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Thesis Title: Smart Car Parking System in Rwanda

By
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A dissertation submitted in partial fulfilment of the requirements for the degree of
MASTER OF SCIENCES IN INTERNET OF THINGS

In the College of Science and Technology

Supervisor: Dr Richard MUSABE

Co-Supervisor: Dr Emmanuel NDASHIMYE

March, 2021

Student Declaration

I declare that this Dissertation contains my own work except where specifically acknowledged

Student Name and Number: Esperance NYIRANSABIMANA (219013579).

Signed……

Date……02/01/2021……

BONIFIDE CERTIFICATE

This is to certify that the project entitled" Smart Car Parking System in Rwanda" Is a record of original work done by Esperance NYIRANSABINA with reg number 219013579 in partial fulfilment of the requirement for the award of masters of sciences in Internet of Things in College of Science and Technology, University of Rwanda, Academic year 2019/2020.

This work has been submitted under the guidance of Dr Richard MUSABE and Dr Emmanuel NDASHIMYE.

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ABSTRACT

This dissertation discusses smart car parking system in Rwanda using IOT based technology. Rwanda is the country that needs to be smart in different domains like in agriculture, health and transportation especially in car parking. There are different problems in parking affecting people such as wasting time and fuel consumption while searching for available parking spaces. Eventually they are parking in areas which are not accepted. These problems cause different consequences like traffic congestion, driver's frustration and air pollution. The proposed smart car parking system facilitates the drivers to find the available parking slots automatically and reduces the waste time and fuel required for searching available parking slots. The objectives of this work achieved are to design the smart car parking system, to automatically detect available parking slots, to send data about parking status to the cloud, to display it to the smart phone using android application and to compare the existing data to new designed system. The existing system used a long time and requires a lot of fuel for searching available parking slot, and new car parking system use short time and save the fuel require for searching available parking slot. The new system is more efficiency, enhances the safety and security and easy to use. It is composed of IR (Infrared) sensors, servo motor, microcontroller (arduino uno), ESP8266 Wi-Fi module and Thingspeak cloud. This cloud supports MATLAB that is used to analyze and visualize the recorded data. The drivers access the data on Thingspeak cloud using a developed android application installed in their smart phones. The smart car parking system developed in this work enables vehicle occupancy, monitoring and managing of available parking space in real-time.

KEY WORDS

Internet of things, Thingspeak cloud and Infrared (IR) sensor

LIST OF SYMBOLS AND ACRONYMS

IOT: Internet of Things
ACEIoT: African Center Excellence Internet of Things
IR: Infrared
MATLAB: Matrix Laboratory
WIFI: Wireless Fidelity
LCD: Liquid Crystal display
RFID: Radiofrequency Identification
WSN: Wireless Sensor Network
LED: Light Emitting Diode
SPC: Smart Parking Controller
AC: Alternating Current
DC: Direct Current
IDE: Integrated Development Environment
PWM: Pulse Width Modulation
ICSP: In Circuit Serial Programming
USB: universal serial bus
SOC: System on Chip
HTTP: hypertext transfer protocol
API: Application Programming Interface
APK: Android Package
ID: Identification
TCP: Transmission Control Protocol
IP: *Internet Protocol*
DEX: (Dalvik Executable)
ADB: Android Debug Bridge

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CHAPTER 1. INTRODUCTION

1.1 Introduction

The idea of making smart city in Rwanda now is possible with an emergence of internet of things (IoT). One can argue that to increase the economic growth, the increase in the productivity and reliability of urban infrastructure, such as reduce traffic congestion and to make better the parking facilities IoT is needed[1]. In Rwanda especially in Kigali city, enterprises started to adopt smart cities notion on several areas such as health, government, energy, water, environment and transportation, just to name a few [2]. In this research work, the focus is in transportation area especially in car parking.

One of the key problems faced by smart cities is the car parking problem and traffic management system. It is not easy because of finding an available parking slot is always difficult for drivers. Many people live in cities where the availability of parking spaces is often less than the availability of vehicles which leads to a shortage of parking space [3]. The drivers use between 3.5 and 14 minutes to find an available parking slot. This brings the consequences such as frustration of drivers, accidents, lost business opportunities, traffic congestion, and increased air pollution [3]. In Rwanda, we have this problem of lack the available parking spaces on real time. There is no standard system to check available parking slots prior to the arrival at parking place. The traditional method of parking depends on human to human intervention which is not efficient [4]. The location reporting has to be done manually by the parking facility employee to the car driver [5]. In 2017, a company of Smart Kigali Parking Ltd started with parking services at major events in Kigali. It started this project as a way of creating jobs for youths, but also helping drivers to get quick parking space and security but this method is manually [6]. In order to solve all problems stated above, IoT based new parking platform is needed. It enables to connect, analyse and automate data gathered from sensors and perform smart parking possible. The smart car parking system developed in this work enables vehicle occupancy, monitoring and managing of available parking space in real-time that reducing the wasting time and fuel spent while looking the available parking spots. It reduces human intervention, the environmental pollution, driver's frustration and traffic congestion. The users are able to check nearest parking slots availability using android application installed in their smart phones. The developed system can be described as follows. It

includes the IR sensor mounted in every parking slot, it easily detects the presence or absence of vehicle in parking slots since it requires low power, simple circuitry and the portable features. It is sensitive to environment. The IR sensors are placed at main entrance and exit the gate to detect the presence or absence of vehicle at the gate and it counts the cars entry and leave the parking. The two servo motors are mounted at main entrance and exit of the gate to open and close the gate respectively. The system also contains arduino uno that process the data from sensors and send it to the Thingspeak cloud for storage using ESP8266 Wi-Fi module. This cloud is a web application and acts as a data base to store all the records related to parking status. This cloud supports MATLAB used to analyze and visualize the data stored on the cloud. This thingspeak cloud is low-cost. It has high storage capacity and the data stored on it can be accessed from anywhere at any time when one has the internet and the smart phone application. The smart phone acts like an interface between end users to the system [5]. The users who have not smart phones application will see the data about parking status on LCD display mounted at main entrance the gate of parking.

1.2 Background and Motivation

1.2.1 Motivation of this research project

The main motivation of this project is to help drivers to find available parking slots on real time and to reduce the traffic congestion and air pollution that usually occur when drivers are looking for available parking space in the Kigali city. In Rwanda, we are still using the manual vehicle parking system. This brings facing problems like wastage of time and energy finding free space across the parking surface. In additional to that, looking for available parking space takes some amount of fuel. This research project saves the time and fuel required by drivers when searching available parking slots.

1.2.2 Background of the research project

In big cities searching available parking slots during peak hours in areas like Shopping center, Hospital, Hotels, Airport, Universities and Convention center is always a big problem for drivers[7]. Sometimes this leads to many consequences among people like traffic congestion; increases air pollution, driver's frustration and waste time and fuel for searching available parking

slot. The existing manual parking system it is too hard to find the available parking slot on time, it is use long time consuming. Sometimes it causes late in meeting or other important works. Due to this disorder in parking our valuable time gets wasted. It also causes economical loss to commercial places like shopping malls, amusement parks as people are more likely not to visit these places due to this parking hazard. Smart Parking System is one of the best available solutions to at least reduce the traffic congestion and air pollution caused due to the above problem. It provides several benefits and save time for drivers and fuel cost. The new system displays available parking slot to the drivers on real time and improves the economy. It provides security and it is efficiency.

1.3 Problem Statement

In developed cities especially Kigali city, on the road there are large numbers of vehicles day by day which increase the parking problems in the city. The finding available parking slots is becoming more challenging on daily life .These challenges cause wasting time and fuel required for looking available parking slot , traffic congestion, driver's frustration and air pollution in the city especially during the peak business hours. In Rwanda, we have this problem of lack the available parking slot on real time, there are no standard system to check for available parking spaces. The traditional method of parking dependent on human to human intervention which is not efficient [4]. It is very clear from this point of view that there is a need to propose a research project of automatic smart car parking system which helps the drivers to find available parking slots automatically without intervention of human. The drivers who have smart phones and Wi-Fi connection are able to see the available parking slot by using android application installs in their smart phones. This solution reduces the waste time and fuel required for searching available parking slot, the air pollution, driver's frustration and traffic congestion and increase efficiency of the parking process.

1.4 The Study Objectives

The objective of this research project is to design smart car parking system in Rwanda and develop a prototype where the drivers can see the available parking slot on their smart phones and LCD display mounted at the main entrance the gate of parking.

1.4.1. General objective

The general objective of this research project is to design and implement the smart car parking system in Rwanda especially in Kigali city.

1.4.2. Specific objectives

The Specific objectives are listed as follow:

- To design the smart car parking system
- To detect the available parking slots automatically
- To send data about parking status to the cloud
- To display it to smart phone using android application
- To compare the existing data to new designed system

1.5 Hypotheses

In Rwanda, especially in Kigali city, to find the available parking slots is the challenges for the drivers. It still uses the manual procedure to see the available parking. This system will solve all those challenges affect the drivers. It is very easy to know the available parking slot by using the android application installs in smart phone of end user.

1.6 Study Scope

To find the practical results required, this thesis focuses on the following steps: The first one is smart parking system consist of Arduino microcontroller, infrared sensors, servo motor and LCD display as the main components. Arduino is used as the main microcontroller for the project. This system uses infrared sensors mounted at every parking slot to detect presence of vehicle in parking space another infrared sensors mounted at main entrance and exit to count the cars entry or leave the parking space. Besides that, there are two servo motors at the entrance and at the exit that will be controlled by the infrared sensors. The second one is communication between microcontroller and cloud which is done using ESP8266 WIFI Module .It is used to send data to the Thingspeak cloud to store, analysis and visualize data from sensors about parking status. The drivers know the available parking slot quickly on the android app installing in their smart phones. The third one is the final implemented system that can be used as an initial model (prototype).

1.7 Significance of the Study

In a smart city everything must be smart, in Rwanda we need to be smart in all domains like in health, environment and transportation .We need to be smart in parking using smart parking. This smart parking makes the city look better and helps the drivers to find the available parking slot on real time without waste the time and fuel for searching available parking slot. A driver with a smart phone and internet connection can get information about parking status from Thingspeak cloud anywhere at any time. The car parking system is simple, efficient, use low time and secure. Anyone who has a smart phone can use it. By using this system no one in the drivers is ever waste the time looking for a parking space to park because this system automatically shows to him or her. The system also helps the parking owner to know which cars came in and out so that it helps the owner to know the income per day. In return, it helps the country to be better because it reduces the air pollution.

1.8 Organization of the Study

The remaining part of this thesis is organized as follows. In Chapter 2, the literature review is explored covering the previously related research done about smart parking. In Chapter 3, the used methodology is explained for achieving the specific objectives, explains the data collection from questionnaire about parking, the proposed system, the hardware and software used to build the system . In Chapter 4, is devoted for the system analysis and design taking into account the simulation model and system flow chats. In Chapter 5, the result and the analysis of the project are presented together with discussion. In Chapter 6, the overall conclusion of the project is drawn and future recommendations that can be done to improve this project are presented.

1.9 Conclusion

This chapter introduces the work to be presented in this thesis. The objectives of the work are presented together with its scope. One can notice that the developed smart car parking system in Rwanda used Thingspeak cloud receiving data about parking status from Arduino uno using ESP8266 WIFI module. The data present on the cloud can be accessed by end users (car drivers)

using the developed android application installed in their smart phones. Hope the reader will enjoy the extensive work presented afterwards.

CHAPTER 2. LITERATURE REVIEW

As far as it is concerned, there are many techniques used to detect the available parking slot in parking space in the studies done so far.

