the progress of the project. The phase two report writing started from week 8 until week 10. Furthermore, in progress meeting 2 with was done in week 11 to demonstrate the whole project the progress presentations with the supervisor were done during the meeting, no need to arrange a time as well as chapter 6 was written in week 11. Finally, in week 12 the Final FYP report had been submitted and the last 2 weeks will be for the (VIVA) final FYP project presentation.

Table 5.6: FYP Phase 2 Gantt Chart

					Final Year Project Phase 2 (Implementation) Gannt Chart													
					MONTH													
NO	**TASKS**	**PROGRESS**	**START**	**END**	**February**				**March**					**April**			**May**	
					W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Buy all necessary implementation components	100%	28/2/2022	07/03/2022														
2	Build-up the RPS Prototype	100%	7/03/2022	09/05/2021														
3	Mandatory Meeting 5	100%	13/03/2022	13/03/2022														
4	Combine & attach all component together and Start in Testing the system	100%	21/03/2022	25/04/2022														
5	In progress Presentation 1 & Mandatory Meeting 6	100%	01/04/2022	01/04/2022														
6	Counite in Building the system & Enhance IOT system	100%	01/04/2022	09/05/2022														
7	Chapter 4 & 5 Writing	100%	01/05/2022	16/05/2022														
8	Mandatory Meeting 7 & Submit FYP draft report to supervisor	100%	21/05/2022	21/05/2022														
9	In progress Presentation-2 & chapter 6 writing	100%	16/05/2022	22/05/2022														
10	Final FYP Report submission	100%	25/05/2022	25/05/2022														
11	FYP presentation (VIVA)	Planned	30/05/2022	10/06/2022														

5.6.2 Finance

Cost estimation is a project management method to evaluate your project budget. Table 5.7 shows the real cost of the project compared to what had expected during the investigation phase.

Table 5.7: FYP Project Cost

NO.	SPECIFICATION	ITEMS	QUANTITY	UNIT COST (RM)	TOTAL COST (RM)
1	Sensors & Microcontroller	IR Sensor	6	1.90	11.40
2					
3		IOT ESP32	1	29	29
4	Actuators	24 RPM DC Gear Motor	1	150	150
5		Micro Servo Motor	5	11.50	57.5
6		L298N Motor Driver	1	6.90	6.90
7	Mechanical Components	Sprocket	4	79.90	319.60
8		Gear Chain	2	13.20	26.40
9		Pallet	5	10	50
10		Pallet's Circular Disc	5	10	50
11		Frame	2	15	30
12		Motor Shafts	2	30	60
13		Pallets Shafts	5	8	40
14	Software	Arduino IDE	1	Free	Free
15		MIT App Inventor	1	Free	Free
16		Google Firebase Database	1	Free	Free
18	Miscellaneous Components	24V 1A Power Supply adaptor	1	13.50	13.50
19		Mounted Ball Bearing	2	2.82	5.64
20		Rigid Motor coupler	8	6	48
21		Front Mirror	1	10	10
Total Cost Estimated (RM)					**366.88**
Total Actual Cost (RM)					**907.94**

As per Table 5.6, it describes the different implemented components which used to implement the RPS as well as it mentioned the estimated cost based on what had proposed during the investigating phase and the actual cost of the final implemented system. The different between the two costs comes from the removed components (E18-IR sensor) as well as the added components (motor coupler and ball bearings) as all of these changes were done based on the project needs during the implementation phase.

5.6.3 Entrepreneurship 2

As per what had been mentioned before in chapter 3 during the investigation phase, the main aspects and methods which could be taken in order to make this IOT RPS project is marketable is to use the rotary park as an adverting area for any company or product as well as adding payment methods to the RPS and market this RPS as the best solution to the population in larger cities to solve the problem congestion and traffic jams.

In addition to that, this RPS project could be profitable, once it is marketed to the 2 main sectors for any city which are the private and the government sector. Moreover, there are many private companies who could incubate this RPS project if they are a software company, they could user their IOT and software knowledge to enhance and implement new smart technologies in the RPS so, it could be more beneficial for them. Also, this project can be marketed to government sector as it will be a great solution to the traffic jams problem as well as it will save time for the government employees while searching for a free parking slot.

