IoT-based Smart Parking System for KCC car park in Sri Lanka

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Abstract

This project report has proposed a new technology based parking system that goes beyond the traditional parking spaces. This new system is proposed for the KCC car park. There, the problems and weaknesses of the current system in this car park have been identified and a new system has been proposed. While proposing this new car parking system, the literature references written on such systems have been studied, and Kandy KCC. The views and suggestions of people using the car park have been taken into consideration.

Acknowledgment

I like to thanks my sincere gratitude to everyone who gave me the chance and help to finish this report. I would like to use this opportunity to convey my sincere appreciation and respect to my supervisor Mrs. Dilini Thamarasee (Lecturer) for her excellent direction and persistent encouragement throughout the project's duration. Her valuable suggestions were of immense help to developing this IoT smart parking system. Working under her was extremely beneficial for my knowledge development. I would like to give my gratitude to all other lecturers and to everyone else those who enriched my knowledge, with this research.

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Chapter 1

Introduction

Nowadays, urban migration can be seen in developing countries and developed countries all over the world and it is increasing day by day. In today's competitive social environment as well as this urbanization, people with financial strength as well as those who do not have very good financial strength are tempted to buy private cars. Additionally, many individuals utilize these private automobiles on a regular basis to do their tasks. As a result, parking and traffic congestion have both become issues in metropolitan places all over the world. Many nations all around the world are utilizing cutting-edge parking management systems as a solution to this issue. By using such management systems, many problems arising from car parking in the city can be solved. For example, parking on the road causes heavy traffic congestion and it directly affects environmental pollution

Kandy is one of the major cities in Sri Lanka. Also, the Dalada Maligaya of historical importance is located here. Different social classes, multiple cultures, multiple universities, and higher education institutions attract people to Kandy. 1.37 million people live in Kandy City, and more than twenty-five hundred thousand People in the central province migrate to Kandy City to fulfill their needs. According to reports, 26000 cars enter Kandy city every day. Due to the high number of vehicles

coming to the city Finding a place to park has become a problem. To remedy this Construction of inner-city car parks began. Kandy City Center Car Park is one of the main such car parks in Kandy Sri Lanka

1.1 The current parking system in KCC

Figure 1.1: KCC Car Park

The Kandy City Center parking lot has the capacity to park 1100 cars at a time. A management system is currently in place and the amount to be collected is calculated by calculating the difference between the time the car mentioned in these two bills entered the parking lot and the time it left. And the amount to be recovered will be informed to the driver. The biggest problem with this technology is that the driver of the car finds a parking spot by himself. The motorist then has

to navigate his car around the parking structure to find an empty spot. Searching for a parking space in this three-story car park wastes time, effort, and fuel. And oppressive situations arise. According to the above-mentioned facts, it is clear that it is essential to present a new system instead of this system or to improve the existing system using new technology. This operating system's inability to determine how many cars are currently in the parking lot is another major flaw.

1.2 Statement of the Problem

Kandy City Center Car Park is one of the major car parks in Sri Lanka as well as Kandy. Why do drivers face the problem of finding a place to park despite the fact that there are facilities for drivers to park in this car park? The main reason for that is the existing inefficient management system. Because of this, certain spots in the parking lot are utilized while others are neglected. As drivers move about the parking lot looking for a space to park, the Car park fills up with vehicles. As a result, both the visitors and the drivers experience inconvenience.

1.3 Project Objectives

1.3.1 General Objectives

- To propose and implement an IOT-based solution process to increase the efficiency of the car park by studying the management system in the Kandy City Centre car park.

1.3.2 Secondary objectives

- To plan and execute an Online Vehicle Parking Reservation framework.
- Increase efficient space in the car park.
- Decreasing the environmental impact.

1.4 Project Plan

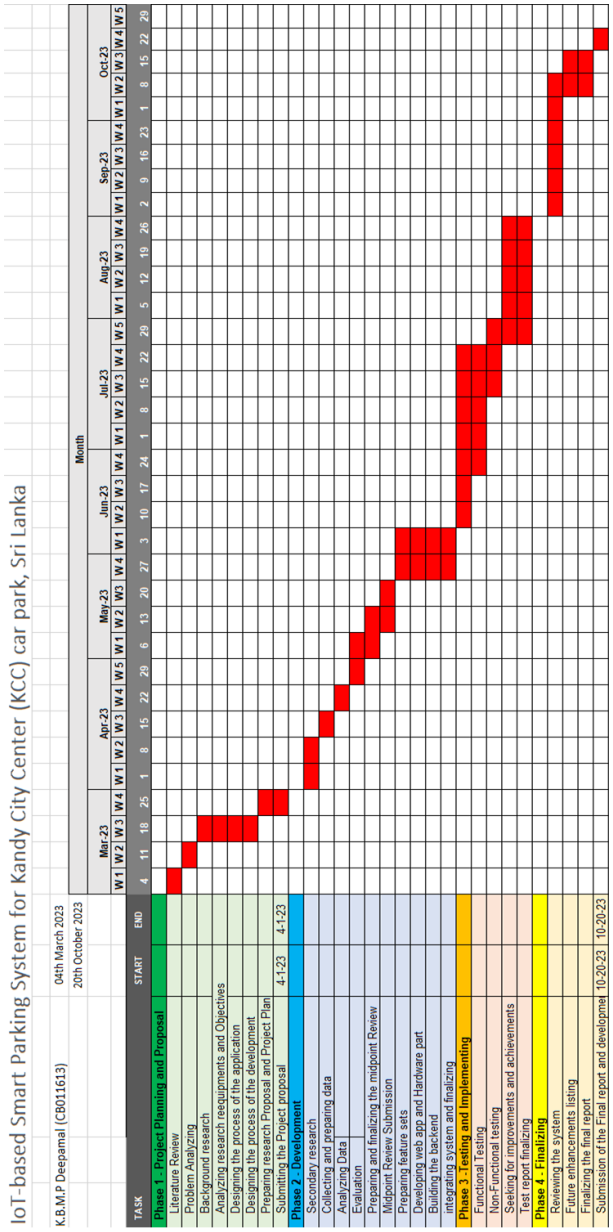


Figure 1.2: Project Plan

Chapter 2

Literature Review

The management of parking spots is a significant issue that many countries are presently confronting due to the fast urbanization taking place today and the growth in vehicles that follows. In the context of the Kandy City Center Car Park, this literature study aims to investigate the use and efficacy of IoT-based smart parking systems. Researchers have presented remedies based on new methodologies as a consequence of the study done to discover answers to this challenge. ***City Parking Solutions Throughout the Time*** **(2019)**

2.1 Introduction

Urbanization is a term that is now widely used and understood by everybody. Due to the increased population density in the globe today, people are accustomed to residing in urban areas to assist their employment, and the usage of private vehicles is also rising daily. As a result, cities have experienced excessive traffic, and parking has also become an issue. Many nations are now constructing inner city parking lots as a solution to this issue. An example is the Kandy City Center car park in Kandy, Sri Lanka. This literature review aims to explore the use of IoT-based smart parking systems for such car parks and their importance in urban

areas.

This car park is one of the busiest places in Kandy city. The car park consists of 3 floors and 1100 parking spaces. However, Due to space constraints, poor use, and a lack of real-time information for drivers, the KCC car park administration struggles, as does management in other metropolitan areas, to successfully manage to park.de Buitleir (2020)

Many of these issues can be resolved by implementing a smart parking system in the KCC parking that is IoT-based. Many issues with traffic management may be resolved by employing IOT to give drivers real-time information, optimizing parking spaces, etc.

This chapter explores the experimental solutions presented in the period 2000-2023 to reduce the social and environmental problems caused by urban traffic congestion. The purpose of this is to build upon the solutions created by previous authors without applying personal opinions or other additional information. Summarizing and synthesizing ideas and identifying central trends or principles and showing how they exist in research papers. In this way, the research area related to the field of research that intend to do has been identified. Furthermore, In this literature review, The components and technologies utilized to construct an IoT-based smart park system for the Kandy City Center parking are investigated in examples where similar systems have been deployed in the past and how they overcame the challenges they encountered.

2.2 Problems and solutions related to urban traffic congestion

This Mr. S.N. Bentotag Bentotage (2006) study found that the oversupply of parking places and people's propensity to park as near their destinations as possible make illegal parking appear to be more common in metropolitan locations. Furthermore, In the research conducted by Mr. Matthew Borg Carr, Carr (2017) several suggestions have been presented as solutions to this problem. One of the main suggestions is to strengthen public transportation. Its main objective is to limit the number of vehicles coming to the city by reducing private car ownership.

As an impractical proposal presented by this research, the proposal to reduce vehicle ownership to prevent traffic congestion can be indicated. That suggestion reflects the weakness of this research. An important part of this research is that a large number of practical solutions to these problems have been proposed. Inclining people to public transport can be mentioned as such a proposal. It is essential that a community-friendly public transport system be implemented to direct the people who are used to using private cars to public transport. Other proposals suggested include imposing parking time limits, Road pricing, construction of car parks and construction of priority bus lanes can be mentioned.Biasotti (n.d.)

In 2021, Mr. Abrar Fahim, Mr. Mehedi Hasan, and Mr. Muhtasim Alam Chowdhury Fahim et al. (2021) presented in their research various technical ideas and technical systems that could be used to construct indoor parking lots as a solution to this problem. Examples of technical ideas and technical systems are a parking guidance and information system, a transit-based information system, a smart payment system focused on parking, an E-parking system, and an automated parking system (APS).

2.3 Indoor Parking Management Systems

In this research, It has been suggested that parking lots with new technology should be constructed. As a result, the concept of building indoor parking garages has been proposed as a solution to the Kandy city parking problem. The inspector has shown in this investigation that people can be attracted to this by offering free parking and discounts in these parking lots. The inspector hopes that this will give the common people the opportunity to roam the streets without facing traffic-related problems. The examiner has shown that the indoor parking management technologies used in the study are an expensive solution. The system displays parking facilities and aggregates and displays networked parking spaces centrally. In this procedure, automatic monitoring systems are used. These systems often use expensive hardware and software. Allows for effective and reliable information assurance. Before entering a parking lot, it is possible to determine its current status using these management systems and the VMS system. Even if the parking spot is detected, when the driver drives the car to that spot, there is a possibility that another car that came before it is parked at that spot. A major weakness identified in this system is the lack of development of a system to reserve the empty space that can be identified in advance.Bentotage (2006) ,Singh et al. (n.d.), Han et al. (2005), Imbugwa et al. (2020), *Lack of Parking in Big Cities: Reasons and Solutions Essay* (2022)

In 2015, Mr. Qun Chen et al, it analysed the parking features of Shanghai, China, and the situation related to parking regulations and facilities for various locations. It has been decided that public parking buildings should be constructed. This research has shown the importance of using new technology for parking as well as the importance of using new technology when drivers find a place to park. However, what type of technique is appropriate to use is not described in this test. It can be stated as a strong weakness of this research.Chen et al. (2015)

This research on traffic congestion in the city of New Delhi in India reviews new design trends and creative technical solutions that help alleviate the stress of the traffic parking problem. Land usage in a specific location has a direct impact on parking demand. Weekends have more parking demand than weekdays.

Parking Strategies To ensure the appropriate operation of the urban congestion model via development, several parking zones should be designated. To prevent emergency parking near planned parking lots, it is advised that suitable parking regulations, such as parking hours and taxes, be established for all residential neighborhoods around the city.

This research has been conducted in Kandy City in Sri Lanka and the system currently operating in the Kandy City Center parking lot has been analysed. As mentioned here, the current system is a semi-automatic system. A good example of that would be data entry by two operators at the entrance and exit of a parking building. *Car Parking System Is Based On Kandy Information Technology Essay* (2015)

Here you can see long queues because computer operators are busy with printing bills as well as data entry. This can be stated as a major problem in this system. In addition, there is a significant risk of data falling into the hands of third parties due to a lack of adequate security measures. A major advantage of this system is high customer satisfaction as there is direct human interaction with customers. The data about the cars are entered into the system by the computer operators, so the data can be used at any time. This method requires little in the way of maintenance expenses. The fact that the computer operator does not require specialized skills to run this system is another benefit. Based on the above information the researcher has suggested that it is appropriate to use a new technology based system. New systems have been proposed to use sensors as the operator instead of an operator to

work at the entry point. The parking fee suggested by the system will be displayed when drivers come to exit the parking building. It helps to reduce congestion in this car park. But this system has not presented a technical method to identify the empty space in the parking lot in advance and pay for it.

2.4 Smart Parking Systems

In 1886, the man produced the world's first automobile. In the 136 years since then, drivers have relied on instinct or luck to find a parking space. Nowadays it has become problematic due to various reasons. The concept of Smart Parking was introduced as a solution to those problems. Wilson Car Park in New Zealand, Cardiff Council Car Park in the UK, and Manuka Car Park in Canberra are car parks built using this concept. Smart parking systems used in the world can be divided into three main categories.

1. Parking lots with overhead sensors or camera-based technology.
2. Parking lots with counter technology.
3. Parking lots with IOT technology.

The Internet of Things can be mentioned as one of the main technologies used when creating smart parking systems. The main purpose of using this technology is By analyzing the data from the sensors, it provides real-time information to drivers, directing them to the nearest empty space. Doing this streamlines the process and brings many benefits to both drivers and administrators.