The first technique used the Image processing and video camera. The work done in [8] proposed smart parking system using the image processing algorithm. Such a system can be described as follows. The surveillance cameras get recorded data about available parking slot and send them to the incoming drivers in the parking building. In the work done in [9],[10] presented an intelligent system for parking space detection based on image processing technique. It captures images covered surface and after processed these images. It produces the information about available parking slot.

The work done in [11] presented the system that provides the information about parking status and guiding users using image processing. The system contains the counter to count the number of vehicle parked in the parking and displays the available parking slots. One can summarize such a technique as follows. The installed camera at main entrance of the gate of parking captures the structure of images and then analysed using digital image processing for vehicle detection. After that, the real time information and guidance is provided to the entering user.

This method of detecting available parking slot using image processing and cameras is not good because the cameras are very expensive and the size of the vehicles is predicted which is not much beneficial. This motivates the research to think of advanced method.

The second technique uses the sensors to detect available parking slots. One can find such interesting technique in work done in [12], where they presented available parking slots using ultrasonic sensor and arduino to detect available parking slots. By using ultrasonic sensor that measures the distance from parking slots, it helps the drivers to find the available parking slot to park their cars. The work done in [13] presented smart car parking using ultrasonic sensor ,arduino uno and mobile application. The users accessed the system about available slot using the mobile application and web page. By using ultrasonic sensor to measure the distance, the users are able to easily find the available parking slot. Arduino uno used in vehicle parking system, designs, creates and delivers data. Such a system is called vehicle stopping framework that help

the drivers to find available slot. This saves the time and fuel required in searching available parking slot.

The work done in [14] proposed a Model of Integrated Smart Parking Solution for a city that used the camera, ultrasonic sensor, arduino uno and mobile application. The camera will open when the ultrasonic sensor detects an object. The captured image will send to arduino for processing. The user will using mobile application to know available parking slot.

The work done in [15], proposed a Smart Parking Management System. It is composed of ultrasonic sensor, arduino uno, and ESP8266 WIFI module and cloud server. The system enables the computation of available parking slot. It helps the users to automatically find available parking slot without waste the time.

The work done in [16] proposed the system that incorporates the RFID technology in the existing system. The system checks-in and checks-out the parking space and increases the functionality of system and efficiency. The system is composed of the IR sensors that used to collect the availability of parking status and notifies the drivers in finding and choosing available parking slot. If RFID tags are damaged or more than one tag reads at time, the system fails to work accurately.

The work done in [17],[18] proposed smart parking using IOT that solve the issue of waste the time in searching available slot for driver. The information about parking status is sent to the drivers through notification. It is composed of 3 parts. Part one is embedded system that includes IR sensors and arduino. By using RFID the drivers can enter in the parking area. The second part is the intermediate between parking area and user called cloud based web service. The third part is the user. By using GSM module the user can get notification about available parking status via the SMS. If RFID tags are damaged or more than one tag reads at time, the system fails to work accurately and GSM module via the SMS makes the system not cheap.

The work done in [19],[20] presented the system with Wireless Sensor Network and RFID. It is used to the parking garage; it includes the work to change the original WSN and use of RFID and zigbee technology. This system displays the number of available parking slot in parking area to the drivers. This reduces the traffic congestion and frustration of drivers in searching available parking slot.

The work done in[21] proposed the system that helps the drivers to find the available parking slot more easily. The system is composed by two ultrasonic sensors that are used to detect the presence of vehicle, proximity sensor that are used to sense the distance of existing parking limit in its surrounding environment, arduino microcontroller, two LED which can turn On if there is information about presence of car, LCD is also used as screen display that reads the data from three sensors, ESP8266 Wi-Fi Module used to send data from microcontroller to the local server, and cloud. The ultrasonic used in this system has low accurate and the system require long time to update parking status. The work done in [22] people in klab worked on smart parking controller(SPC) in Rwanda. Their goals were to develop a new system called smart parking controller (SPC) that informs the drivers about available parking slot in parking space using short time.

For the interests of lower cost system and high efficiency to monitor the available parking slot, we developed the system of smart car parking system in Rwanda that composed by Infrared sensors which is low cost, low power requirements, simple circuitry, their portable features, more accurate and sensitive to environment .It detects the presence of vehicle in parking slot, Arduino uno for processing, ESP8266 WIFI module used as sender to send data to the Thingspeak cloud. Thingspeak cloud used as web application that stores, analyses and visualizes data from sensors and android application used as interface between system and users, it helps the drivers to find the available parking slot on real time. Through this work exist elsewhere, they are new in Rwanda.

CHAPTER 3. METHODOLOGY

The current chapter concerns the methodology used to achieve the objectives of the smart car parking system in Rwanda.

3.1 The data analysis from research questionnaires

We worked on a sample of 30 drivers who makes the parking in Kigali city every day. We asked them the questions about parking in the city. The analysis of data from questionnaire was done using excel. The data collected from questionnaire are used for designing an IOT solution about smart parking.

The questions and analyses are in the following tables.

Q1. What are the challenges associated with parking in the Kigali city

Table 3.1 The challenges associated with parking in the Kigali city.

Responses	Frequency	Percentage
Get available space is difficult	18	60
Time dependent to get parking	3	10
Reserved to others	1	3.33
Waiting	8	26.67
Total	30	100

This table shows that 60.00% of responders gave responses of getting available parking space is difficult, 10.00% of responders gave responses of time dependent to get parking, 3.33% gave the responses of parking is reserved to others and 26.67% gave responses of getting available parking is waiting.

Q2: Do you easily to find the location to park your car in Kigali city? Answer Yes or NO

Table 3.2 Do you easily to find the location to park your car in Kigali city? Answer Yes or NO

Responses	Frequency	Percentage
Yes	0	0
No	30	100

Total	30	100

The table 3.2 shows that 100% Responder give responses NO. This means to find the location to park their cars is not easily, no one find available parking slot easily

Q3. What is the time spends to find the available parking in Kigali city?

1. Less than 5 minutes
2. In 10 minutes
3. Above 10 minute

Table 3.3: What is the time spends to find the available parking in Kigali city

Responses	**Frequency**	**Percentage**
Less than 5 minutes	2	6.67
In 10 minutes	10	33.33
Above 10 minutes	18	60
Total	30	100

This table shows that 6.67% of responders gave responses of time spent to find available parking slot in Kigali city is less than 5 minutes, 33.33% of responders gave the responses of time spent to find available parking is in 10 minutes and 60.00% gave the responses of time spend to find available slot in Kigali city is above 10 minutes.

Q4. Are the time spent to find available parking slot related to the cause of traffic congestion? Answer YES or NO

Table3.4. Are the time spent to find available parking slot related to the cause of traffic congestion? Answer YES or NO

Responses	**Frequency**	**Percentage**
Yes	19	63.33

No	11	36.67
Total	30	100

The table 3.4 shows that 63.33%Responders gave the responses YES. This means that the time spent to find available parking slot was related to cause traffic congestion and 36.67% Responders gave the responses NO. This means that the time spent to find available parking slot was not related to cause traffic congestion.

Q5.How do you find the free space to park your car in Kigali city is it easy or not easy?

Table 3.5. How do you find the free space to park your car in Kigali city is it easy or not easy

Responses	Frequency	Percentage
Easy	1	3.33
Not easy	29	96.67
Total	30	100

The table 3. 5 show that 96.67% Responders gave the responses of Not easy. This means that to find free space to park their cars is not easy and 3.33% Responders gave the responses of Easy .This means that to find free space to park their cars is easy.

Q6. There is any advantage of using existing system of parking in Kigali city? Answer Yes or No

Table3.6.Any advantages of using existing system of parking in Kigali city? Answer YES or NO

Responses	Frequency	Percentage
Yes	0	0
No	30	100
Total	30	100

The table 3.6 shows that 100% responders gave the responses NO .It means that no advantages of using existing system of parking in Kigali city

Q7.What is the method do you use to find the available parking slot in Kigali city?

Table 3. 7 The method used to find available parking slot in Kigali city.

Responses	Frequency	Percentage
Circulation	20	66.67
Coming early in the morning in the city	7	23.33
Waiting other driver	1	3.33
Get underground parking	2	6.67
Total	30	100

This table shows that 66.67% of responders gave responses of finding available parking slot in Kigali city used the method of circulation, 23.33% of responders gave responses of finding available parking slot using coming early in the morning before 8h00 in the city, 3.33% of responders gave the responses of finding available parking slot used method of waiting other drivers and 6.67% of responders gave the responses of get underground parking.

Q8.Are you satisfied to use this existing method of parking? Answer Yes or No

Table3.8. Are you satisfied to use this existing method of parking in the city? Answer YES or NO

Responses	Frequency	Percentage
Yes	2	6.67
No	28	93.33
Total	30	100

This table shows that 93.33% responders gave the responses NO. This means that the existing method is not satisfied to the users parked in the city and 6.67% responders gave the responses YES .This means that are satisfied of using this existing method.

Q9.Do you know any technology helps you to find nearest parking easily in Kigali city? Answer YES or NO

Table 3.9.Do you know any technology helps you to find nearest parking easily in Kigali city? Answer YES or NO

Responses	Frequency	Percentage
Yes	1	3.33
No	29	96.67
Total	30	100

This table shows that 96.67% responders gave the responses NO, This means that they did not known any technology that help them to find nearest parking easily in the city and 3.33% responder gave the responses YES, This means that they did known any technology that help them to find nearest parking easily in the city.

Q10.Do you use any technology to get help in finding available parking slot in Kigali city? Answer YES or NO

Table3.10. Do you use any technology to get help in finding available parking slot in Kigali city? Answer YES or NO

Responses	Frequency	Percentage
Yes	4	13.33
No	26	86.67
Total	30	100

This table shows that 13.33% responders gave the responses YES, This means that they used any technology to get help in finding available parking slot in the city and 86.67% responders gave the responses NO, This means that they did not used any technology to get help in finding available parking slot in city

Q11.Do you know anything about smart parking? Answer YES or NO

Table3.11 Do you know anything about smart parking? Answer YES or NO

Responses	Frequency	Percentage
Yes	4	13.33
No	26	86.67
Total	30	100

This table shows that 13.33% responders gave the responses YES, This means that they knew smart parking as something smart and 86.67% responders gave the responses NO, it means that they did not known anything about smart parking.

Q12.Is it the first time do you understand smart parking? Answer Yes or NO

Table3.12. Is it the first time do you understand smart parking? Answer Yes or NO

Responses	Frequency	Percentage
Yes	28	93.33
No	2	6.67
Total	30	100

This table shows that 93.33% of responders responded YES. This means that most of asked drivers have no idea about the smart parking technology and only 6.67% of responders responded NO.

According to the data coming from the survey done, we developed the system called smart car parking system in Rwanda especially in Kigali city that will solve all problems see in the tables above facing the drivers in Kigali city.

3.2 Proposed system diagram

The system diagram of proposed system is show in Figure 3.1 below. The system consists of IR (infrared) sensors that are attached in every parking slot to detect the parking status like presence of vehicle or absence of vehicle in each parking slot. The other IR sensors mounted at main entry and main exit the gate to detect the presence of vehicle at the gate and count the vehicles entry and leave the parking. When there is vehicle cross around the main entrance the gate the counter would be incremented by one however when the vehicle cross around the main exit the gate the counter

decremented by one. This would give the real-time exact number of vehicle inside in parking. Moreover the IR sensors at the gate have another application, they have activated the servo motors mounted at the gate to open and close the gate. The data about parking status from sensors capture by arduino uno for processing. The output from arduino uno about parking status is send to Thingspeak cloud, web page based application using ESP8266 WIFI module. The ESP8266 Wi-Fi module based network adaptor is used to connect to internet using TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. A HTTP GET message is used to send sensor data about parking occupied or parking available to the thingspeak cloud using REST full API over a TCP connection. The web page application can update these recorded data about parking status every 20 second. The drivers get the data about available parking slot from web page using developed android application install in their smart phones.