Furthermore, this project could be marketable since it is considered a sustainable product. Based on the sustainability aspects which had been mentioned in section (5.4), many companies and the government sectors would like to invest in project like that, which facilitate the people life in a process they do it every day (Parking their Car) as well as at the same time it does not have much negative effects on the environment.

5.7 Contribution in this Project

The main contribution of the project is the implementing of IOT technology in order to control the process of parking and retrieving for the RPS, as it had been developed an IOT GUI, which allow the user to register (Sign-up or Login) to the system and has his own account as well as all his information is saved on an online cloud database (Google firebase) as well as the IOT mobile application gives the user another options like writing his/her own feedback and experience which this feedback is sent to the owner email which could be used later for further development.

Not only that but also, the main advantage of the implemented IOT GUI is that the user could park & retrieve his/her car easily and simply only just by push of buttons as well as check the conditions of the 5 slots either they are free or occupied and that's done due to the connectivity between the Sensors, actuators (ESP32 Microcontroller) and the GUI because of the IOT technology.

Additionally, the second main contribution is the implementing the circular disc on each pallets, so from the GUI the user after retrieving the car he/she could click on the (Rotate) button which rotate the circular disc (Car) 180 degree. Moreover, the exiting process of the car from the park is much easier for the user as this feature had not implemented before in any of the reviewed past proposed rotary park systems.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

To conclude up, an Automated Rotary Car Park IOT based System is developed through this project. The project had divided into 2 phases, investigation phase and implementation phase. Moreover, the main 3 objectives of this project had been successfully achieved. That's because it had been successfully designed and built-up a prototype for the rotary car park by using PVC boards which could hold-up 5 vehicles slots as well as it had been implemented mechanical components like : (Sprockets , gear chains, couplers and shafts), which are essential for the rotary process.

Furthermore, the parking & retrieving process for the RPS had been successfully achieved and that was done through the developed IOT system which used a IOT mobile application (GUI), where the user from this mobile application could fully control the whole process of the RPS like (Parking & Retrieving) as well as all the electronic components like (IR sensors, DC-motor and Servomotors) are connected to the IOT system through the ESP32 IOT microcontroller and the cloud database (Google Firebase), so by implementing the IOT technology the process of parking & retrieving is much easier and had been facilitated for the user and that is considered the second main objective of the project.

Not only that but also, all the required testing and analysis process to test the efficiency of the IOT GUI developed system had been successfully done as it had been tested the efficiency and the response time which taken to transfer the data from the ESP32 microcontroller to the GUI through the cloud database.

6.2 Limitations

First limitation is Wiring Tension problem, since the RPS prototype frames is (75cm) long and the pallets is attached with the gear chains along the frame. Therefore, it was hard to put for each pallet from the 5 pallets its own IR sensor as well as its own micro servo motor, since these sensors and actuators is connected to ESP32 microcontroller through the main breadboard which is located on the ground as shown per Figures in section (4.3). Moreover, if each pallet attached with its own sensor as well as its own micro servo motor, there will be a great tension for the wires as the length of the wire is not long enough.

Therefore, during the rotation process of the pallets, they (the wires) will dis-attached form the pallets. Not only that but also, it will delay the process of DC motor, and the pallets will not rotate in the proper way.

Second limitation for this project is that the developed IOT mobile application is applicable only for the (Android) operating systems mobile phones only and not available for the (IOS) users. That's because the IOT GUI developing process had been done through MIT APP Inventor IOT platform as one of the disadvantage of this IOT platform is that some of its features is not work with (IOS) operating system. Furthermore, the usage of Google Firebase database also is not applicable to work for (IOS) phones as well as IOS mobile application development requires more higher and advanced programming knowledge, so it had been chosen to go with the (MIT APP Inventor).

6.3 Recommendations and Suggestions for further research

The first recommendation that could be given in order to modify and enhance the experience of using the RPS, is to develop the IOT GUI application in way to be applicable to work with both phones operating systems (Android & IOS). Moreover, developing an online website for the RPS could be also a useful enhancement for the user as there will be both options for the user either mobile application or online browsing website.