2.5 Technologies Used for Smart Parking System

2.5.1 Internet of Things (IoT)

IoT or Internet of Things refers to a technology that enables communication between devices, communication between devices and the cloud, and communication between interconnected device systems. SCOTT (2023)

2.6 Internet of Things in Smart Parking System

The Internet of Things is a network of physical devices. Here first real-time data is collected and then the data is analyzed and exchanged. Currently, this technology is widely used in smart parking systems. The reasons for this are the high accuracy and efficiency of this technology.

Here sensors are used to collect data. Examples include ground sensors, ultrasonic sensors, or camera-based sensors. By those sensors Data such as where vehicles are parked is collected. A technology called Wi-Fi or cellular networks is used to transmit the data collected in this process. The last step is to analyze and show the obtained data to the observer.

A key finding in this literature review is that this method is very successful and real-time data collection and analysis can help in effective parking space management, shorten parking search time, and facilitate traffic. And that parking resources can be used correctly and usefully. In addition, the weaknesses and problems of this methodology were also identified in this literature review. *What is the Internet of things* (2022)

2.7 Challenges and Solutions

Many challenges have to be faced in the practical creation of an IoT-based smart parking system. For example, Providing good Connectivity, Ensuring the accuracy of the sensors, Scalability, and User Data Security and Privacy.

2.7.1 Challenges

- Providing good Connectivity: In the practical design of such a system, a large number of sensors are used and it is essential to maintain a continuous connection between them. In some cases doing it is a problem and as a result the entire system may crash.
- User Data Security and Privacy: Protecting the data generated by the system is a must. It helps to improve the confidence of drivers and others using the yard. This is also a strong challenge as this is a costly task.
- Ensuring the accuracy of sensors : Accuracy of sensors is essential in a smart parking system. The main reason for this is that these systems work on real-time information. Malfunctions in sensors can cause variations in the data generated by these sensors due to physical disturbances.
- Scalability: There are about 1100 parking spaces in the Kandy City Center car park and providing IoT sensors and infrastructure to all of them is a challenging and costly task. Another challenge is the simultaneous management of data generated by a huge number of sensors. *Ultimate Guide to IoT-Based Smart Parking System* (2023)

2.7.2 Solutions

- Establishing a strong connection between technical devices. For this, building a connection between the sensors and the control center using technology such as WIFI or cellular networks.
- Proper maintenance of sensors and other equipment.

- Power supply management is also essential. This problem can be avoided by maintaining an additional power supply in addition to the main power supply. Examples include using generators and using solar panels.

The application of appropriate technological approaches and ongoing, adequate maintenance can successfully address these issues.

2.8 Conclusion

In this review, why do drivers face the problem of finding a parking space in this Kandy City Center car park when parking facilities are available? In order to find a suitable timely solution to solve this problem, more than ten previous research were conducted and a suitable solution was presented. It was found that the resulting rapid urbanization and an increasing number of vehicles have led to severe traffic congestion and parking problems in many countries.

In each research, one of the examiners offered different ideas and suggestions in response to this problem. Some suggestions are practical and some suggestions cannot be implemented in practice. For example, reducing personal car ownership may be an impractical proposition. The promotion of public transport can be described as a practical proposal suitable for the modern era.

Furthermore, the review discussed the concept of indoor parking management systems, emphasizing the importance of using new technologies to alleviate the stress associated with parking as a solution to this problem. The limitations of this method could also be identified in further study. For example, lack of a way to reserve spaces in advance.

The literature review further explored the concept of smart parking systems, thereby gaining insight into the benefits and limitations of IoT-based smart parking

systems in solving problems and improving traffic flow. Finally, the implementation of an IoT-based smart parking system at the Kandy City Center car park can improve the utilization of parking space and thus reduce the heavy traffic in Kandy City as well as the inconvenience to drivers in parking.

Chapter 3

Project Specification

3.1 Tools and Technology Requirements for the Prototype

IoT-based smart parking system is a prototype that uses the Internet of Things to produce accurate results in the real world. The prototype is mainly created by combining several devices. For example, Ultrasonic Sensors, IR sensors, ESP32 Wireless Communication Protocols, and Real-time clock modules.

All components are controlled by ESP32 Wireless Communication Protocol. In addition, all data is transmitted to the web application through this. The main purpose of this system is to indicate the places where people can park their cars in the web application and on the LCD screen at the entrance to the car park. Although it is better to use LED screens than LCD screens, LCD screens have been used here due to the difficulty of mounting for the prototype. The Ultrasonic Sensors used in this system, it is checked every time vehicles can be parked at each parking lot. Here, instead of Ultrasonic Sensors, IR sensors can be used if necessary. Here, the data obtained by these sensors is sent to the Firebase database and LCD display through ESP32 Wireless Communication Protocol. LED bulbs

are used here and if a car is parked, the LED bulbs light up to inform the drivers.

Another special feature of this system is to count the number of cars arriving at the parking lot every day. IR Sensor and Real time clock module are used for that. An advantage of this is that it can collect a large amount of data needed to manage the parking lot.

The prototype was built using IoT as its primary technology. The Arduino software is used to upload C++ coded commands to the ESP32 device. The implementation is tested using toy cars.

3.2 Tools used for Smart Parking System

3.2.1 Servo Motors

Figure 3.1: Servo Motors

A servo motor is a motor with extremely precise rotational capabilities. Servo motors are divided into two main types according to the power supply methods. AC servo motor and DC servo motor are those two types. Every servo motor

consists of three main parts. For example, Controlled devices, Output sensors, and Feedback systems. A software interface with the control electronics allows for precise parameterization and programming for the motor's actuation, providing a high level of dynamism and innovation.?, ?

3.2.2 Ultrasonic Sensors

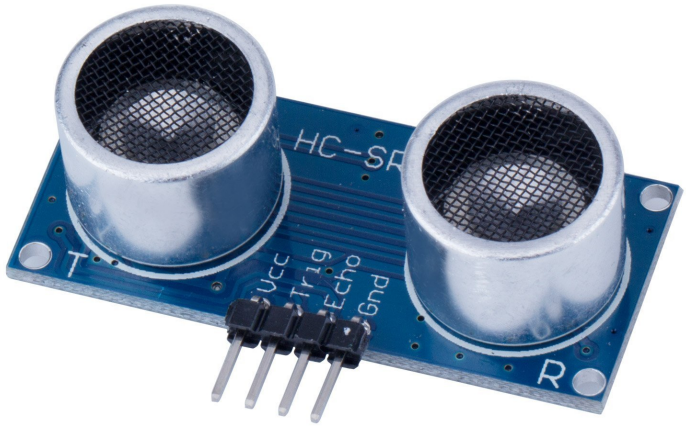


Figure 3.2: Ultrasonic Sensors

Ultrasonic sensors are electronic devices. It uses sound waves to measure distance and detect objects. for example, The way animals like bats and dolphins detect distant objects. These ultrasonic sensors are widely used in robotics, liquid level measurement, home automation, etc. There are two main reasons for the widespread use of Ultrasonic sensors. These are the affordability and the high accuracy of these.

3.2.3 Jumper wire

Figure 3.3: Jumper wire

Jumper wires are used to link different parts of circuit equipment together. Three types of jumper wire are mainly used for this. The fact that these wires don't require soldering is a benefit of employing them.

3.2.4 Liquid-crystal display (LCD Display)

A Liquid-crystal display is a flat panel display operating primarily on liquid crystals and LCD displays are often used in mobile phones, televisions, computers, and tablets. LCD is a Liquid crystal display that is a passive device, which means it doesn't produce any light to display characters, images, video, and animations. But it simply alters the light traveling through it.

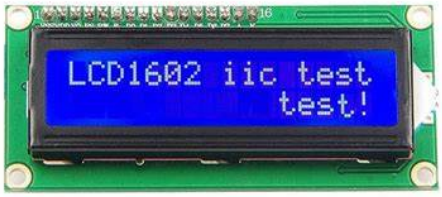


Figure 3.4: LCD Display

3.2.5 Power Pack (S-25-5)

Figure 3.5: Power Pack (S-25-5)

Power packs are technological gadgets that change the form of electrical energy. As an illustration, AC power to the DC or AC power from DC. These gadgets are frequently employed to give electrical equipment a steady power source.

3.2.6 Breadboard

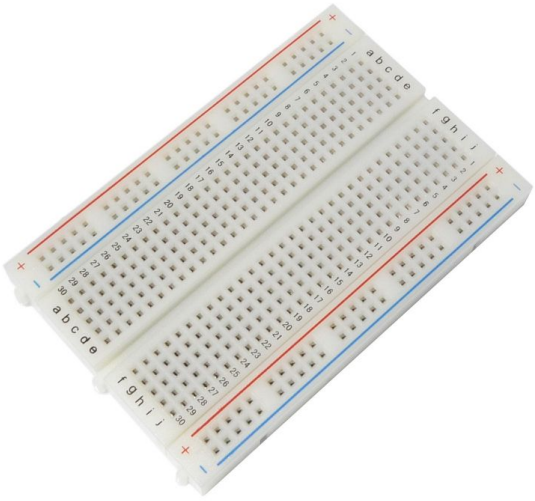


Figure 3.6: breadboard

Breadboard is a basic tool in electronic prototyping and experimentation. This makes it simpler to alter and modify a circuit while it is being designed and debugged.

3.2.7 ESP32 Wireless Communication Protocols

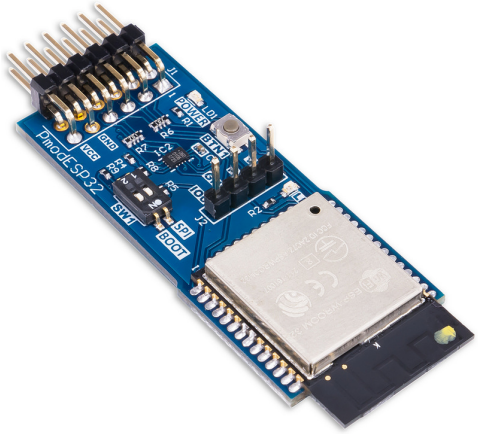


Figure 3.7: ESP32 Wireless Communication Protocols

ESP32 Wireless Communication Protocols is a very popular microcontroller. This is mainly used for wireless communication purposes. These devices use WiFi technology for that.

3.2.8 IR Sensor

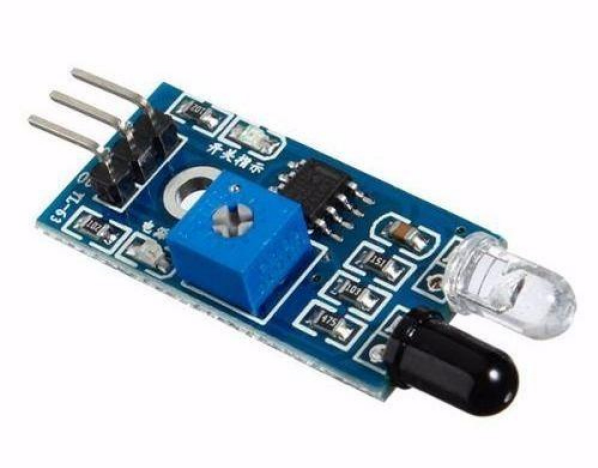


Figure 3.8: IR Sensor

The IR sensor is an electronic component. It detects specific characteristics in its surroundings through emitting or detecting IR radiation. IR sensors can also be used to detect motion.

3.2.9 Real time clock module

A Real time Clock is an integrated circuit that keeps track of time. These modules use a crystal with a frequency of 32768Hz and an internal binary counter to create a frequency of exactly 1Hz and count seconds.

Figure 3.9: RTC module

3.2.10 Pin headers

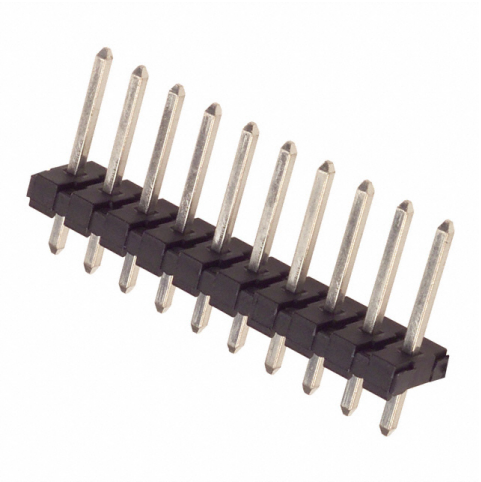


Figure 3.10: Pin headers

A pin header is a form of electrical connector. A male pin header consists of one or more rows of metal pins molded into a plastic base and a female pin header consists of a socket header.

3.2.11 LED

Figure 3.11: LED

LED is a semiconductor device. That emits light when current flows through it.

3.2.12 Resistance

Figure 3.12: Resistance

Resistors are used to reduce the current by interrupting the current passing through two characteristics. Resistance is measured in ohms.

3.3 Tools and Technology Requirement for the Web Application

This web application is mainly used to display all data taken from sensors. In addition, this web application contains almost all the main features of the general web application.