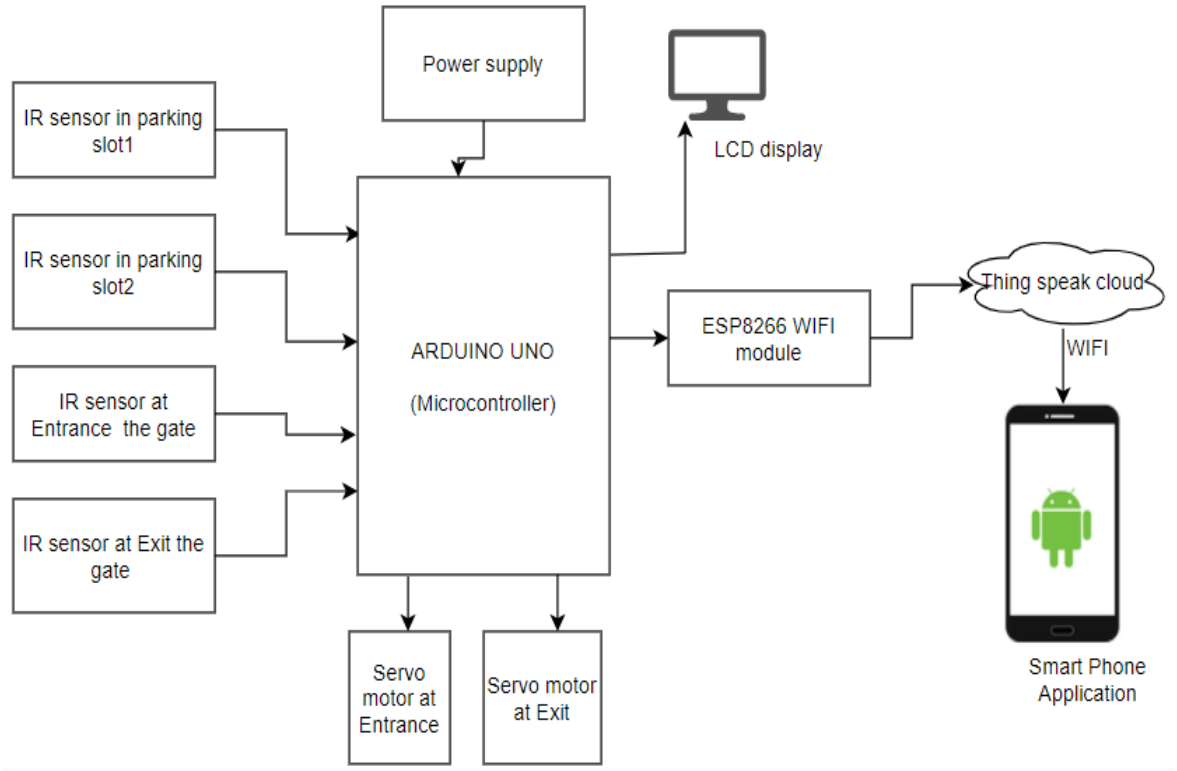

Figure 3.1 Smart parking system architecture

3.3 Hardware and Software used in this Project

3.3.1 The hardware components

3.3.1.1. Arduino/Genuino Uno

In this proposed system we use the Arduino uno for microcontroller that process data about parking status from sensors. Arduino Uno is a microcontroller board that is based on the ATmega328P. It has 14 digital input/output pins and 6 of them can be used as PWM outputs, 6 analog inputs pins, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. It is simple connection to the computer by using USB cable or powers it with an AC-to-DC adapter or battery to get started. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0.

The Uno board is the first in a series of USB Arduino boards, reference model for the Arduino platform[23].

Figure 3.2 Arduino uno used in the circuit

3.3.1.2. IR Sensor module

In this proposed system we use the IR sensor to detect the data from environment like presence or absence of vehicle in parking slot. The infrared (IR) sensor is used to detect any obstacle in front of the sensor module. IR sensors are also used to differentiate between black and white faces. White faces reflect all types of light while the black faces absorb them .It includes IR transmitter and IR receiver. The infrared (IR) transmitter is a light emitting diode (LED) which emits the infrared radiation[24] .IR receiver detects the radiation from IR transmitter. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined[25]

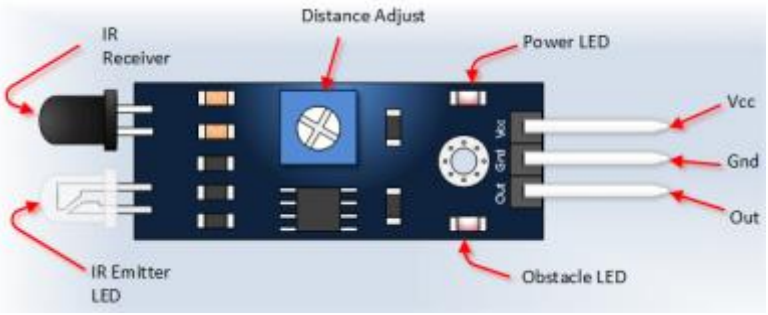

Figure 3.3 IR(Infrared) sensor used in the circuit

3.3.1.3. Servo Motor

In this proposed system we use the servo motor to open and close the gate. A **servo motor** is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through **servo mechanism**. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. The servo motors sometimes have a revolution cut off from 90° to 180°. A few servo motors even have revolution cut off 360° or a lot of. But servo motors do not rotate constantly. Their rotation is restricted in between the mounted angles[26].

Figure 3.4 Servo motor used in the circuit

3.3.1.4. The ESP8266 WIFI module

In this proposed system we use the ESP8266 WIFI module to transmit data from arduino to cloud server. The ESP8266 WIFI module is low cost standalone wireless transceiver that can be used for end point IOT development. It allows microcontroller access to Wi-Fi network. It enables internet connectivity to embedded application and it uses TCP/UDP communication protocol to connect with server/client. The microcontroller to communicate with ESP8266 Wi-Fi module needs to use set of AT commands and using UART having specified Baud rate (Default 115200)[27].

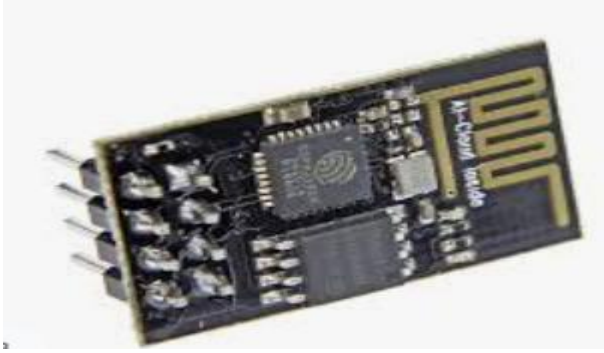

Figure 3.5 The ESP8266 WIFI module used in the circuit

3.3.1.5. USB cable

A Universal Serial Bus (USB) is a common interface that enables communication between devices and a host controller such as a personal computer (PC) or smartphone. It connects peripheral devices such as digital cameras, mice, keyboards, printers, scanners, media devices, external hard drives and flash drives. It used to connect any board with personal computer (pc) like arduino uno and arduino Mega 2560.

Figure 3.6 USB cable used in the circuit

3.3.1.6. The LED (Light Emitting Diode)

A *light-emitting diode* (*LED*) is a semiconductor *light* source that emits *light* when current flows through it. It has two pins such as cathode which is flat (negative) pin and anode which is longer (positive).

Figure 3. 7 Light Emitting Diode in circuit

3.3.1.7. Jump wires

The jump wires are simply wire that used for connection between two points in a circuit. They are typically used with breadboard and other prototyping tools in order to make it easy to change a circuit as needed.

Figure 3. 8 Jump wires

3.3.2The software used

3.3.2.1. Arduino Software (IDE)

The Arduino Integrated Development Environment or Arduino Software (IDE) is open source and to write the codes in arduino IDE is easily and upload it to the board. It is easy to use for beginners, yet flexible enough for advanced users to take advantage of well. It runs on Windows, Mac OS X and Linux. It is published as open source tools, available for extension by experienced programmers. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures[28].

3.3.2.2 .Thingspeak cloud platform

Thingspeak is an open source IOT platform where anyone can visualize and analyse live data from their sensor devices. Also, we can perform data analysis on data posted by remote devices with MTLAB code in Thingspeak[29].

3.3.2.3. Android application

In this proposed system we use android application as interface between users and system. The users can know available or occupied parking slot using this android application installs in their smart phone without waste the time and fuel required for searching available slot. An Android app is a software application running on the Android platform. Because the Android platform is built for mobile devices, a typical Android app is designed for a smartphone or a tablet PC running on the Android OS. It is created using android studio. The android applications are developed using the JAVA programming language and use java core libraries. It uses the SDK to support older versions of the Android platform in case developers wish to target their applications at older devices. The SDK includes tools, sample code and relevant documents for creating Android apps. Android applications are packaged in .apk format and stored under data app folder on the Android OS. APK package contains dex (Dalvik Executable) file. The dex file contains code which is ultimately execute by the android runtime. In order to display available parking slot on smart phone android application is developed for the smart parking[30].

3.4 The System Prototype

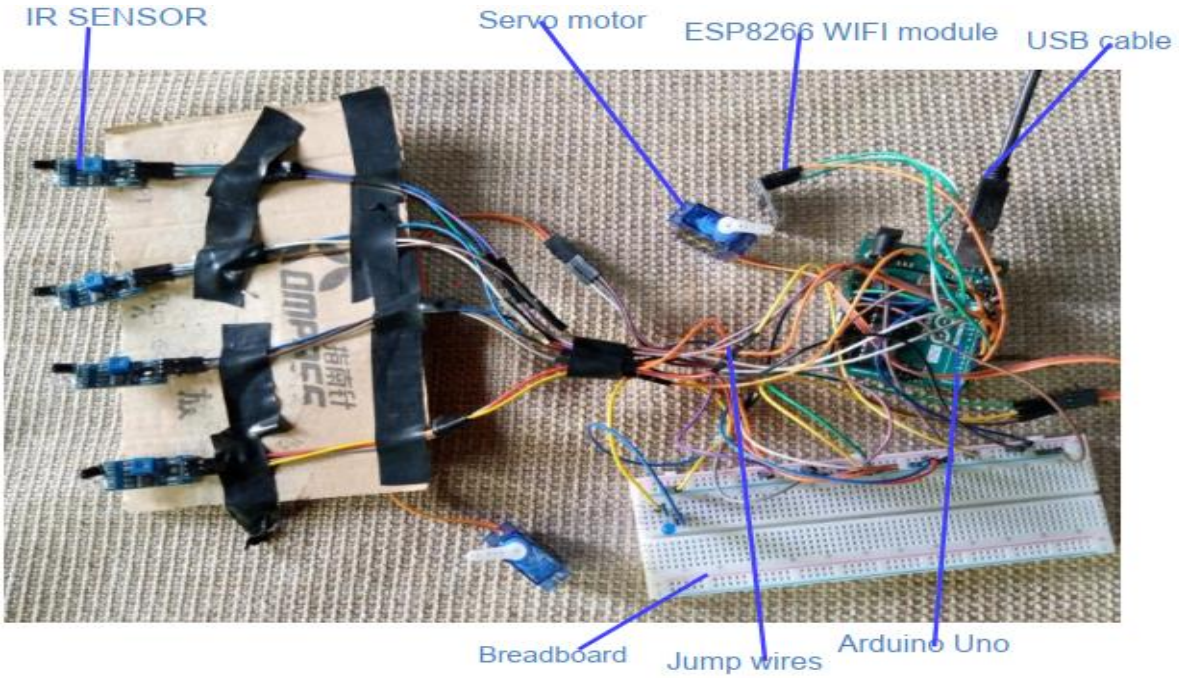

Figure 3.9 System circuit

In this system prototype, the two IR sensors for slot1 and slot2 and IR sensors at main entry and main exit the gate are working and send the parking status to microcontroller (arduino uno) where the data processing is done. The Microcontroller processes this data and transmits to the thingspeak cloud over ESP8266 Wi-Fi module, in achieving the task the controller is loaded with a program written using Embedded „C" language. The Thingspeak cloud stores recorded data about parking status and support MATLAB that helps to analyse and visualize the data stored in thingspeak. The users who have android application installs in their smart phones and want to park their vehicles are connected to the Wi-Fi network. They are able to know available parking and number of available parking slots in parking area. This way the user can easily find a parking slot without any congestion and in less time.