Second recommendation is the implementation of a solar cell, which could be placed on the top of the Rotary car park and used as the main source of power to the DC motor and the whole system in order to be a clean source of energy for the system.

Third suggestion is to enhance the user experience while using the IOT GUI by implementing the GPS option to the mobile application as well as to the RPS. Moreover, this GPS option will allow the user from the application to identify the exact location of the rotary parking and could easily navigate through the map from his/her location to the parking and in case there are more than one parking the user could identify the nearest one to him and navigate towards it.

6.4 Summary

In this chapter the project objectives, system limitations, proposed enhancement and further recommendation were illustrated. It has been illustrated that the objectives related to the project are successfully achieved, the development of Automated Rotary Parking system that controlled by an IOT mobile application system was achieved as well as the design of a rotary car park prototype which could hold 5-vechicels slots was achieved. Furthermore, both prototype with all the mechanical components and the IOT software had successfully integrated all together.

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P.S.Shri Harish, G. K. (2018). AUTOMATED ROTARY CAR PARKING SYSTEM. *INTERNATIONAL RESEARCH JOURNAL OF AUTOMOTIVE TECHNOLOGY (IRJAT), 1*(2), 104-111.

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APPENDIX A

LOG SHEETS

(APU: Serial Number)

PLS V1.0

Project Log Sheet – Supervisory Session

Notes on use of the project log sheet:

1. This log sheet is designed for meetings of more than 15 minutes duration, of which there must be at minimum SIX (6) during the course of the project (SIX mandatory supervisory sessions).
2. The student should prepare for the supervisory sessions by deciding which question(s) he or she needs to ask the supervisor and what progress has been made (if any) since the last session, and noting these in the relevant sections of the form, effectively forming an agenda for the session.
3. A log sheet is to be brought by the STUDENT to each supervisory session.
4. The actions by the student (and, perhaps the supervisor), which should be carried out before the next session should be noted briefly in the relevant section of the form.
5. The student should leave a copy (after the session) of the Project Log Sheet with the supervisor and to the administrator at the academic counter. A copy is retained by the student to be filed in the project file.
6. It is recommended that students bring along log sheets of previous meetings together with the project file during each supervisory session.
7. The log sheet is an important deliverable for the project and an important record of a student's organisation and learning experience. The student **must** hand in the log sheets as an appendix of the final year documentation, with sheets dated and numbered consecutively.

Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** ……15/10/2021…

Meeting No: …1…

Project title: **Rotary Automatic Car Park System.** **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signatur**

Items for discussion (noted by student before mandatory supervisory meeting):

1. The main idea, methodology about the project.
2. Explain IOT idea about the project and get my supervisor opinion about it.

Record of discussion (noted by student during mandatory supervisory meeting):

1. The main Idea of IOT that is represented which is to implement mobile application to let the driver connected to the smart car park and be able to get his car through the app.
2. The overall idea is mainly agreed on it, but still need more research and modification if needed based on the past researchers.

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Focus more on the research of the previous articles, Journals (Literature Review) that related to the project.
2. From the research the main methodology, and objects will be developed more.

Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.

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PLS V1.0

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Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** ……1/11/2021…

Meeting No: ..2..

Project title: **Rotary Automatic Car Park System.** **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signature:**

Items for discussion (noted by student before mandatory supervisory meeting):

1. To discuss about the Project Objectives
2. To Discuss about the PSF From and see if it need any modification.

Record of discussion (noted by student during mandatory supervisory meeting):

1. The objectives needed to be more narrowed and specific.
2. The literature review and past a papers that found could be focus son the IOT systems, used sensors and the designs of rotary car parks.

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Focus more on the research problems by reading and review mor past papers.
2. Modify the project objectives to be more narrowed.

Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.

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PLS V1.0

Project Log Sheet – Supervisory Session

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Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** …05/12/2021…

Meeting No: ..3..

Project title: Rotary Automatic Car Park System. **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signature:**

Items for discussion (noted by student before mandatory supervisory meeting):

1. To discuss about the written content of Chapters 1 & 2.
2. To check if there anything need to be modified in chapters 1 & 2.
3. To have suggestions about Chapter 3 content.