Several techniques are mainly used to create these web applications. This web application is created on the VUE.JS framework and the Bootstrap framework is used to develop the front end. Furthermore, the Firebase database is used to store data. This project included the main two databases. They are the Firebase Real-time Database and Firestore Database. Basically, the data obtained from sensors is sent to the Firebase Database by ESP32 Wireless Communication Protocols. The data is then sent to the web application by the database. Also, the Vercel cloud platform is used to host this web application.

Finally, Visual Studio Code is used to codeING in this web application and Github is used for Version control.

3.4 The technology used for the Web Application

3.4.1 Vue.js JavaScript framework

Figure 3.13: Vue.js JavaScript framework

Vue.js is a very popular JavaScript framework. It is highly used to develop the web application. versatility and simplicity of interaction with other libraries and projects are the key causes of this.

3.4.2 Bootstrap Web design front-end framework

Figure 3.14: Bootstrap framework

Bootstrap is open source web design front-end framework. It is a fully free framework. Using this has the effect of increasing the speed of software development.

3.4.3 Firebase Database

Figure 3.15: Firebase

Firebase is a backend cloud computing service. It was developed by Google. It provides a wide range of services and tools for mobile and web applications. for example, Realtime Database, Cloud Firestore, and Firebase Authentication.

3.4.4 Vercel

Figure 3.16: Vercel

Vercel is a cloud platform service. It is deployments are handled through Git repositories with support for GitHub, GitLab, and Bitbucket repositories

3.5 Functional and Nonfunctional Requirements

3.5.1 Functional Requirement

In this project, Ultrasonic Sensors are installed at each parking lot to monitor whether there is a vehicle in that parking lot or not. A special feature here is that the data is always updated. All data is displayed on the LCD screen and web applications. That way everyone using this car park can see that information. Another feature here is that when a vehicle is parked in a parking space, the driver is notified by lighting a specific LED bulb. When the car park is fully loaded with cars, 2 servo motors must be activated to close the gates. The gates open as soon as one vehicle leaves the parking space. Another special feature of this system is counting the number of cars arriving at the parking lot. IR Sensor and Real time clock module are used for that. This data can provide car park administrators with information on things like car park busy times and dates.

3.5.2 Nonfunctional Requirement

The prototype's work must be completed quickly and accurately, among other non-functional requirements. Those are the essential properties that this system must have in real world use. It can be stated that there should be an additional power supply to operate in the event of a main power supply failure. All the devices used by the parking slots must also be resistant to all weather conditions.

3.6 Use Case Diagram

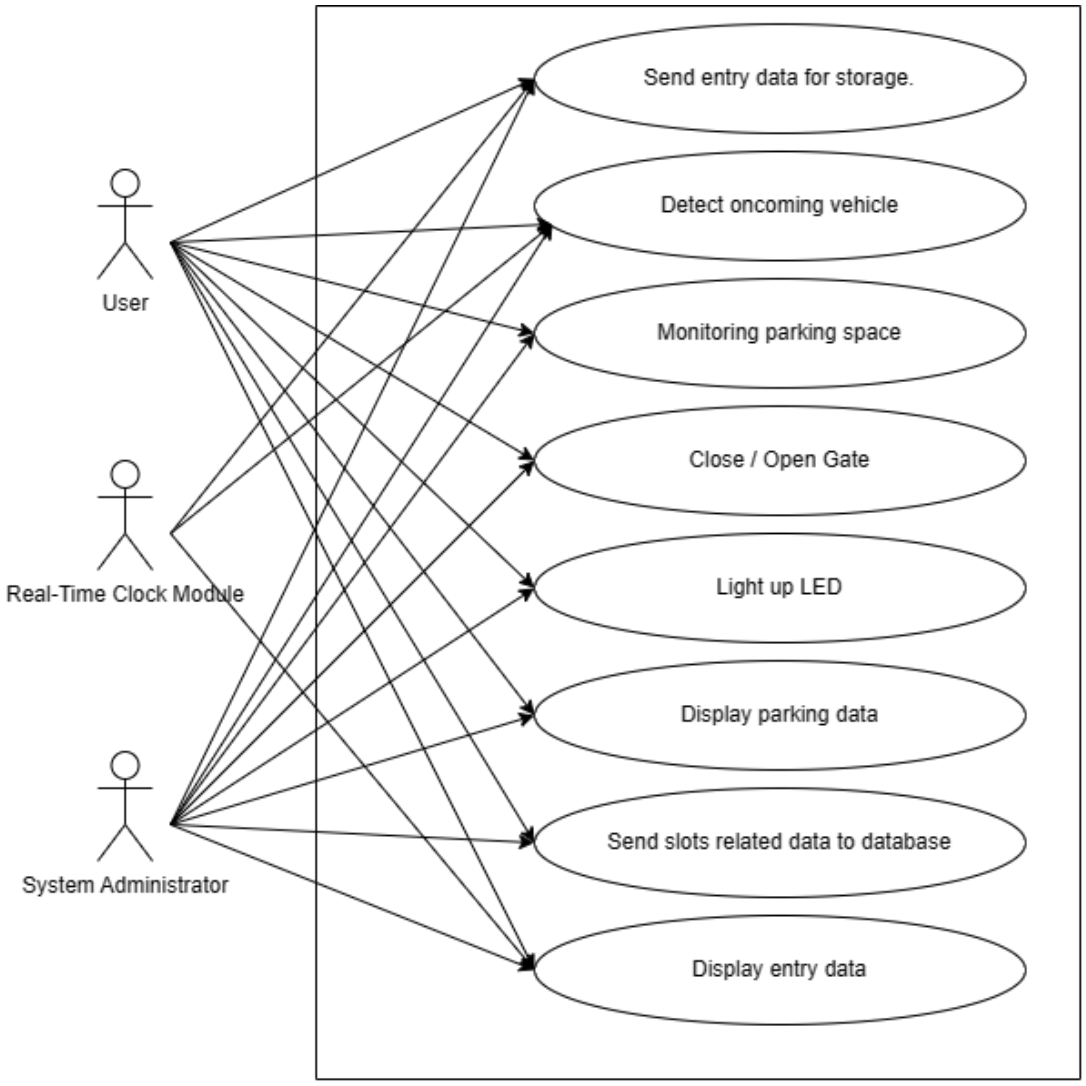


Figure 3.17: Use Case Diagram

Actors: User / Real Time Clock Module / System Administrator

Use cases: send entry data for storage / Detect oncoming vehicles / Monitor parking space / Close and open gate / Light up LED / Display parking data / Display entry data / send slot related data to database

Chapter 4

Methodology

4.1 Introduction

There are many sub-objectives as well as the main objective of implementing this project. The main objective is to implement a systematic traffic management system in the Kandy City Center car park to solve the problems of finding parking spaces and traffic congestion in Kandy City.

A new system based on IoT technology is designed and implemented for this purpose. The new system is expected to help drivers find empty spaces for parking faster, thereby reducing traffic congestion and achieving other project objectives.

4.2 Problem Statement

Why do drivers face the problem of finding a place to park despite the fact that there are facilities for drivers to park in the KCC car park? It is affected by several main reasons. The main reason for that is the inefficiency of the current parking system in the KCC car park. Another reason is this functioning system is not to use technical means. A long description of the Problem Statement has been made in the other chapters.

4.3 Kandy City Center current parking system survey

This project has been designed in such a way as to identify the weaknesses of the existing system in the Kandy KCC car park and solve them. By creating this new system, it contributes to reducing traffic congestion in Kandy City. In addition, this new system can see a lot of other benefits. People who used the KCC car park as well as many people who come to Kandy city can be mentioned as beneficiaries. Therefore, primary research was conducted using fifty people living in the vicinity of Kandy City before creating the system.

To conduct this primary research, data collection was done in two main ways. The first way is to meet ten people and interview them. (All the data collected from the interview is included in the Appendix section.) The second way is to collect data using a Google form. Data were collected from forty individuals in this manner.

Here, for ease of representation, the following pie chart has been created using the data collected through interviews and all the data collected using Google Forms.

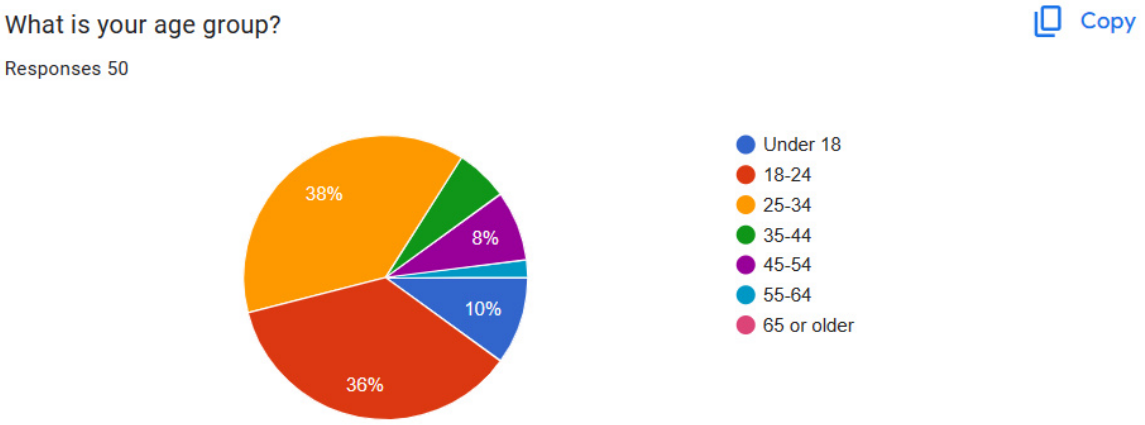


Figure 4.1: What is your age group?

People of different age groups have participated in this primary test. The largest number of people in the age group of 25-34 years can be stated as the age group that contributed to the tests. it is 38/100. The above graph shows the information about the age groups of all the participants.

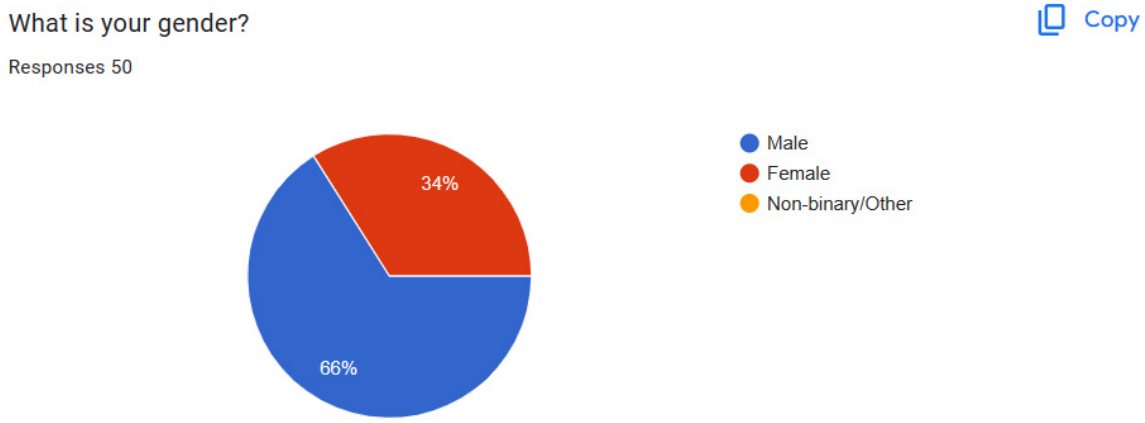


Figure 4.2: What is your gender?

Both men and women have been used for this survey. more percentage of men have contributed to this survey. The main reason for that is the increase in car ownership among men compared to women.

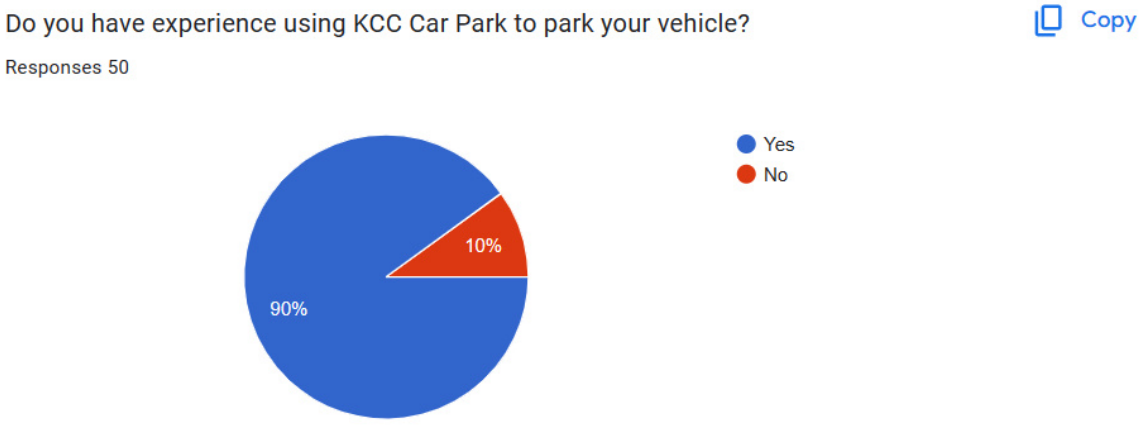


Figure 4.3: Do you have experience using KCC Car Park to park your vehicle?