CHAPTER4. SYSTEM ANALYSIS AND DESIGN

4.1 Smart car parking system flow chat

4.1.1 The system flow chat to display the parking slot occupied or parking slot available

The sensors are the key elements for this parking system. The sensors used are Infrared (IR) sensors mounted at every parking slot to detect the presence or absence of vehicle in parking slot. The arduino uno captures the data about parking status from sensors for processing and sending them to the thingspeak cloud using ESP8266 Wi-Fi module. The ESP8266 Wi-Fi module based network adaptor is used to connect to internet using TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. A HTTP GET message is used to send sensor data about parking occupied or parking available to the thingspeak cloud using REST full API over a TCP connection. The thingspeak cloud platform was stored the data from sensors about parking occupied or parking available and support MATLAB that used to analyse and visualize the data about parking status stored on it. It synchronizes every 20 second and users access these data using android application installs in their smart phones. The system flow chat summarizing the above description is presented in Figure 4.1.

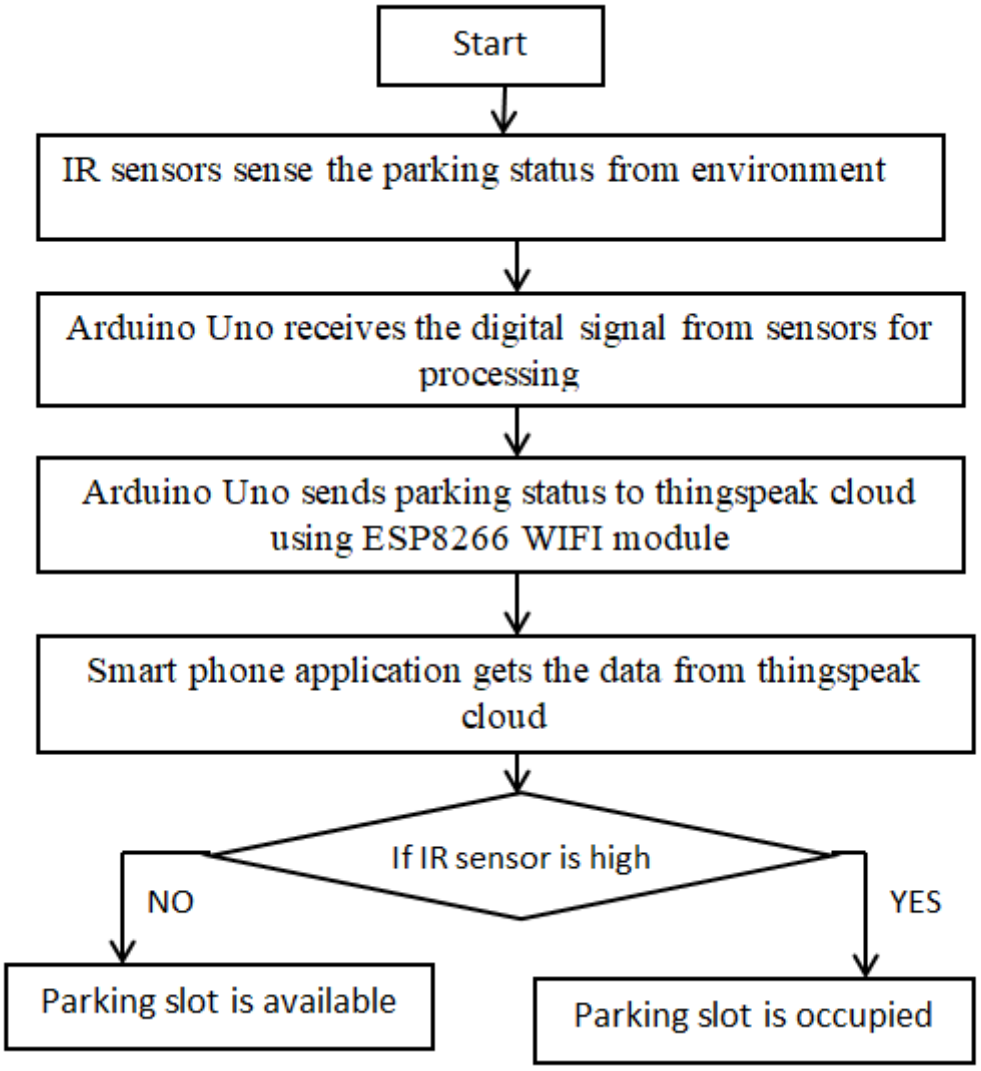

Figure 4.1 The system flow chat to display the parking slot occupied or parking slot available

4.1.2 The system flow chats of servo motor at the gate to open and close the gate

The IR sensors mounted at the main entry and main exit have activated the servo motor at the gate to open and close the gate when they detect the vehicle at the gate. This summary shows in figure 4.2 presented below

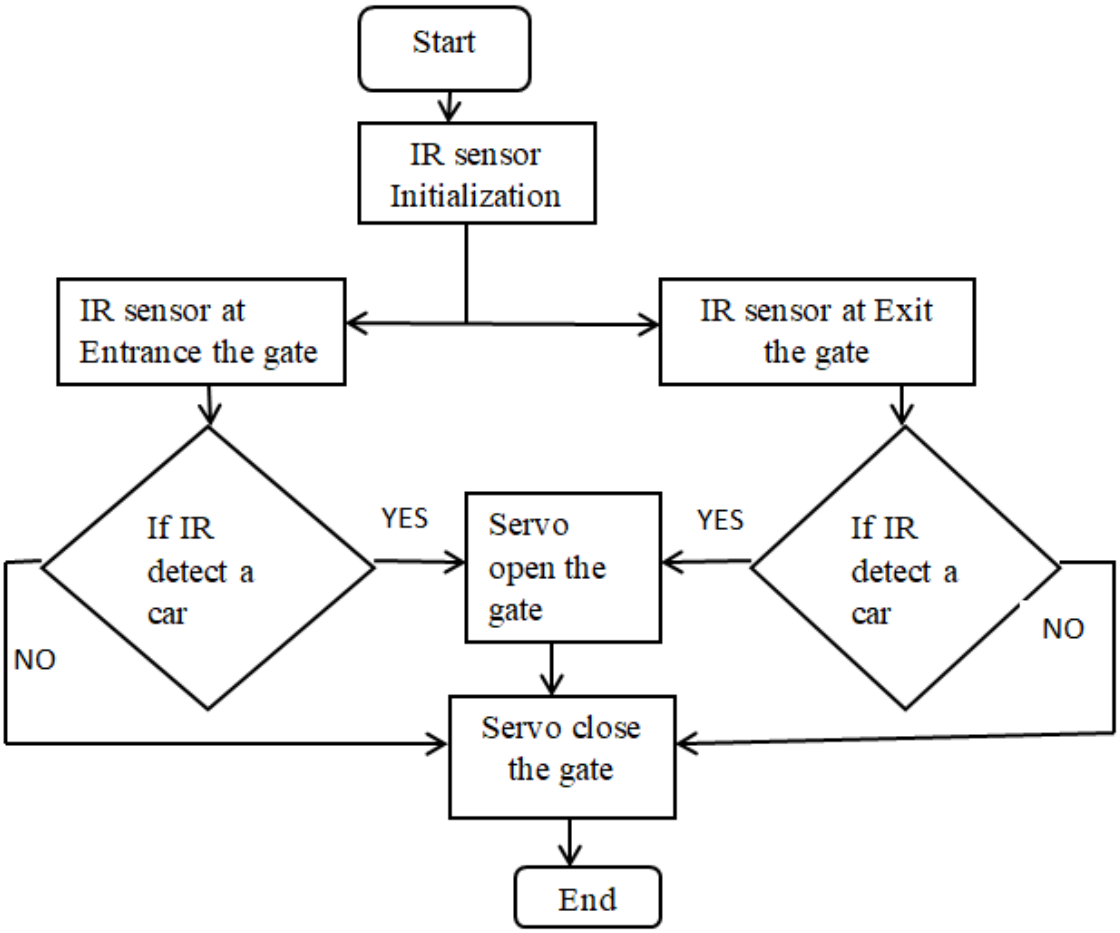

Figure 4.2 The system flow chat of servo motor at the gate to open and close the gate

4.1.3 System flow chat of IR sensors at the gate that Count the vehicles entry and vehicles leave the parking

The IR sensors mounted at main entrance and main exit gate detect the presence of vehicle at the gate and count the vehicles entry and leave the parking. When there is vehicle cross around the main entrance the gate the counter would be incremented by one however when the vehicle cross around the main exit the gate the counter decremented by one. This would give the real-time exact number of vehicle inside in parking space. This Sammy is show in figure 4.3 below