Record of discussion (noted by student during mandatory supervisory meeting):

1. The Figures needed to be more visible as they are blur.
2. To Add a short sentences or a summary for the limitation for each Literature review.

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Begin in the Design of the park system prototype in chapter 3.
2. Modify what needed in Chapter 2.
3. Continue in Chapter 3 and check it frequently with my supervisor

Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.

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PLS V1.0

Project Log Sheet – Supervisory Session

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Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** ...20/12/2021...

Meeting No: ..4..

Project title: Rotary Automatic Car Park System. **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signature:**

Items for discussion (noted by student before mandatory supervisory meeting):

1. To discuss about the written content for Chapter 3.
2. To check if there anything need to be modified in chapter 3.

Record of discussion (noted by student during mandatory supervisory meeting):

1. The format of flowchart needed to be modified.
2. Try to add some calculations for the design.
3. Complete the prosed design for the prototype.

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Modify the format of flowchart
2. Continue in Chapter 3 and check it once done with my supervisor.

(APU: Serial Number)

PLS V1.0

Project Log Sheet – Supervisory Session

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Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** **13/03/2022**
Meeting No: **..5..**

Project title: **Rotary Automatic Car Park System.** **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signature:**

Items for discussion (noted by student before mandatory supervisory meeting):

1. To discuss about the progress of the project.
2. To ask about the wiring issue of the (IR sensor & servo motor).
3. To discuss about he main points that should be written for Chapter 4

Record of discussion (noted by student during mandatory supervisory meeting):

1. Check online (Cytron) for the Hardware Components (Sprockets & Gear Chain)
2. Chapter 4 will be mainly the enhanced & improved version of Chapter 3.

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Counite in the testing and Building the First Porotype for the RPS to check any issues and be able to solve it.
2. Update my supervisor regularly my progress for the project.

Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.

Project Log Sheet

(APU: Serial Number)

PLS V1.0

Project Log Sheet – Supervisory Session

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Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** 01/04/2022
Meeting No: 6 & IN Progress-Metting-1

Project title: Rotary Automatic Car Park System. **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signature:**

Items for discussion (noted by student before mandatory supervisory meeting):

1. The First In-progress Meeting with supervisor and second Marker.
2. To discuss about the progress of the project.
3. To know my supervisor and second Marker opinion & recommendation on my progress so far.

Record of discussion (noted by student during mandatory supervisory meeting):

1. Check for more innovative solutions for the Rotary Car Park.
2. Check for plan B solution for the rotation process of the system in case anything go wrong.

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Counite in the testing and Building the Porotype for the RPS.
2. Update my supervisor regularly with my progress for the project.
3. Search for more Innovative solution could be added to the system.

Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.

Project Log Sheet

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PLS V1.0

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Student's name: ZEIAD AHMED TAHA ABDELHAMID **Date:** **21/05/2022**

Meeting No: **7**

Project title: **Rotary Automatic Car Park System.** **Intake:** APU4F2110ME

☐ **Entry logged into PAGOL**

Supervisor's name: Dr. Raed Mohammed Taher Abdulla **Supervisor's signature:**

Items for discussion (noted by student before mandatory supervisory meeting):

1. Submit to my Supervisor First Draft of FYP Report.
2. Ask my supervisor to me any suggestions about what kind of Test that is should do in order to include it for chapter 5

Record of discussion (noted by student during mandatory supervisory meeting):

1. check the papers from the literature review and see what kind of test can be done in this field of rotary car park

Action List (to be attempted or completed by student by the next mandatory supervisory meeting):

1. Counite in writing the report ().
2. To Submit the Final FYP phase report on time (25/05/2022).

Note: A student should make an appointment to meet his or her supervisor (via the consultation system) at least ONE (1) week prior to a mandatory supervisor session – please see document on project timelines. In the event a supervisor could not be booked for consultation, the project manager should be informed ONE (1) week prior to the session so that a meeting can be subsequently arranged.