According to the pie chart given above, about 90/100 people who participated in the survey have used the Kandy KCC car park at least once.

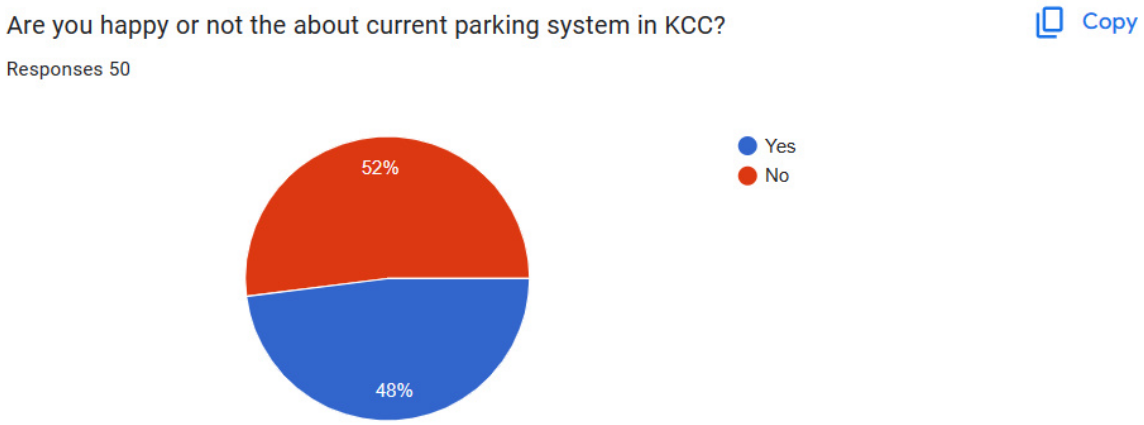


Figure 4.4: Are you happy or not the about current parking system in KCC?

According to the pie chart shown above, most of the people who contributed to the survey are not happy with the existing parking systems in the KCC car park.

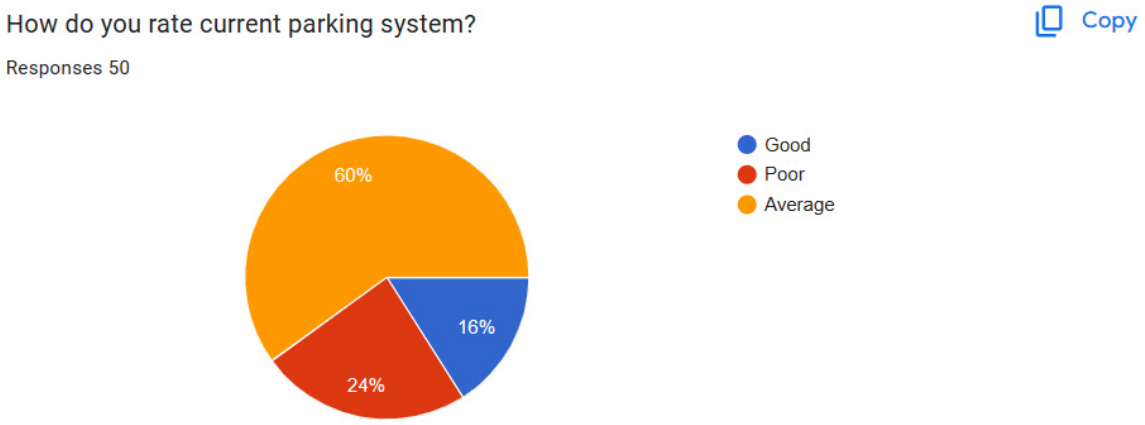


Figure 4.5: How do you rate the current parking system?

According to the above chart, sixteen percent are happy with the current system and 24 percent have a neutral opinion about it. Thirty out of fifty people surveyed said that the current system of vehicle regulation is a very weak system.

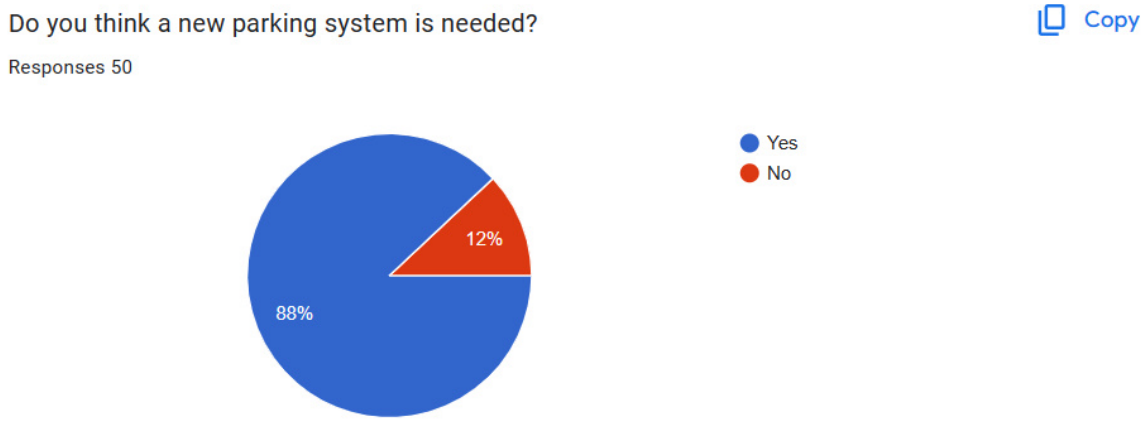


Figure 4.6: Do you think a new parking system is needed?

According to this pie chart, Many people are of the opinion that a new system is needed to regulate the parking lot. It is 88 / 100 as a percentage.

The final results of this survey show that many people do not like the current system used to regulate the KCC parking lot and many people expect a new

regulatory system. Also, the problem used for this research is a timely problem for which it is essential to present a solution with new technology.

4.4 Review of related research

In this research, more than ten IEEE research papers written by scholars were read in order to find a solution to the problem. Some of the research papers are written after conducting research in Sri Lanka and some are written after conducting research in foreign countries. These research papers found various solutions to these problems, but most of them were not practical to implement in Sri Lanka. but By reading the IEEE research papers, several ideas were found to implement a new system for Sri Lanka. Furthermore, It is also special to be able to get an understanding of the problems that may arise while creating an improved system, as well as an understanding of how to solve them. Chapter 2 contains more information about the literature review.

4.5 System Design and implementation

This project mainly consists of two parts. The first part is the hardware application and the second is the software application.

4.5.1 Hardware application

This section can be described as the main unit of this project. All other parts work based on the data collected by the sensors in this part. All the information about the devices used for this is contained in the Project Specification (Chapter 3) section.

Several key functions are performed by this original model. Users are monitored and notified of available parking spaces as well as non-parking spaces making it

easier for them to find a place to park their cars, saving them time and money. Also, collecting information about the number of cars arriving at the parking lot daily. This will enable its administrators to understand the busy dates and times of the car park and thus take steps to prevent unnecessary congestion A long description of this has been made in the Solution Concept (Chapter 5) and Implementation (Chapter 6) sections.

4.5.2 Software application

Used multiple technologies to develop this web application. Vue.js JavaScript framework and Bootstrap framework have mainly been used for creating web applications and Firebase Database has been used for data storage. Here Vercel is used for hosting web applications. A complete description of this technology has been made in the Project Specification section (chapter 3).

The web application mainly consists of two parts. One section is the user part and the second section is the admin part. More details on each of these pages are given in the Implementation part (chapter 6).

- User part

If explain how the web application works, the most special part of this web application is the part that displays the information about parking slots and gates. This section displays real-time information on whether or not a vehicle is available at all the parking spots and whether the gates are open or not. In addition to this, another special feature is showing information about how many more vehicles can be parked in the parking lot. This web application is automatically updated with new information every second. Its primary objective is to always provide authentic real time information to customers.

This web application has a Contact Us section that is included in a typical web application. Customers using these web applications can use this section to communicate with administrators. A method of pre-booking a car parking space using this web application is given in the Future enhancement section (chapter 8) and it has been created in the Booking Page to notify the administrators.

- admin part

Ordinary citizens who are web application users are not allowed to enter this section; only the governing authority is allowed to enter this section. Chapter 6 Given about description of all pages in the admin part.

The main purpose of the admin dashboard page is to show information about how many more vehicles can be parked in the parking lot. In addition, it also shows the number of existing vehicles. The contact analysis chart and booking analysis chart can be seen here. They are created using the data available in the database and are automatically updated to show the current data.

The Contact US Analysts page shows the data that all users have filled and submitted and allows administrators to call their phones and start conversations with them.

The number of vehicles arriving at the parking lot is always counted and the number of cars arriving in 24 hours is shown to the administrator. After twenty-four hours, the data is automatically removed, so the number of vehicles that arrived in that period is stored in another data table once every twelve hours. Every data in this system is provided to download to the administrator in the form of CSV files.

4.6 Hardware and Software testing

Two types of tests are mainly used to test this system. They are manual testing and automation testing. Manual testing is used to test the prototype. A combination of these two test types is used to test web applications. Here, The Lighthouse plugin is used to do automation testing in web applications. All the details of the testing are given in the part of Testing and Evaluation (chapter 7)

Chapter 5

Solution Concept

5.1 High-level Component Diagram

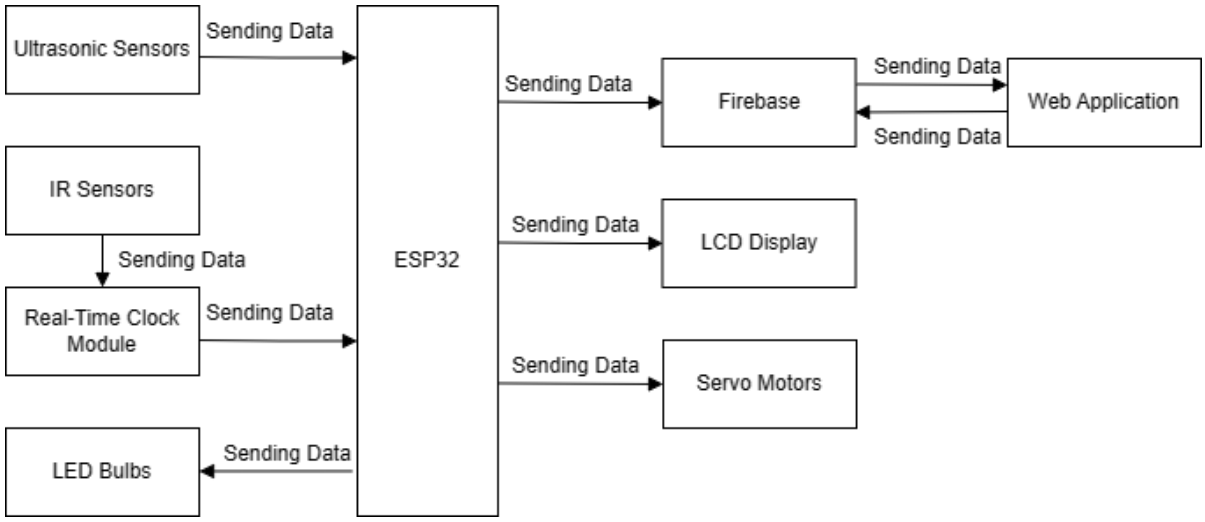


Figure 5.1: High-level Component Diagram

An ultrasonic sensor is attached to each parking space. The data received by the ultrasonic sensor is transmitted to the ESP32 Wireless Communication Protocols. The ESP32 Wireless Communication Protocols communicate with the database to update the parking space status. In addition, this sends data to the LCD display. As a result, the current status of the parking space can be seen through the LCD

display. Each parking space has a corresponding LED bulb. When the parking spaces are full of vehicles, the corresponding LED bulbs light up. Also, the ESP32 Wireless Communication Protocols checks the database to see if all parking spaces are filled. If so, it activates the servo motors to close the gates.

IR Sensors are installed at the point where vehicles enter the parking lot. This counts the number of cars entering the parking lot. IR Sensors are connected to ESP32 Wireless Communication Protocols via Real time clock module. This sends all the data acquired by the sensors to the database. Here Firebase database is used the maintain the connection between the web application and the prototype.

All the data that is sent to these system databases is also transmitted to the web application by the Firebase database. It is also special that the data sent every two seconds is updated.

Users of the KCC web application will be shown how many vehicles are currently parked in the KCC parking lot and how many more vehicles can be parked in the KCC parking lot. Information about which parking lots are with and without vehicles in the car park, as well as whether the gates at the entrances and exits to the car park are open or not, are also displayed.