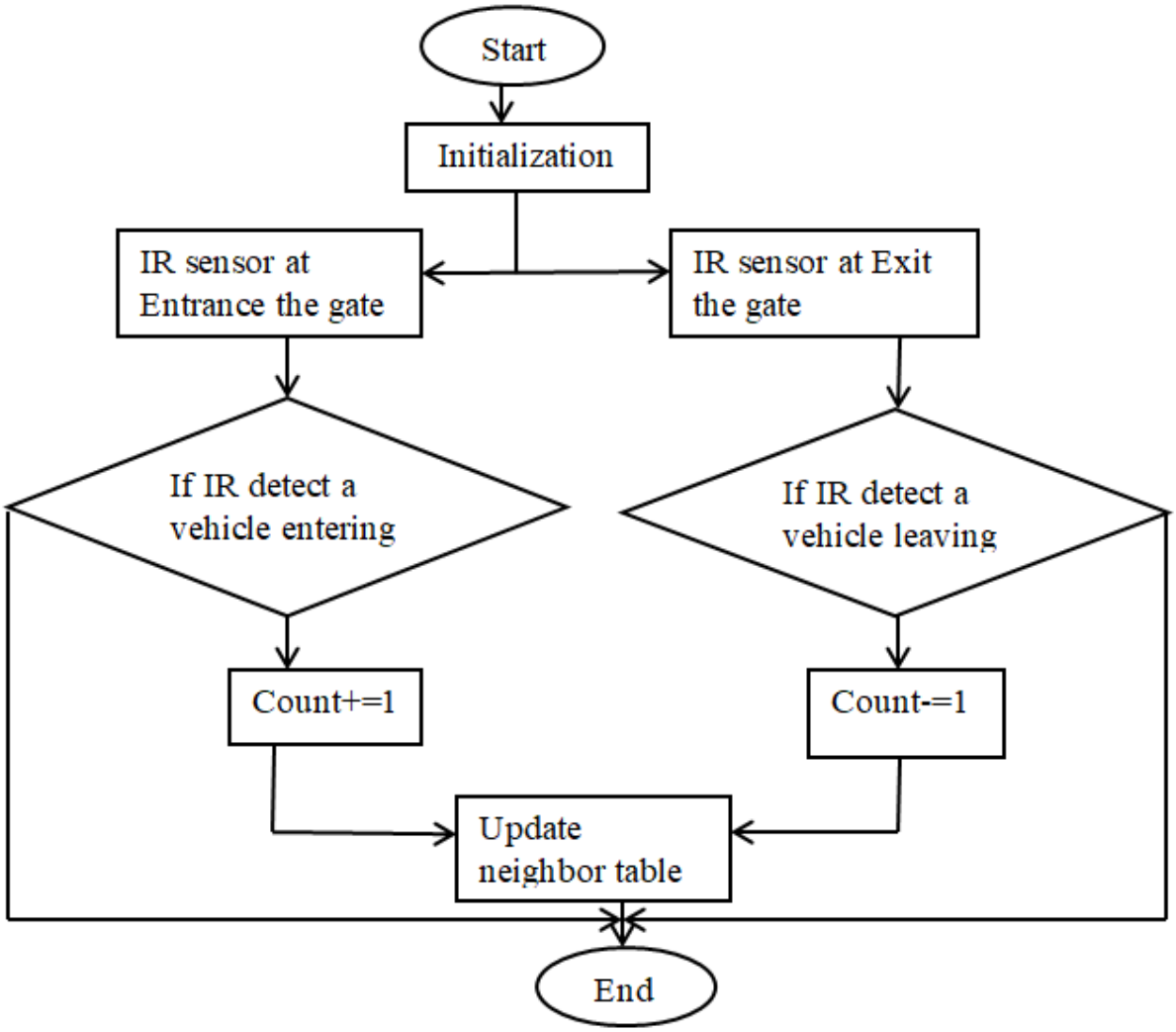

Figure 4. 3 System flow chat of IR sensors at the gate that Count the vehicles entry and vehicles leave the parking

4.2 To display the number of slot available in parking

N=all parking slots in parking space

Count= Number of vehicle entry or leave parking

A= Number of slot available in parking space

A=N-Count

4.3 Simulation Model

The simulation model used is proteus 8 professional for anticipating the results of the system. This proteus helps the drivers to get data about parking status on Serial monitor and LCD display mounted at main entry gate of parking.

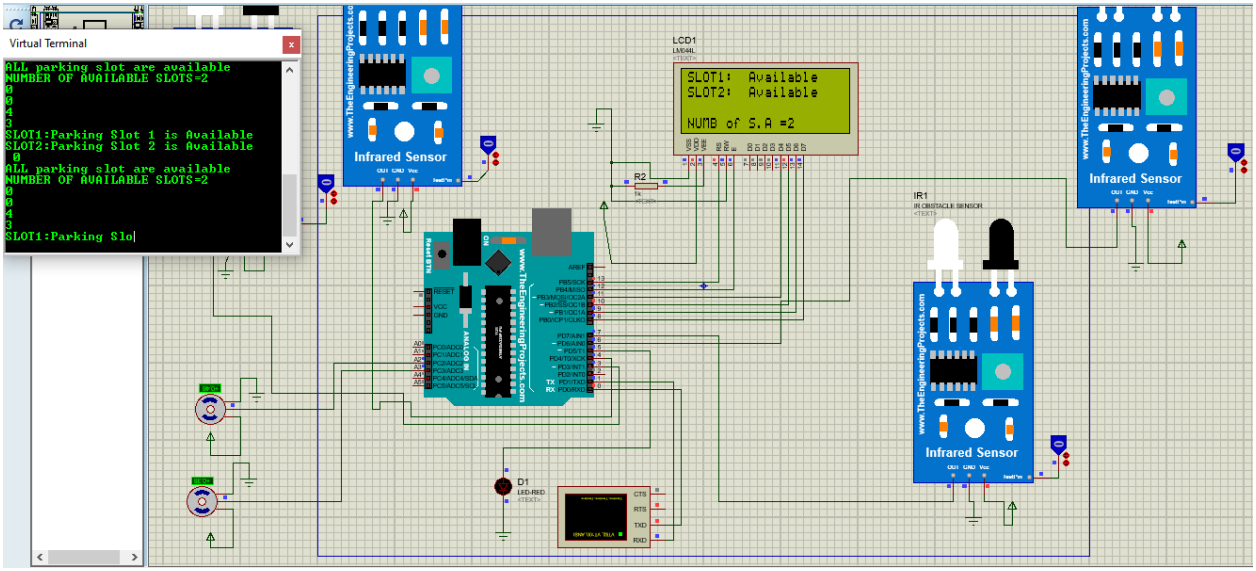

Figure 4.4 Proteus simulation to display the availability of parking slots and number of available slot in parking space

The figure 4.4 shows data about parking status in Proteus simulation that displays on serial monitor and LCD display all parking slots available and number of slots available in parking is 2 and LED red is OFF.

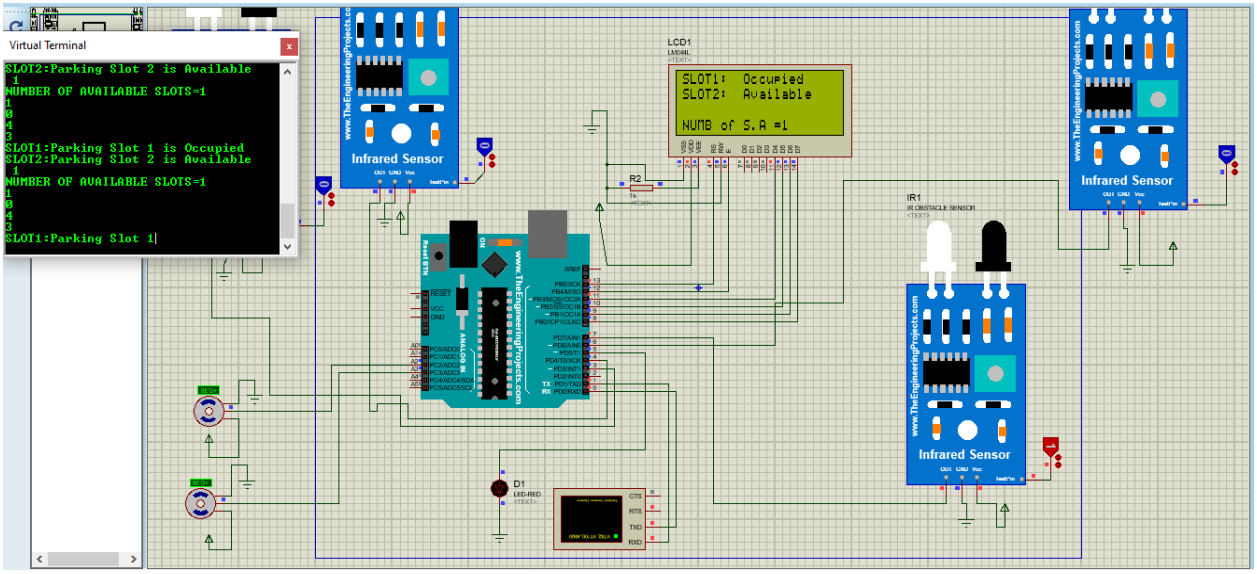

Figure 4.5 Proteus simulation to display the parking slots occupied and parking slots available and number of available slot in parking space

The figure 4.5 shows the data about parking status in Proteus simulation that display on serial monitor and LCD display the parking slot1 is occupied and parking slot2 is available and number of slot available is 1 and LED red is OFF.

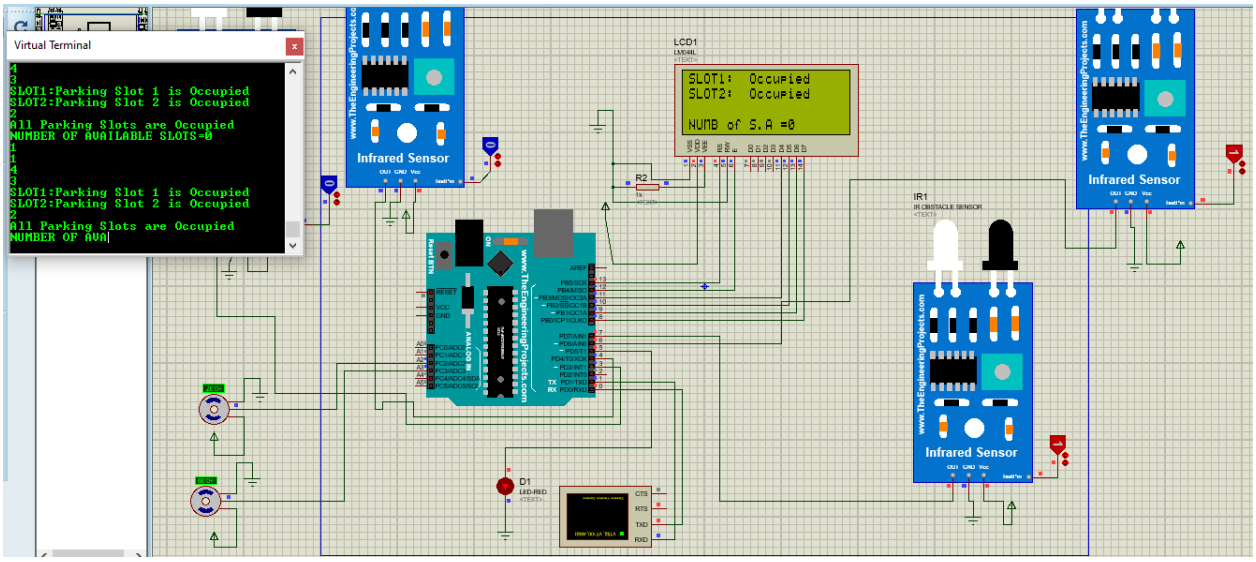

Figure 4.6 Proteus simulations to display all parking slots occupied.

The Figure 4.6 shows the data about parking status in Proteus simulation that displays on serial monitor and LCD display occupied of all parking slots and LED red is ON.

Because of proteus software has not internet connection that helps to send data to the cloud. We develop the smart car parking system prototype that explain in chapter3.

CHAPTER5: THE RESULTS AND ANALYSIS

5.1 Discussion of Results

The discussion of the results start from the proteus simulation, in proteus simulation there are 3 Figures that show the parking status on Serial monitor and LCD display mounted at entrance the gate of parking. Figure 4.4 shows the data about parking status on serial monitor and LCD display. It monitors that all parking slots available and number of available slots in parking is 2 and LED red is OFF. The figure 4.5 shows the parking slot1 occupied and parking slot2 available and number of available slot is 1 on Serial monitor and LCD display mounted at main entrance the gate of parking and LED red is OFF. The Figure 4.6 shows the data about parking status on serial monitor and LCD display. It displays that all parking slots occupied and LED red is ON; it means that the parking is full. Because of proteus software has not internet connection that helps to send data to the cloud, we developed the smart car parking system prototype in Figure 3.4 using physical devices like IR sensors, arduino uno(microcontroller),ESP8266 WIFI module, web application and android application. The IR sensors mounted at every parking slot to detect the presence of vehicle in parking slot and IR sensors mounted at main entry and exit the gate to detect the presence of vehicle at the gate. It counts the cars entry and leaves the parking, Servo motor to open or close the gate, Arduino uno for processing data from sensors, ESP8266 WIFI module used to send data from arduino uno to thingspeak cloud. The users can access the data from cloud using android application installs in their smart phones.