Project Log Sheet

APPENDIX B

STUDENT'S ONLINE FYP SELECTION

ZEIAD AHMED TAHA ABDELHAMID(TP048126-APU4F2110) - Approval status of your request to continue working on the project proposal chosen from our our FYPBaNK

fypbank@gmail.com <fypbank@gmail.com>

Thu 10/7/2021 9:11 PM

To: ZEIAD AHMED TAHA ABDELHAMID <TP048126@mail.apu.edu.my>; Dr. Raed Mohammed Taher Abdulla <raed@staffemail.apu.edu.my>; Dhason Padmakumar <dhason@staffemail.apu.edu.my>

Dear ZEIAD AHMED TAHA ABDELHAMID(TP048126-APU4F2110),

Thank you for selecting this project proposal from our FYPBaNK https://fypbank.apiit.edu.my/

Your supervisor has approved your request to continue working on this project proposal below.

You may continue working on this project proposal.

Project proposal id : 3053
Project Title : Design and Implementation of of Rotary Automated Car Parking System
Name of Supervisor : Dr. RAED MOHAMMED TAHER ABDULLA Email: dr.raed@apu.edu.my

Regards,
Customer Support Department,FYPBaNK,APU

This is a system generated Email. Please do not reply.

APPENDIX C

PROJECT SPECIFICATION FORM

PROJECT SPECIFICATION/PROJECT BRIEF OF ENGINEERING

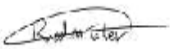
FYP Title: Design and Implementation of Rotary Automatic Car Park System

Supervisee Name: ZEIAD AHMED TAHA ABDELHAMID

Supervisee TP Number: TP048126

Programme: Mechatronic Engineering. (APU4F2110ME)

Supervisor Name: Dr. RAED MOHAMMED TAHER ABDULLA

Supervisor Signature: 

Date:1 November 2021

Project Specification Form (Engineering)

Note: The PSF is an online submission. Use this form to discuss your proposal with your supervisor. Please complete all sections before meeting your supervisor so that relevant comments can be furnished.

A. Project Title.

To Design and Implement Rotary Automatic Car Park

B. Brief description on project background. (.i.e. Introduction about project and problem statement)

Rotary Parking System (RPS) is the design that the cars are parked on a rectangular plate in a vertical way where the plate that hold the car could rotate vertically clockwise or anti-clockwise, In this project a RPS model that hold 5-vechile will be designed and built-up and the control system will be developed based on innovative IOT technology so, the process of using RPS is more easy, smooth, save and smart.

The main Problems statement that had been found is firstly, the Insuffifcient space for the cars in the big cities to be parked and these insuffifcient spaces leads to unorganized way of parking cars which lead to road blocking and traffic jams is the big cities.

Secondly, is Wasting of drivers' Time to find a free parking slot as in the traditional parking designs let the drivers take time while driving in the panels of the park or if the park is designed with many levels in some cases the driver will need to search for a free space among the levels.

Thirdly, Lack of fully automated rotary car park systems, most of the rotary car park proposed systems need a physical deal from the user with the control panel for the parking and retrieving car process, so a smart IOT web or mobile applications needed to be developed.

Fourth, in all the RPS designs the driver had a problem that while retrieving their car they need to rotate their car as the car is had parked vertically on the plate in a specific direction, so a spinning platform could be implanted to give the driver the chance to rotate his car through the GUI App and get in his car and drive on the road directly and instantly.

C. Brief description of project aim and objectives. (i.e. scope of proposal)

Aim:

The aim of the project is to Develop and Modify a Rotary Automatic Car Park System that can hold 5 vehicles slots with innovative IOT Solutions to facilitate the process of Parking & Retrieving the Car.

Objectives:

1. To Design a Rotary Car Park Model that hold 5-cars.
2. To Develop a Fully Automated Smart system through a GUI IOT Application for the users to control the rotary parking system in the process of parking and retrieving.
3. To Evaluate the accuracy of parking sensors and conduct trials for measure the connectivity between the smart IOT application system and the process of parking and retrieving.