A section is also installed inside the web applications for the people using these web applications to contact the administrators. Here the data from the web application is sent to the Firebase database

5.2 Activity diagram of the vehicle detection system

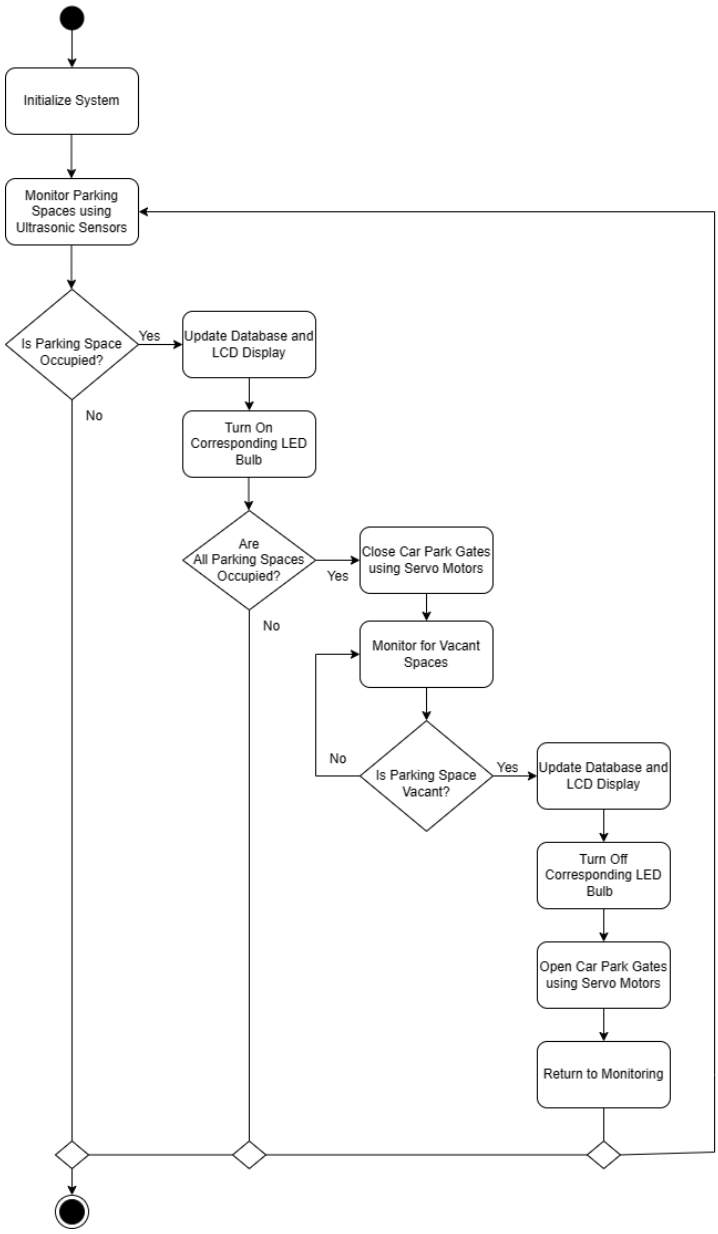


Figure 5.2: Activity diagram of the vehicle detection system

5.3 Activity diagram of the vehicle counting system

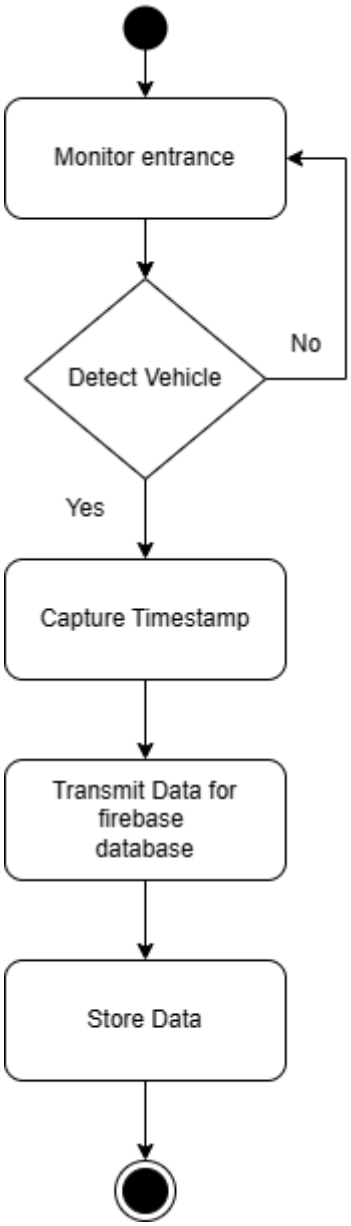


Figure 5.3: Activity diagram of the vehicle counting system

5.4 Wireframes

5.4.1 Wireframe of the Home Page

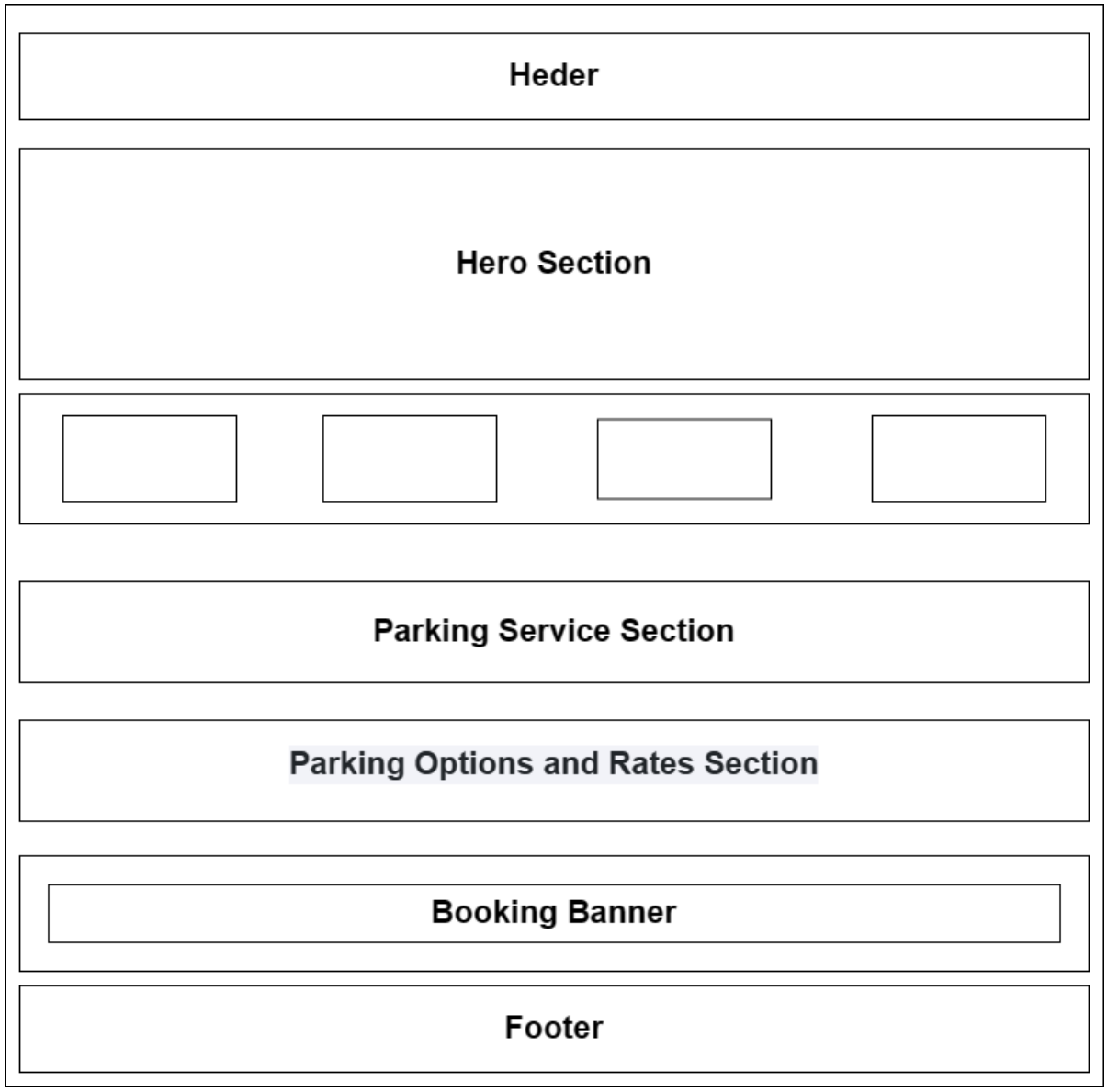


Figure 5.4: Home page

5.4.2 Wireframe of the Available Slots Page

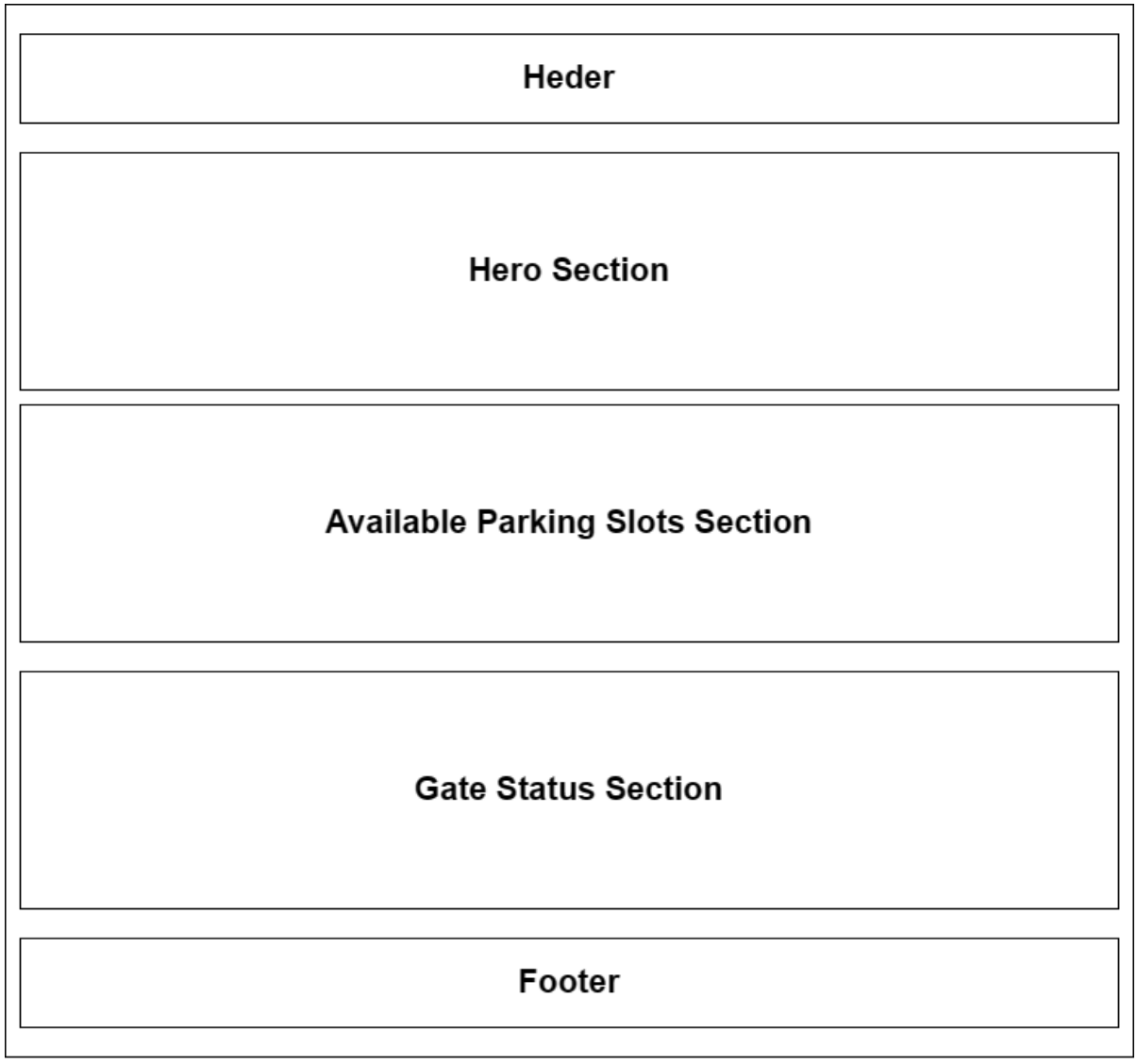


Figure 5.5: Available Slots page

5.4.3 Wireframe of the Contact Us Page

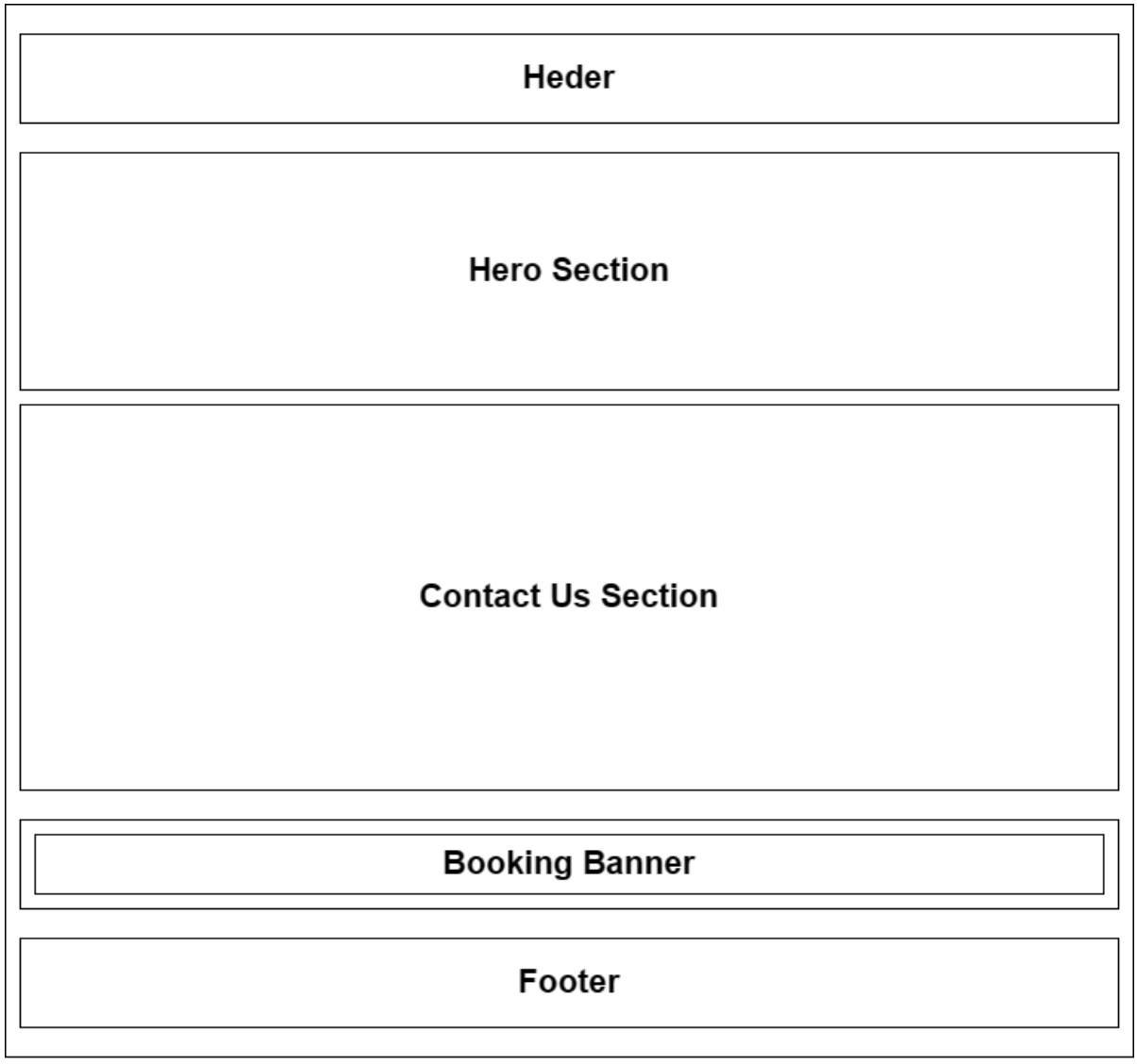


Figure 5.6: Contact Us page

5.4.4 Wireframe of the Booking Page

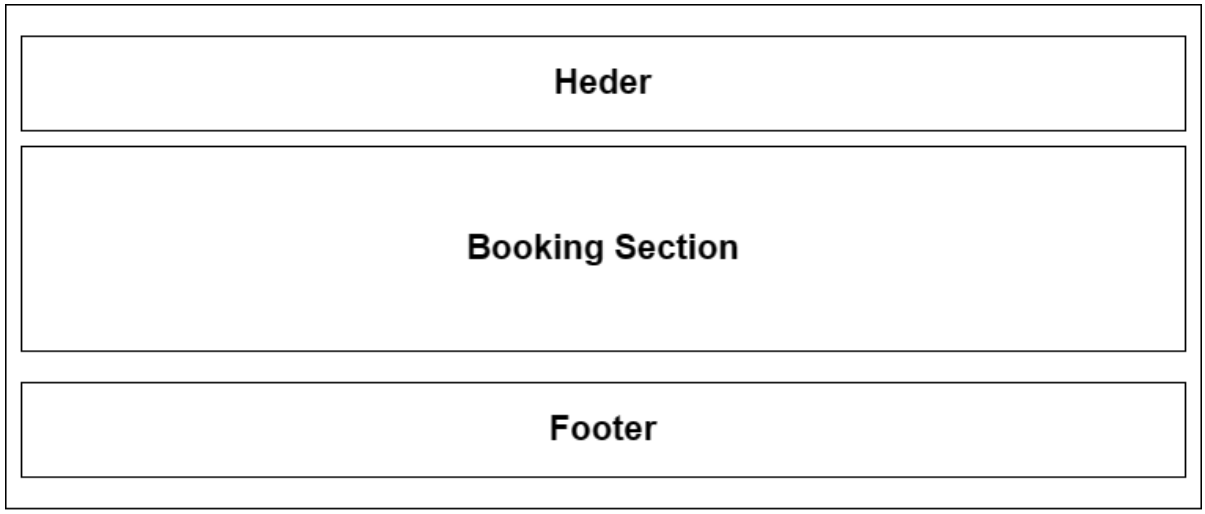


Figure 5.7: Booking page

5.4.5 Wireframe of the Login Page

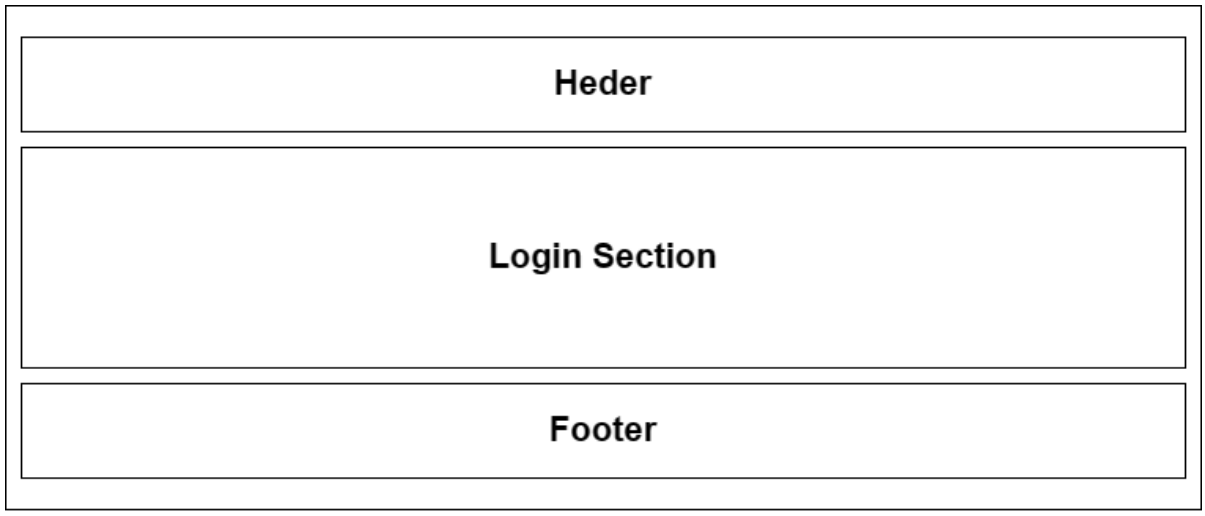


Figure 5.8: Login page

5.4.6 Wireframe of the Admin Page

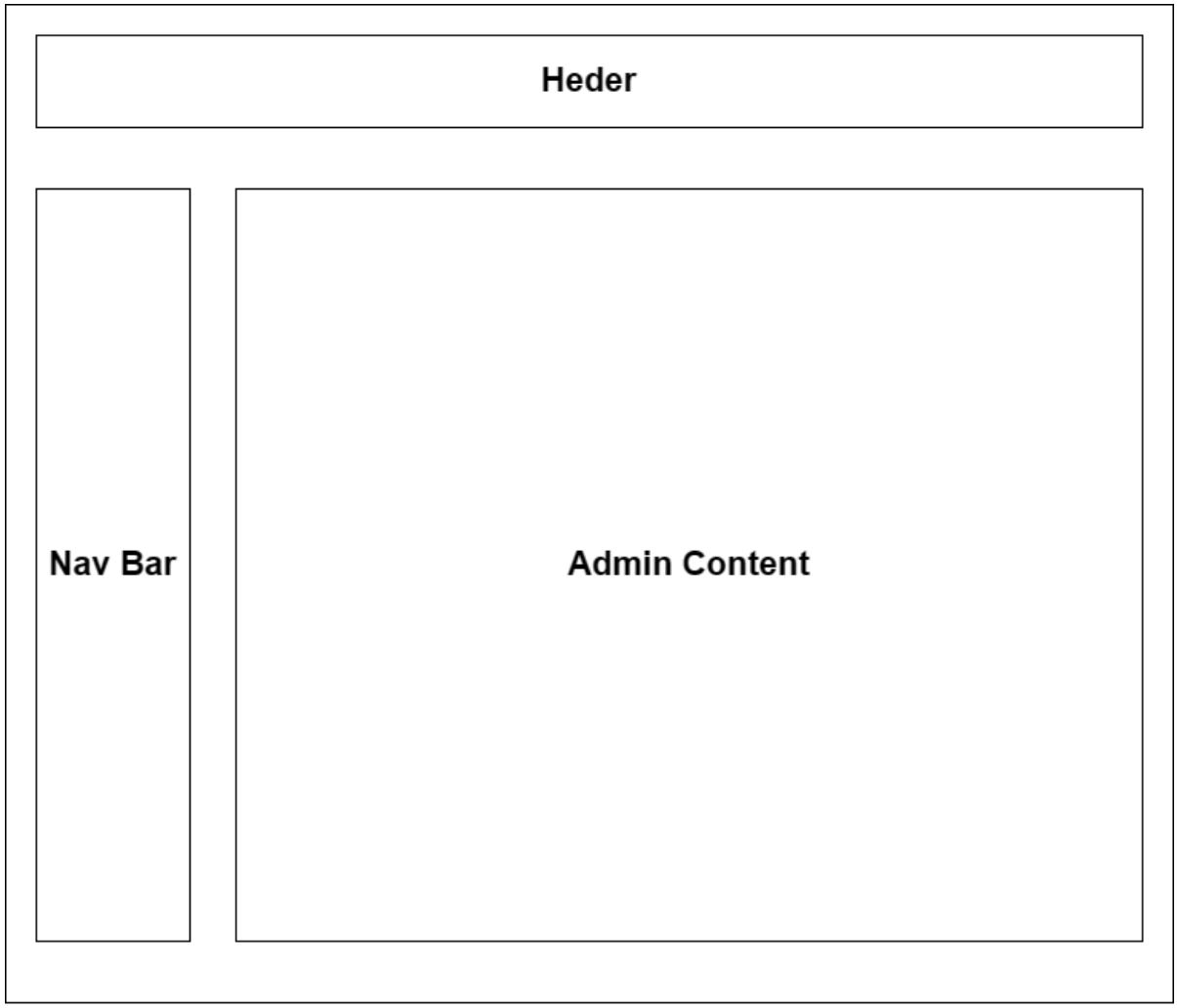


Figure 5.9: Admin page

This website contains multiple admin pages But overall admin page content is equal to This wireframe design.