The interpretation of results on thingspeak cloud is presented below: Figure 5.1 shows result of Thingspeak Field1 graphic display and numeric display of parking status in form of 0 and 1. This Figure shows that the parking slot1 is occupied; it means that the numeric value show occupied of parking slot1 is 1. The Figure 5.2 shows result of Thingspeak Field1 graphic display and numeric display of parking status in form of 0 and 1. This Figure shows that the parking slot1 is available; it means that the numeric value shows availability of parking slot1 is 0. The Figure 5.3 shows result of Thingspeak Field 2 graphic display and numeric display of parking status in form of 0 and 1**.** This Figure shows that the parking slot2 is occupied; it means that the numeric value show occupied of parking slot2 is 1. The Figure 5.4 shows result of Thingspeak Field2 graphic display and numeric display of parking status in form of 0 and 1**.** This Figure shows that the parking slot2

is available; it means that the numeric value shows availability of parking slot2 is 0. The Figure 5.5 shows result of Thingspeak Field 3 graphic display and numeric display of parking status in form of 0 and 1.This figure shows the status of IR sensor mounted at main entrance that has numeric value 1. It means that when a vehicle arrives at main entry, the IR sensor at the gate activates the servo motor at entry to open the gate and also counts the vehicle entry in the parking. The Figure5.6 shows result of Thingspeak Field 4 graphic display and numeric display of parking status in form of 1 or 0. This figure shows the status of IR sensor mounted at main exit that has numeric value 1. It means that when a vehicle arrives at main exit, the IR sensor at the gate activates the servo motor at exit to open the gate and also counts the vehicles leave the parking. The Figure5.7 shows result of Thingspeak Field 5 graphic display and numeric display. This figure shows that the number of available slots in parking is 2 because all parking slots are available. The Figure 5.8 shows result of Thingspeak Field 5 graphic display and numeric display. This figure shows that the number of available slots in parking is 0 it means that no available parking slots because all parking slots are occupied. The Figure 5.9 shows result of Thingspeak Field 5 graphic display and numeric display. This figure shows that the number of available slots in parking is 1 because one parking slot is occupied and other parking slot is available. The Figure 5.10 is visualisation of data stored in Thingspeak cloud about number of available slots in parking space from day one to day seven. The Figure 5.11 displays the parking status variation of each parking slot. This figure shows the variation (histogram) of parking status of parking slot in form of 1 or 0.

The interpretation of results on android application is presented below**:** The users who have smart phones and Wi-Fi connection can access the data about parking status from Thingspeak cloud using android application install in their smart phones. The Figure 5.12 shows the parking status on smart phone of user using android app. It displays all parking slots available and number of slots available is 2. The Figure 5.13 shows the parking status on smart phone of user using android application. It displays parking slot1 occupied and parking slot2 available or parking slot1 available and parking slot2 occupied and number of slots available is 1. The Figure 5.14 shows the

parking status on smart phone of user using android application. It displays all parking slots occupied and number of available slots is 0.

5.2 Thingspeak Result Display

The Result of Thingspeak Field1 chat graphic display and numeric display.

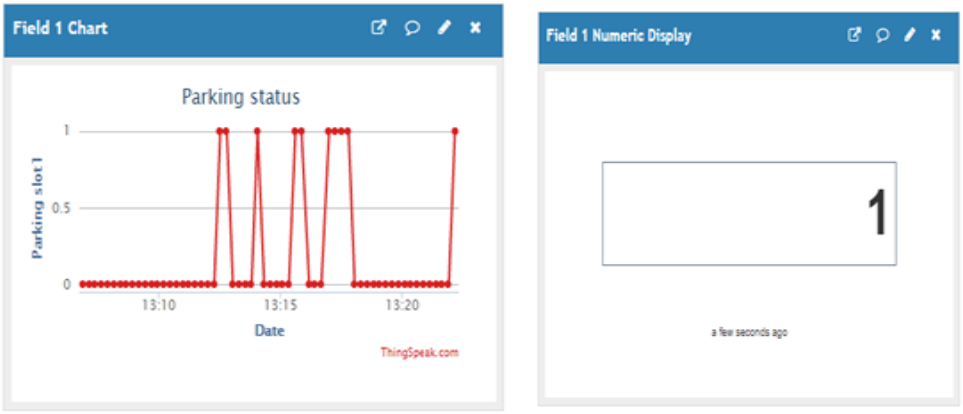

Figure 5.1 Result of Thingspeak Field1 graphic display and numeric display of slot1 occupation

The figure 5.1 shows the result on thingspeak cloud about the parking slot1 occupation. If the parking slot1 is occupied the numeric value of thingspeak is 1.It means that there is a vehicle parked in parking slot1.

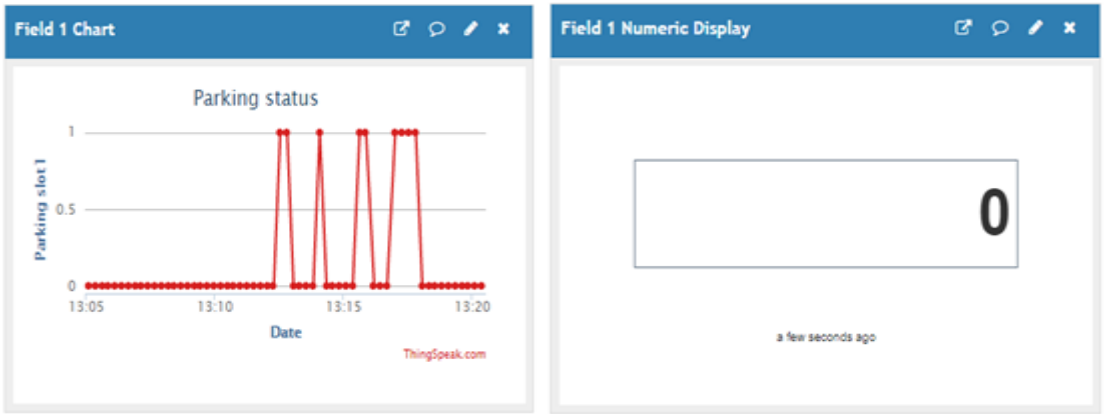

Figure 5.2 Result of Thingspeak Field1 graphic display and numeric display of slot1 availability

The figure 5.2 shows the result of availability of parking slot1 on thingspeak cloud. If thingspeak displays numeric value 0 it means that the parking slot1 is available.

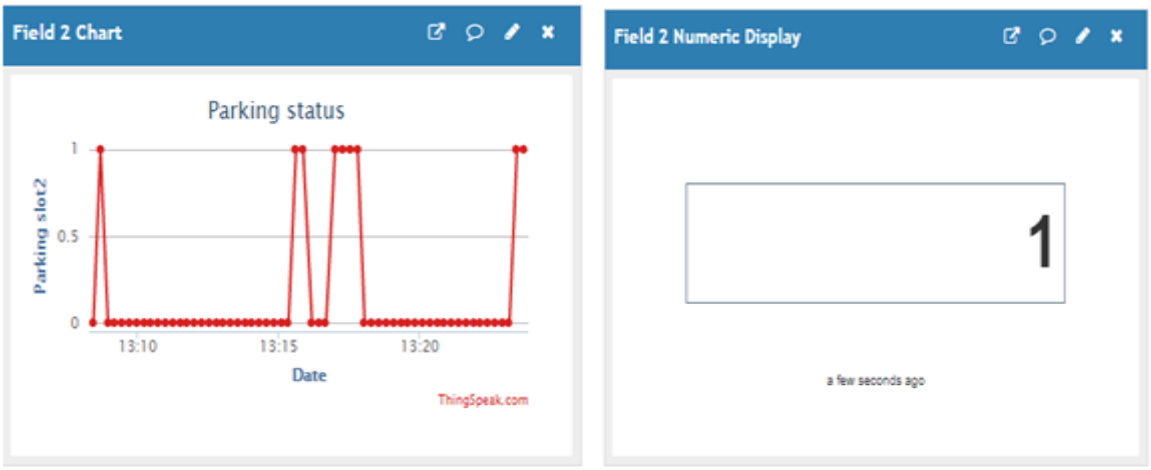

Figure 5.3 Result of Thingspeak Field 2 graphic display and numeric display of slot2 occupation

The figure 5.3 is the result on thingspeak cloud of parking slo2 that shows the occupation of parking slot2.If parking slot2 is occupied the numerical value is 1 it means that the parking slot2 is occupied.

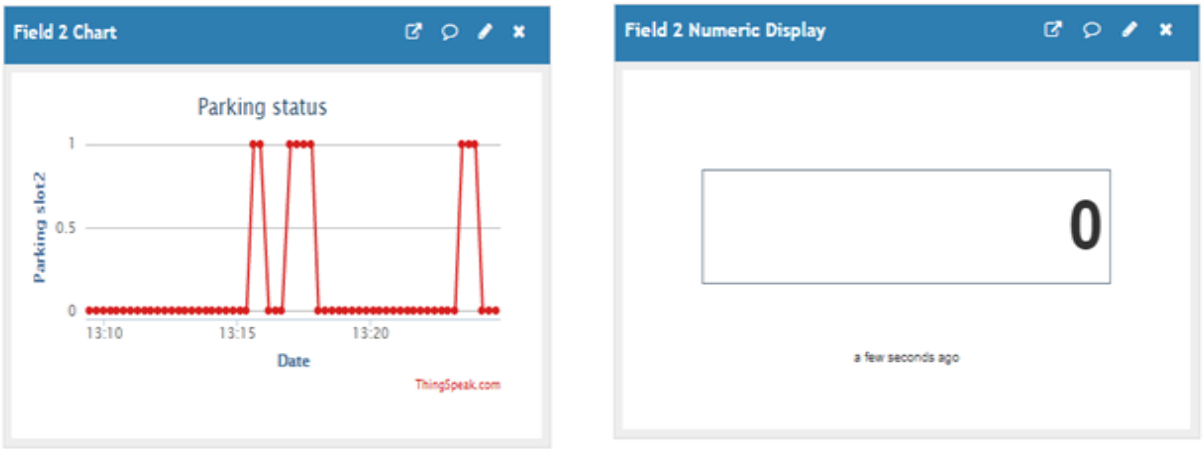

Figure 5.4 Result of Thingspeak Field 2 graphic display and numeric display slot2 availability

The figure 5.4 is the result on thingspeak cloud of parking slo2 that shows the availability of parking slot2.If parking slot2 is available the numerical value is 0 it means that the parking slot2 is available

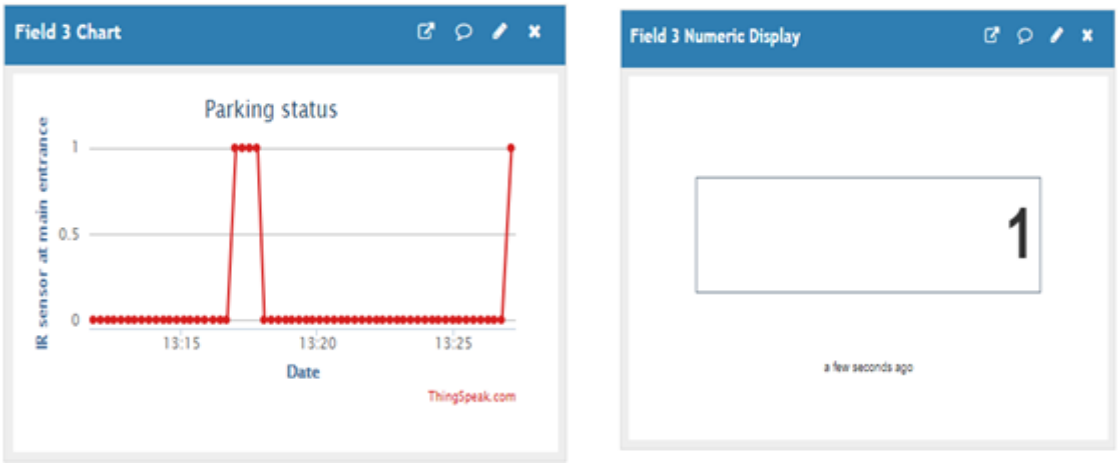

Figure 5.5 Result of Thingspeak Field 3 graphic display and numeric display.