D. Brief description of the system/model/design that will be used in this proposal.

In this project it planned to design and construct up a model for a rotary car park that could hold up 5- cars, then the control system of the car park will be developed in order make facilitate the process of parking on the drivers,

so, it will be implemented sensors like ultrasonic distance sensors, mirrors and LCD screen to help the driver in the parking process. The system will be developed in a way to insure safety for the users , so it will be implanted sensors that make sure the stop is stop if any person is detected inside the area of rotating the car to ensure the safety.

In order to ensure that the system save time and facilitate the process of paring IOT Innovation technologies will be added, as the user will be able from his mobile or web application to know the free slots, Know the slot that he parked his car in it and also from the application he will be able to retrieve his car back as all of these information will be saved and connected to an IOT cloud platform.

E. Academic research being carried out and other information, techniques being learnt. (i.e. literature - what are the names of books you are going to read / data sets you are going to use)

For this project it had been referred to journal articles is mailing for Designing and Developing Automatic Rotary Car pars system projects and also the Research that related to IOT technology Implementation for the car park systems had been reviews. All the Literature review that had been examined are from the past 5 years.

The following are the names of the Journals that is used for this project for the Literature Review :

Dhamyaa Saad Khudhur, A. E.-A. (2020). Analysing the efficient use of solar energy in an automatic. *IOP Conference Series: Materials Science and Engineering*.

Dr.R.Gandhi, D. ,. (2021). IoT based Automatic Smart Parking System with EV- Charging Point in Crowd Sensing Area. *Annals of R.S.C.B.*, 6398-6409.

ElakyaR, J. S. (2019). Smart Parking System using IoT. *International Journal of Engineering and Advanced Technology (IJEAT)*, 6091-6095.

Hugeng Hugeng, A. D. (2020). Implementation of rotary parking system model using wi-fi as. *IOP Conference Series: Materials Science and Engineering*.

J., D. (2020). Design and Analysis of Components of a Rotary Car Parking System. *Proceedings of International Conference on Intelligent Manufacturing and Automation*, 555-569.

Mehala Chandran1, N. F. (2020). An IoT Based Smart Parking System. *International Conference Computer Science and Engineering*.

Mohummad Shariful Islam, A. M. (2017). Launching automated rotary parking system:. *Department of Mechanical Engineering, Military Institute of Science and Technology*.

Muhammad Asyraf Bin Mahmood, S. S. (2018). Design and Implementation of a Rotary Parking System for a Truly Smart City. *IEEE International Conference on Control System, Computing and Engineering (ICCSCE)*.

P.S.Shri Harish, G. K. (2018). AUTOMATED ROTARY CAR PARKING SYSTEM. *Internaltional Research Journal of Automotive Technology (IRJAT)*, 104-111.

Rajeev Tiwari, H. K. (2019). Automated Parking System-Cloud and IoT based Technique. *International Journal of Engineering and Advanced Technology (IJEAT)*, 116-123.

Ravi Kishore Kodali, K. Y. (2018). An IoT based Smart Parking System using LoRa. *International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery*.

S.Poornimakkani1, S. S. (2018). A CLOUD BASED END-TO-END SMART PARKING SOLUTION POWERED. *International Research Journal of Engineering and Technology (IRJET)*, 56-72.

Saidur Rahman, P. B. (2019). IOT Based Smart Parking System. *International Journal of Advances in Computer and Electronics Engineering*, 11-16.

Vishal Tayade, S. W. (2019). Automatic rotary car parking system. *International Journal of Advance Research, Ideas and Innovations in Technology*, 1233-1235.

Zeeshan Sheikh, S. L. (2021). SMART CAR PARKING SYSTEM USING IOT. *International Journal For Advanced Research In Science & Technology*, 49-54.

The Citation of the Research papers Review :

1. (M Sodiq, 2017)
2. Mohummad Shariful (2017)
3. Muhammad Asyraf Bin (2018)
4. Ravi Kishore Kodali (2018)
5. (S.Poornimakkani1, 2018)
6. (Mehala Chandran1, 2020)
7. (Hugeng Hugeng, 2020)
8. (Zeeshan Sheikh, 2021)
9. (Dr.R.Gandhi, 2021)
10. (ElakyaR, 2019)
11. (Vishal Tayade, 2019)
12. (P.S.Shri Harish, 2018)
13. (Rajeev Tiwari, 2019)
14. (Dhamyaa Saad Khudhur, 2020)

f. Brief description of the materials/methodologies needed by the proposal. (i.e. data collection methods, equipment's, testing and etc.)