Chapter 6

Implementation

6.1 Implementation of Hardware Project

The original model of this project was designed to solve the problems that arose in connection with the Kandy KCC car park. There are 2 main parts of this IoT-based Smart Parking System system. One part automates the car park and the other part counts the number of vehicles arriving at the car park But this system is driven by one ESP32 Wireless Communication Protocol.

6.1.1 Circuit diagram of IoT smart parking system

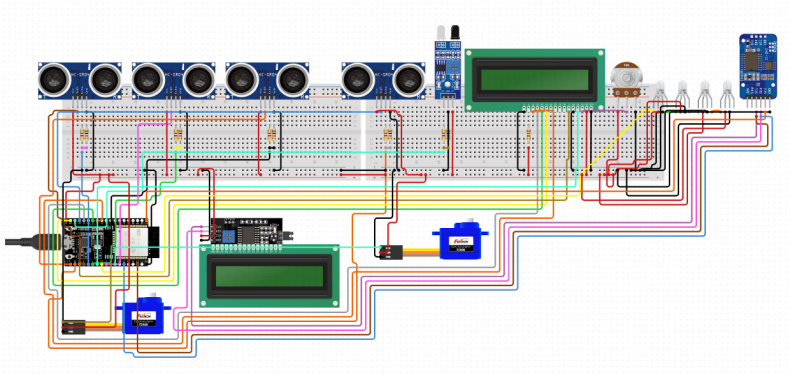


Figure 6.1: Circuit diagram 1

6.1.2 Circuit diagram of the vehicle detection system

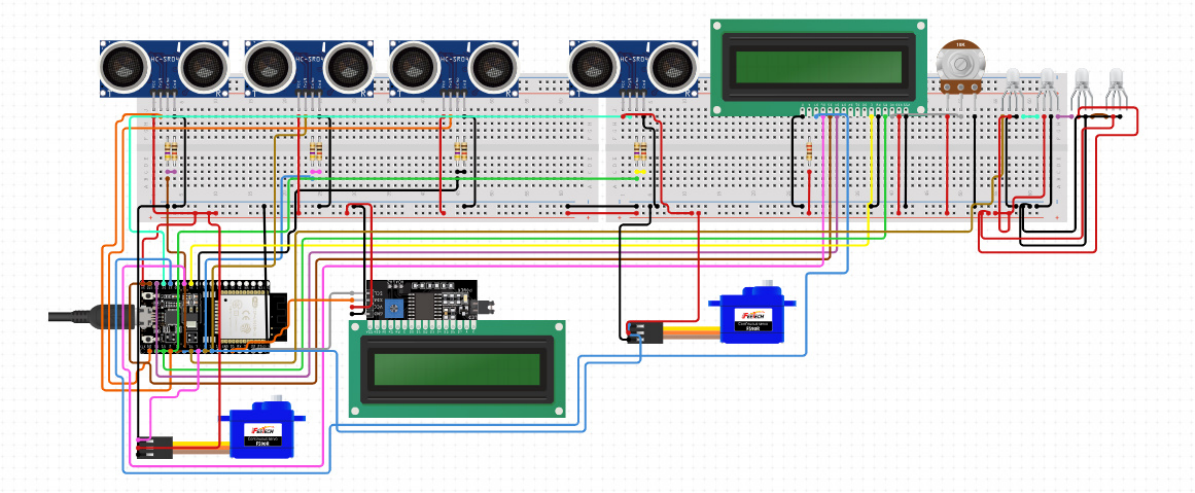


Figure 6.2: Circuit diagram 2

Ultrasonic sensors in this circuit monitor the presence of a car at each parking space separately. It can be described as the main function of this system. The data acquired by the sensors is sent to the database and LCD display using ESP32 Wireless Communication Protocols. The LCD display here displays the same information on both. When the car park is fully filled with Vehicles, its gates are closed using Servo Motors. Furthermore, In this system, there is an LED bulb corresponding to each parking space and the bulb lights up when the parking space is full of Vehicles.