The figure 5.5 is the result on thingspeak cloud of IR sensor at main entrance the gate. If numerical value is 1 it means that there is a vehicle at entrance the gate, the IR sensor at the entrance the gate activate the servo motor at entrance the gate to open and close the gate and also it counts the vehicle entry in parking.

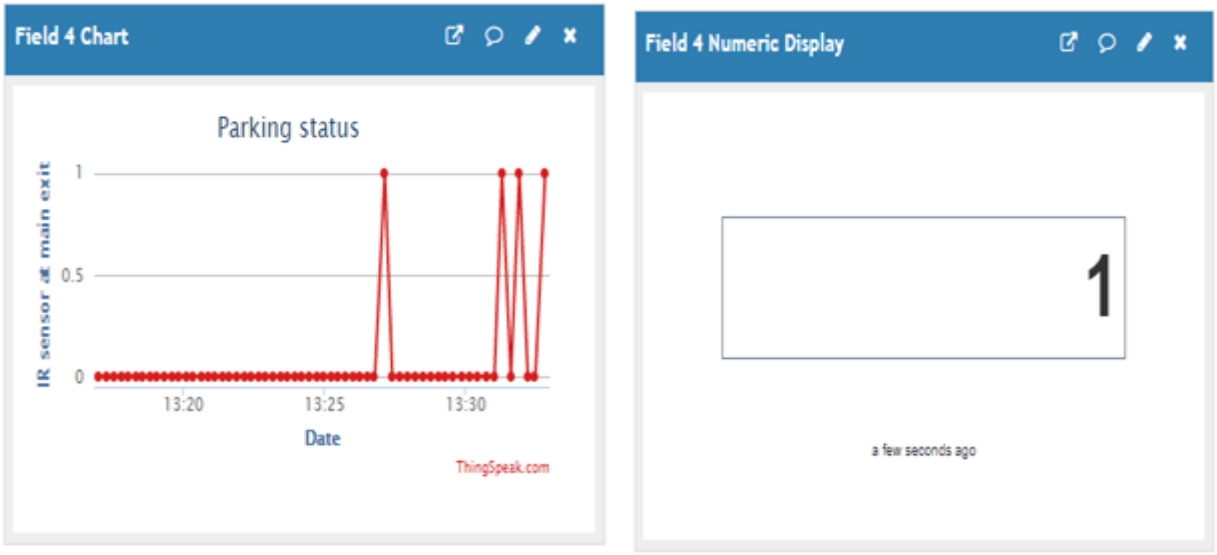

Figure 5.6 Result of Thingspeak Field 4 graphic display and numeric display

The figure 5.6 is the result on thingspeak cloud of IR sensor at main exit the gate. If numerical value is 1 it means that there is a vehicle at exit the gate, the IR sensor at the exit the gate activate

the servo motor at exit the gate to open and close the gate and also it counts the vehicle leave in the parking.

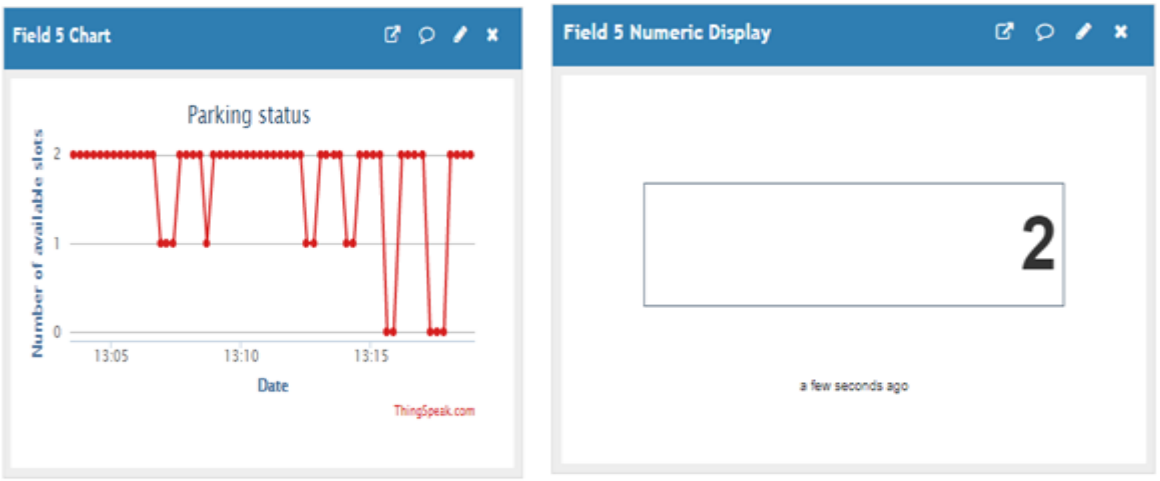

Figure 5.7 Result of Thingspeak Field 5 graphic display and numeric display

The figure 5.7 shows the result of thingspeak about number of available parking slots. We worked sample of 2 parking slot in parking. This figure shows all parking slots available .The number of available slot in parking is 2.

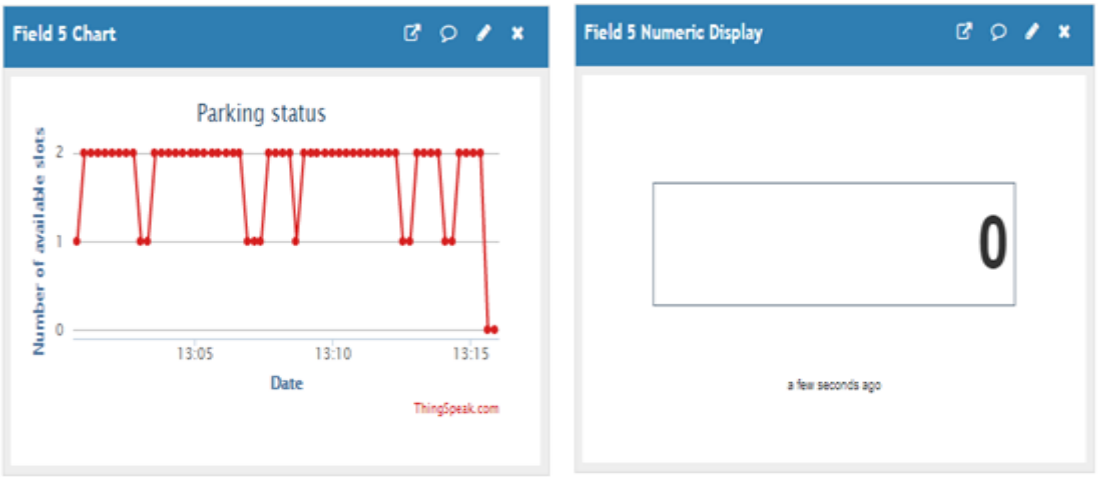

Figure 5.8 Result of Thingspeak Field 5 graphic display and numeric display

The figure 5.8 shows the result of thingspeak about number of available parking slots in parking space. We worked sample of 2 parking slot in parking. This figure shows all parking slots occupied. It means that the parking is full no parking slot available and the number of available slot is 0.

Figure 5.9 Result of Thingspeak Field 5 graphic display and numeric display

The figure 5.9 shows the result of thingspeak about number of available parking slots in parking space. We worked sample of 2 parking slot in parking. This figure shows the availability and occupation of parking slot in parking space. If parking slot1 is occupied and parking slot2 is available or parking slot1 is available and parking slot2 is occupied. The number of available slot in parking space is 1.

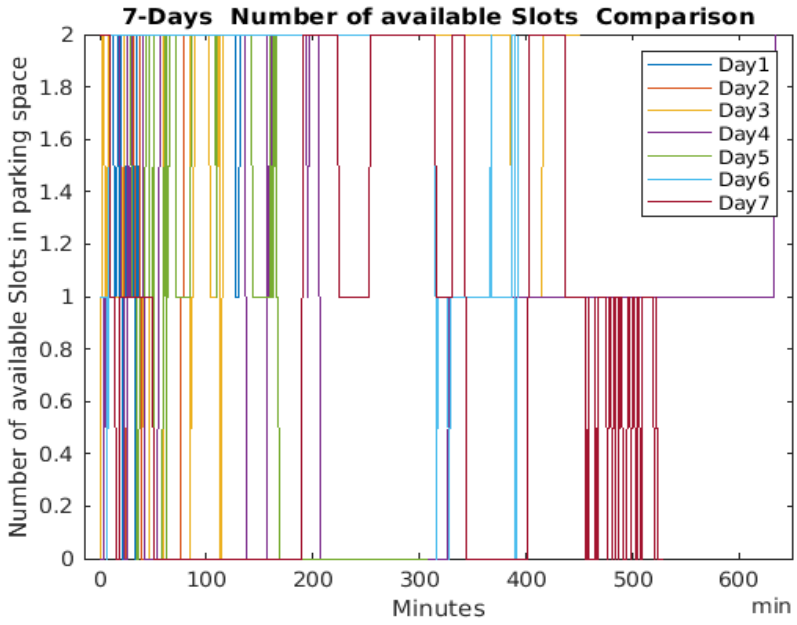

Figure 5.10 The visualisation of data stored in Thingspeak cloud about number of available slots in parking space in weekly from day one to day seven

The figure 5.10 shows the visualisation of data stored in Thingspeak cloud about number of available slots in parking space in weekly from day one to day seven. The blue color shows the data about number of available slot for day one. The orange color shows the data about number of available slots for day two. The yellow-orange color shows data about number of available slots for day three. The violet color shows the data about number of available slots for day four. The green color shows the data about number of available slots for day five. The cyan color shows data about number of available slot for day six. The rose color shows the data about number of available slot for day seven.

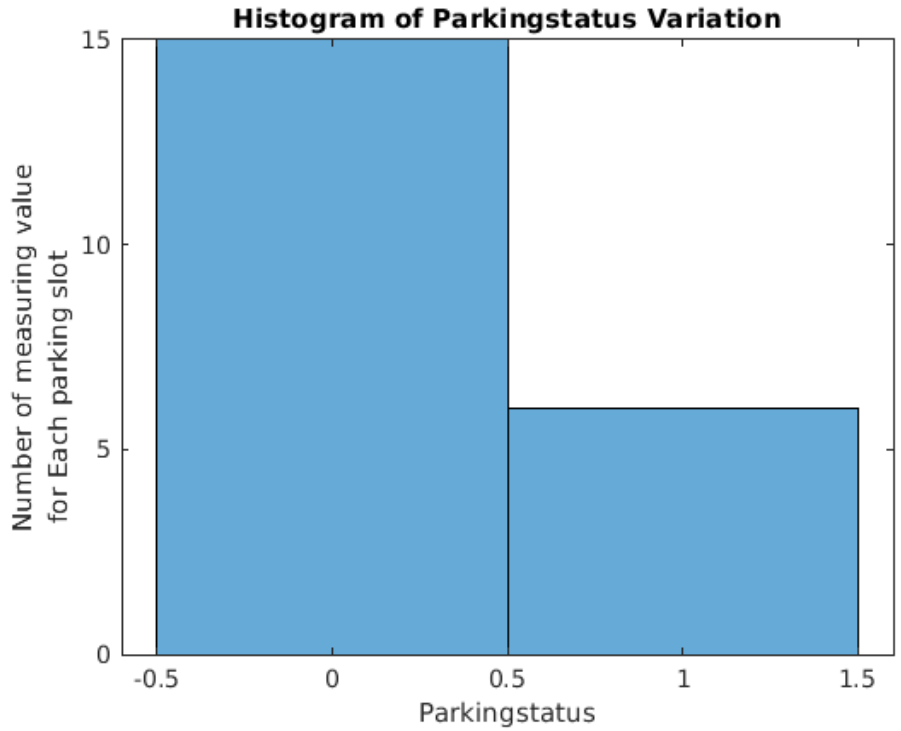

Figure 5.11 Parking status variation of each parking slot

The figure 5.11 shows the histogram of parking status of parking slot1 or parking slot2.The variation of parking status is in value 1 and 0. It means that parking status must be 1 or 0.