1. **Design the Rotary Car Park:**

SOLIDWORKS CAD software will be sued in order to design the Model of the rotary car park that is able to hold 5 car plate slots. This design will be used for the construction process of the model

2. **Parking The Car Process:**

- A Sensor Knows that a Car Arrives.
- A Slider Open to Let the Car Enter.
- Sensors, Led, Mirror help the Driver in parking the Car.
- Driver Exit the Car and get out from the park area.
- Since no person is detected, the rotary process done.
- Another Empty slot is ready and the Slider close.

3. **Retrieve The Car Process (IOT & QR Code):**
    - Through an IOT Mobile Device the diver will select the slot that he had parked his car in it.
    - The IOT system Will send to the driver a specific QR Code for the slot of his car.
    - When Driver want to retrieve his car , he will scan this QR Code that sent to him.
    - The fastest Rotary process is done based on Scanned Code & the car location.
    - On the application the driver have the option to rotate the car slot plate, so he can take his car easily.

The above following steps is considered the main proposed methodology for the implementing the project as first the design of the model will be done in order to help us in the construction process.

then secondly in the developing system part it will be used sensors like (Ultrasonic, Proximity, Infrared, LCDs and Mirror) for helping in the parking process .

the Third step is mainly for the IOT technology that will be sued to facilitate the process of retrieving the car. The proposed techniques for implanting the IOT technology are (Arduino IOT cloud, Blynk, IBM Watson, Thing Speak and MITApp Inventor). All of these are considered a IOT cloud platforms that one of them will eb sued to link between the data that will be get from the sensors and the GUI mobile app that the driver will use it to know his car slot number and retrieve back his car.

G. Brief description of the evaluation and analysis proposed for this project. (i.e. testing, project deliverables and hypothesis, correlation test etc)

The main Deliverables of the Automatic Rotary Car Park project is 4 main aspects which are:

1. The Allocated Building space area.
2. Time Taken to find a Free Car Park Slot.
3. Implement a Fully Automatic control system by the user though a Mobile App VIA IOT Cloud Technology.
4. Smart, Smooth, Save and Easy experience for the user while the Parking and Retrieving Process.

These are the main things that proposed to be delivered by at the end of implantation of the project and all of the aspects will be evaluated and test to make sure that they are achieved.

H. Illustration of how this project will benefit in the future.

This project if benefit for the congested large cities, as constructing a Rotary car park will give the option to give many slots for cars and it does not required large space area to be built on it. Also, it saves time for the users to park their car in less time than ordinary car park designs as rotary car park let the user direct park the car without searching for a free spaces as free slots are always available. From the main advantages of this project that it will be fully automated developed system and that will save time and make the process of parking and retrieving is more easy, smart and smooth for the drivers.

APPENDIX D

ETHICS FORM

Office Record	*Receipt*
Date Received: Received by whom:	Student name: Student number: Received by: Date:

ACADEMIC RESEARCH ETHICS DISCLAIMER

Declaration about ethical issues and implications of research project/assignment proposals to be included on project/assignment application forms

Project/Assignment Title:

Design and Implementation of Rotary Automated Car Parking System

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The following declaration should be made in cases where research project/assignment applicants for a particular project/assignment and the supervisor(s)/lecturer(s) for that project/assignment conclude that it is not necessary to apply for ethical approval for the research project/assignment.

We confirm that the University's guidelines for ethical approval have been consulted and that all ethical issues and implications in relation to the above project/assignment have been considered. We confirm that ethical approval need not be sought.

Zeiad Ahmed Taha Abdelhamid	Zeiad Ahmed	05/12/2021
Name of Research Project/Assignment Applicant	E-signature	Date

Dr. Raed Mohammed Taher Abdulla		07/12/2021
Name of Research Project Supervisor/ Assignment Lecturer	E-signature	Date