6.1.3 Circuit diagram of the vehicle counting system

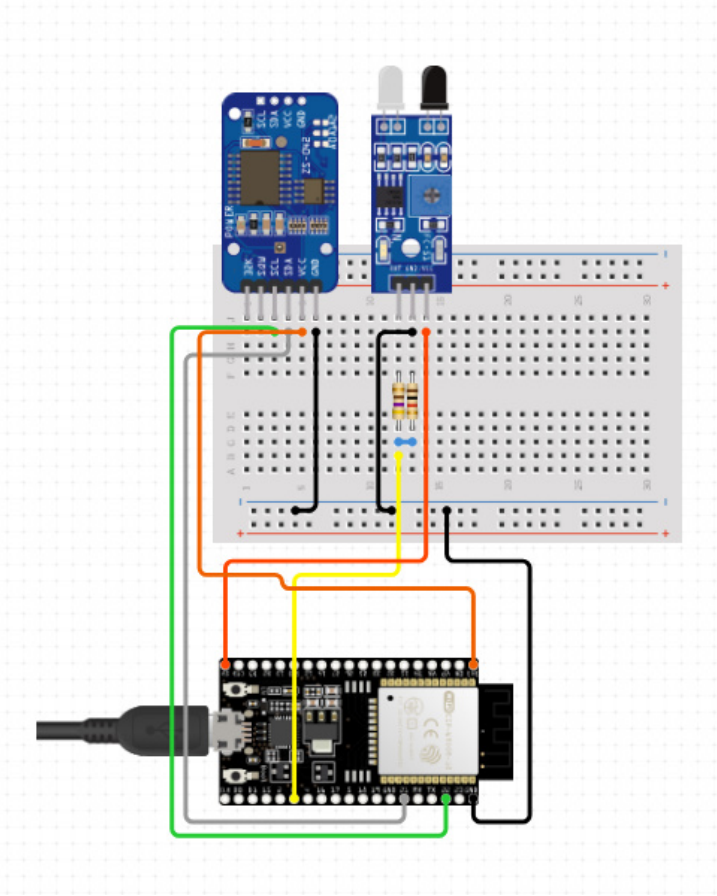


Figure 6.3: Circuit diagram 3

This part of the circuit is used to count the number of vehicles entering the parking lot. IR sensors are used here to detect incoming cars. And Real time clock module is used for this process. Here, the data obtained by the IR sensor is sent to the data storage using ESP32 Wireless Communication Protocols. Circuit diagram 2 shows how these parts are connected to each other.