5.3 Android Application Display

Smart parking application was developed for drivers to easily communication between systems with drivers. The drivers monitor the parking status using android application installs in their smart phones.

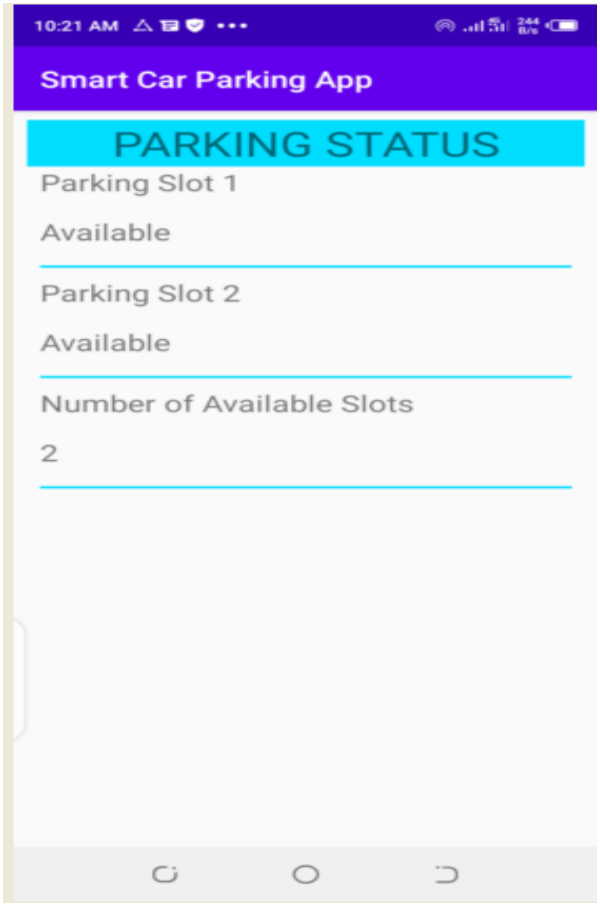

Figure 5.12 Result of Android application display all parking slots available and number of available slots is 2.

The figure 5.12 shows the result of android application of all parking slots available. The drivers who have smart phone and android application installs in their smart phone can know the number of available slot in parking space. For this figure the parking slot1 is available and the parking slot2 is available .Therefore the number of available slot in parking space is 2.

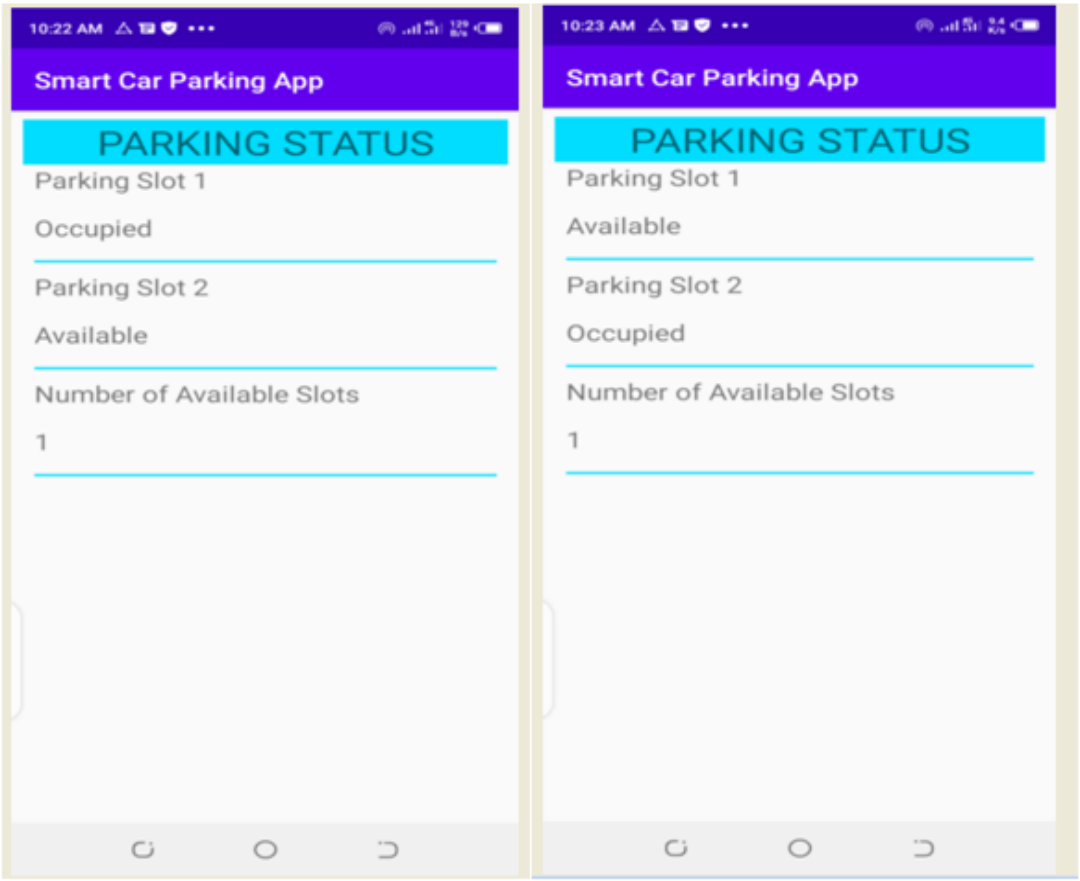

Figure 5.13 Result of Android application displays one parking slots available, second one parking slot occupied and number of available slots is 1.

The figure 5.13 shows the result of android application of parking slot availability and parking slot occupation. The drivers who have smart phones and android application installs in their smart phone can know the number of available slot in parking space. For this figure the parking slot1 is available and the parking slot2 is occupied or parking slot1 is occupied and parking slot2 is available .Therefore the number of available slot in parking space is 1.

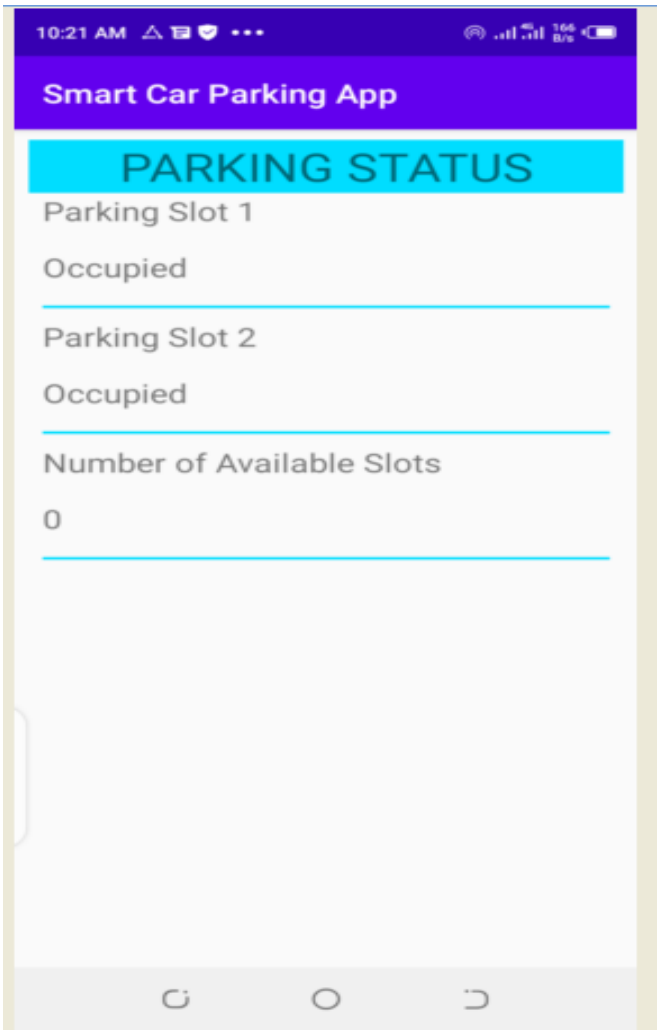

Figure 5.14 Result of Android application displays all parking slots occupied and number of available slots is 0.

The figure 5.14 shows the result of android application of all parking slots occupied. The drivers who have smart phones and android application installs in their smart phone can know the number of available slot in parking space. For this figure the parking slot1 is occupied and the parking slot2 is occupied .Therefore the number of available slot in parking space is 0.

5.4 Comparison between using Existing System to New Smart Car Parking System

The comparison facts of existing system and new smart car parking system are huge but for the current concern, one can list in the following table:

Table 5.1 Comparison between using Existing System to New Smart Car Parking System

Using existing system	**Using new smart car parking system**
1. The existing system uses long time for searching available parking slot.	The new system uses short time to find available parking slot (20 seconds).
2. To find available parking slot is not easy.	Using the new system is very easy by using the smart phone with installed application at hand.
3. It uses circulation or coming in the city in the early morning to find available parking slot.	It is automatically to find available parking slot.
4. For existing system searching for available parking slot stresses the drivers.	It reduces the stress of drivers and improves the urban area.
5. For existing system searching available parking slot requires lot of fuel and lot of time.	It saves the fuel and time required to find available parking slot.
6. The existing system is not efficiency.	The new system is more efficiency.
7. The existing system is not secure.	It is easy to use and enhances the safety and security.

CHAPTER6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This work focus on implementation of smart car parking system in Rwanda based on IOT. By using several physical devices like infrared sensors to check available parking slots and count the vehicle entry and leave the parking, Arduino uno to process, parking status from sensors, ESP8266 WIFI module to send data to Thingspeak cloud from arduino. Android application installs in smart phones of users allow them to access the data about available parking slot or occupied parking slot of system. The Thingspeak cloud platform used helped to analyse and visualize the stored data and be manipulated in different ways. For instance, after displaying the status of individual parking slots, see Figure 5.1, Figure 5.2, Figure 5.3, and Figure 5.4. The number of available slots in parking see in Figure5.7, Figure 5.8 and Figure 5.9, The combinations of total parking available slots for seven different days are plotted in Figure 5.10,in additional to that in Figure 5.11,the histogram of parking slot representation is done. Such attempts show how extensive and flexible is to use Thingspeak cloud platform with build-in MATLAB application that help to analyse and visualize the stored data. The information about parking status are available on both LCD display placed at the entrance the parking and on the smart phone that installed the developed android application, see Figure 5.12, Figure 5.13 and Figure 5.14.The drivers can easily recognize the available spaces in the parking prior to the arrival the gate of the parking due to the developed android application. The system is low cost, low power, secure and efficiency. It saves time and fuel required for user to search available parking slot and also reduces the traffic congestion and air pollution.

6.2 Recommendation

It is recommended that for future work improvement, the research based on reservation about available parking slot be emphasized, this will help the drivers to find available parking slot on real time through booking added in the system. This will reduce time used by drivers when the parking is full and return back to search other parking available.

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