6.1.4 Flow Charts of the Implementation

- Flow chart of the Smart Parking System

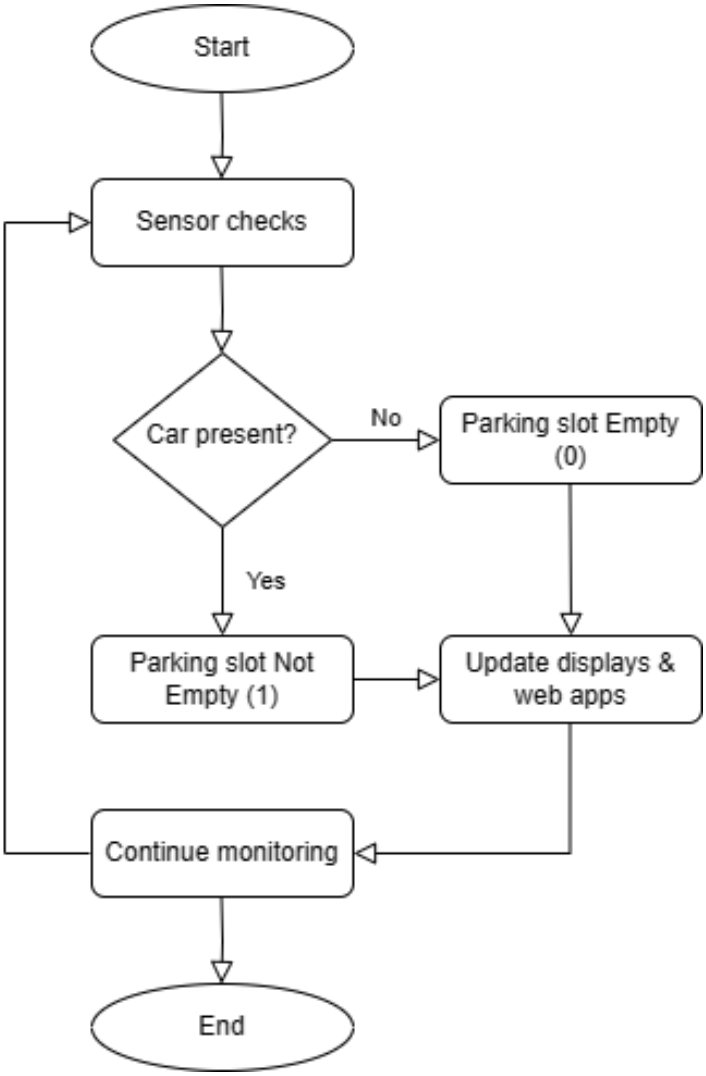


Figure 6.4: Flow chart of the Smart Parking System

- Flow chart of the Detect vehicle count

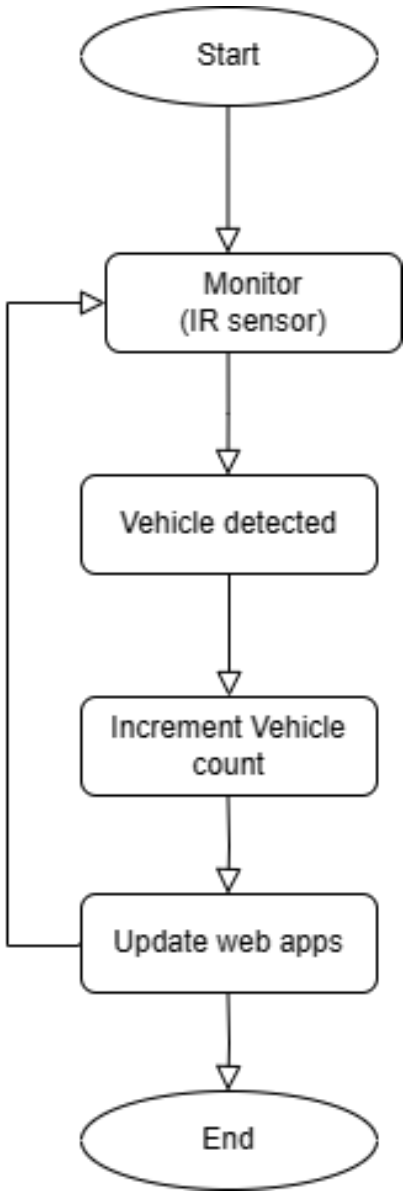


Figure 6.5: Flow chart of the Detect vehicle count

- Flow chart of the Gate opens and close

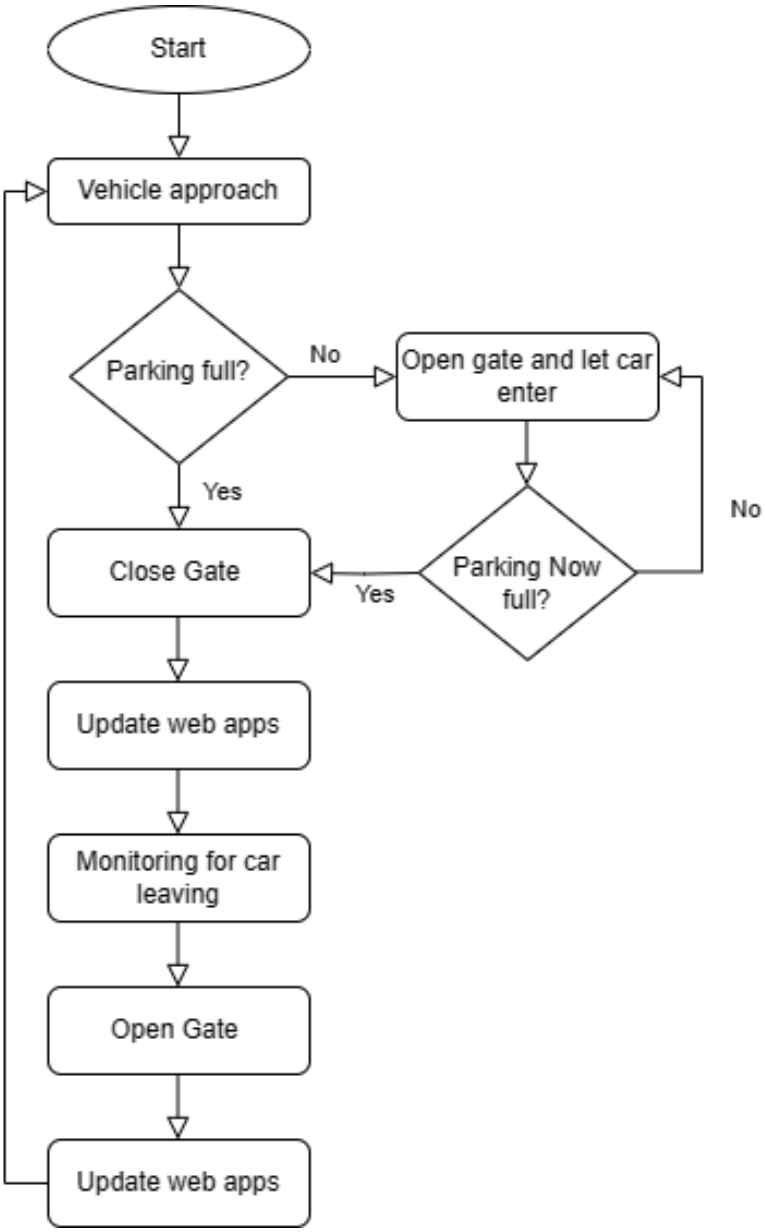


Figure 6.6: Flow chart of the Gate opens and close

6.1.5 Figures of Hardware Part

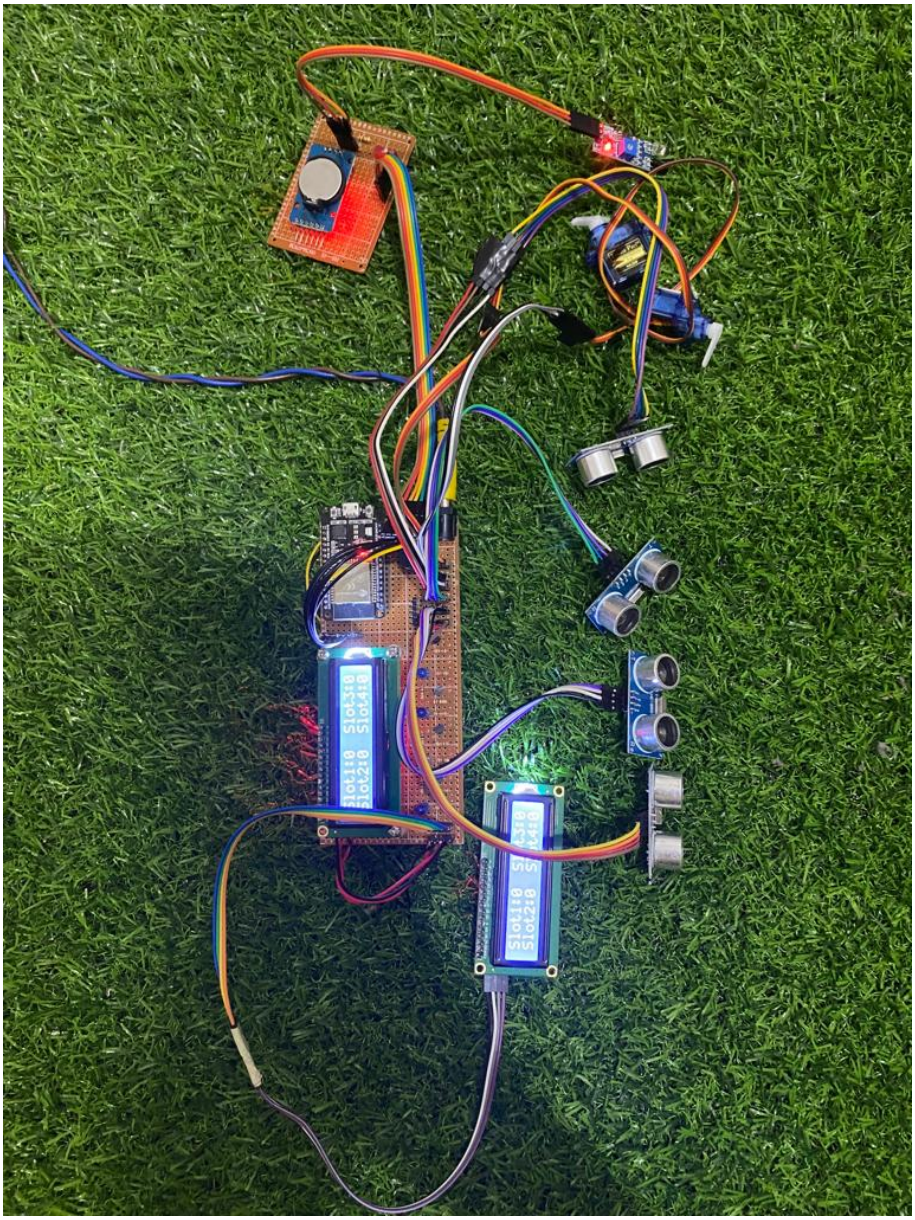


Figure 6.7: Implementation 1

This figure (Figure 6.7: Implementation 1) shows the all sensors and other electronic components used to create this prototype. For example, IR and ultrasonic sensors and LCD displays.

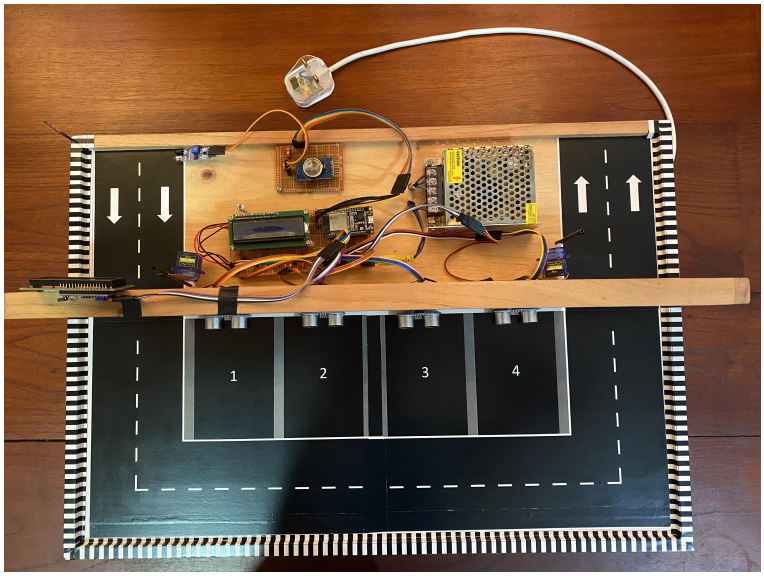


Figure 6.8: Implementation 2

This figure (Figure 6.8: Implementation 2) shows what the prototype car park looks like from the sky.

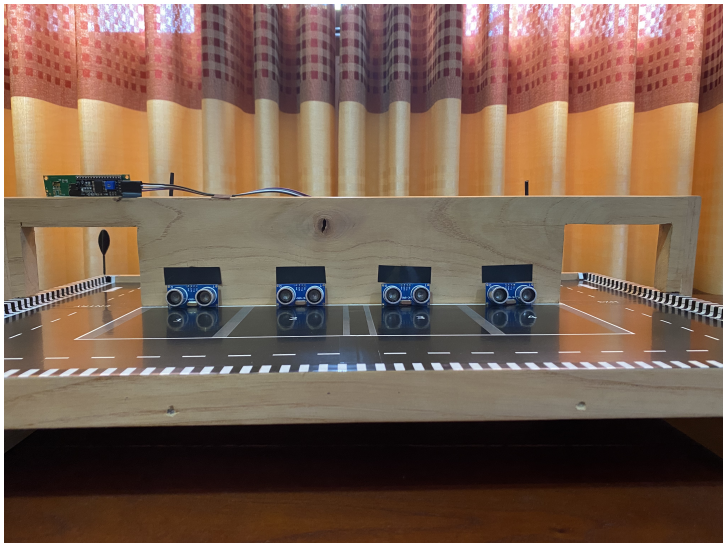


Figure 6.9: Implementation 3

This Figure(Figure 6.9: Implementation 3) shows the placement of the ultrasonic sensors To check whether or not vehicles are parked in the parking lot.

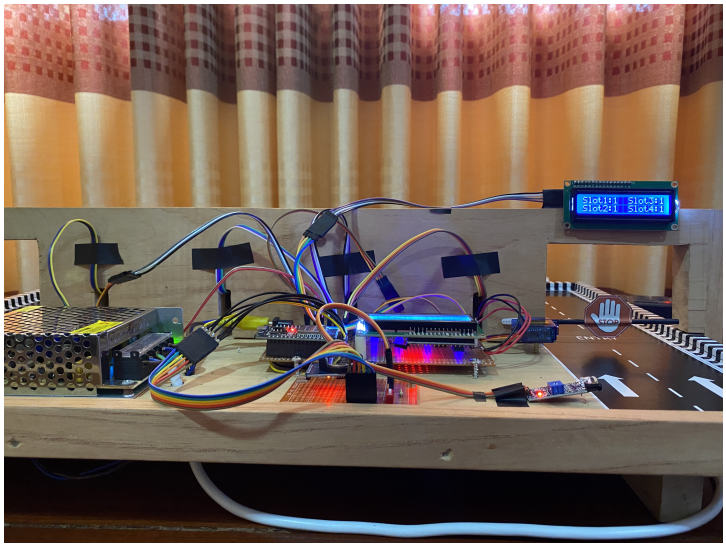


Figure 6.10: Implementation 4

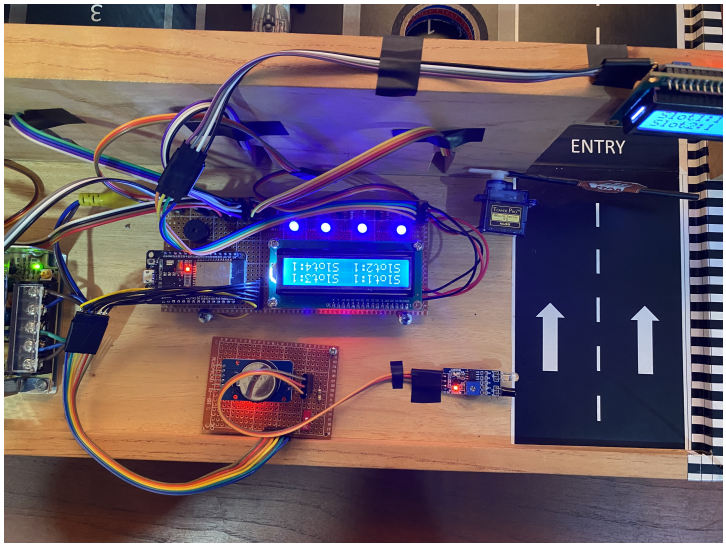


Figure 6.11: Implementation 5

These two Figure(Figure 6.10: Implementation 4 / Figure 6.11: Implementation 5) shows the placement of all elctronic components without ultrasonic sensors.

6.1.6 Codes that are used in IoT-based Smart Parking System

Smart Parking System is coded in the Arduino IDE using C++ language.

Set up Firebase and Wi-Fi

Code_Smart_Parking_System.ino

```
#include <FirebaseESP32.h>
#include  <WiFi.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <ESP32Servo.h>

#define FIREBASE_HOST "smart-parking-system-acf8a-default-rtdb.firebaseio.com/"
#define WIFI_SSID "iPhone"
#define WIFI_PASSWORD "12345678"
#define FIREBASE_Authorization_key "um1a4J0tPZjOCsS7TUviCyjDwxwxhBmuoFhHnhOw"

FirebaseData firebaseData;
FirebaseJson json;

```

Figure 6.12: Set up Firebase and Wi-Fi

```
void setup() {
  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);

```

Figure 6.13: Set up Firebase and Wi-Fi

Initialize Components

- Initialize LCD displays

```
70
71    lcd1.init();
72    lcd1.backlight();
73
74    lcd2.init();
75    lcd2.backlight();
76
```

Figure 6.14: Initialize LCD displays

- Initialize LEDs

```
76
77    for (int i = 0; i < numLeds; i++) {
78      pinMode(ledPins[i], OUTPUT);
79    }
80
```

Figure 6.15: Initialize LEDs

- Initialize Ultrasonic Sensors

```
81    pinMode(trigPin1, OUTPUT);
82    pinMode(echoPin1, INPUT);
83    pinMode(trigPin2, OUTPUT);
84    pinMode(echoPin2, INPUT);
85    pinMode(trigPin3, OUTPUT);
86    pinMode(echoPin3, INPUT);
87    pinMode(trigPin4, OUTPUT);
88    pinMode(echoPin4, INPUT);
```

Figure 6.16: Initialize Ultrasonic Sensors

- Initialize Servo Motors

```
93    ESP32PWM::allocateTimer(0);
94    ESP32PWM::allocateTimer(1);
95    ESP32PWM::allocateTimer(2);
96    ESP32PWM::allocateTimer(3);
97    myservo.setPeriodHertz(50);
98    myservo.attach(servoPin, 500, 2400);
99    myservo.write(openAngle);
100   delay(300);
```

Figure 6.17: Initialize Servo Motors

- Initialize Real time clock module

```
116   if (! rtc.begin()) {
117     Serial.println("Couldn't find RTC");
118     Serial.flush();
119     while (1) delay(10);
120   }
121   pinMode(buttonPin, INPUT);
122   pinMode(irPin,  INPUT);
123
```

Figure 6.18: Initialize Real time clock module

Distance Measurement

```
103   long getDistance(int trigPin, int echoPin) {
104     digitalWrite(trigPin, LOW);
105     delayMicroseconds(2);
106
107     digitalWrite(trigPin, HIGH);
108     delayMicroseconds(10);
109     digitalWrite(trigPin, LOW);
110
111     long duration = pulseIn(echoPin, HIGH);
112     return duration * 0.034 / 2;
113   }
```

Figure 6.19: Distance Measurement

Parking slot status

```
43    bool slot1;
44    bool slot2;
45    bool slot3;
46    bool slot4;
47
48    bool gate;
```

Figure 6.20: Parking slot status

```
void loop() {

  unsigned long currentMillis = millis();

  long distance1 = getDistance(trigPin1, echoPin1);
  long distance2 = getDistance(trigPin2, echoPin2);
  long distance3 = getDistance(trigPin3, echoPin3);
  long distance4 = getDistance(trigPin4, echoPin4);



  if ( (distance1 > threshold) && (distance2 > threshold) && (distance3 > threshold) && (distance4 > threshold) ) {
    slot1 = 0;
    slot2 = 0;
    slot3 = 0;
    slot4 = 0;

    gate = 0;
  }

  if ( (distance1 < threshold) && (distance2 > threshold) && (distance3 > threshold) && (distance4 > threshold) ) {
    slot1 = 1;
    slot2 = 0;
    slot3 = 0;
    slot4 = 0;

    gate = 0;
  }

  if ( (distance1 > threshold) && (distance2 < threshold) && (distance3 > threshold) && (distance4 > threshold) ) {
    slot1 = 0;
    slot2 = 1;
    slot3 = 0;
    slot4 = 0;
```

Figure 6.21: Parking slot status

```
  gate = 0;
}

if ( (distance1 > threshold) && (distance2 > threshold) && (distance3 < threshold) && (distance4 > threshold) ) {
  slot1 = 0;
  slot2 = 0;
  slot3 = 1;
  slot4 = 0;

  gate = 0;
}

if ( (distance1 > threshold) && (distance2 > threshold) && (distance3 > threshold) && (distance4 < threshold) ) {
  slot1 = 0;
  slot2 = 0;
  slot3 = 0;
  slot4 = 1;

  gate = 0;
}

if ( (distance1 < threshold) && (distance2 < threshold) && (distance3 < threshold) && (distance4 < threshold) ) {
  slot1 = 1;
  slot2 = 1;
  slot3 = 1;
  slot4 = 1;



  gate = 1;
}

if ( (distance1 < threshold) && (distance2 < threshold) && (distance3 > threshold) && (distance4 > threshold) ) {
  slot1 = 1;
  slot2 = 1;
```

Figure 6.22: Parking slot status

Update LEDs

```
103  long getDistance(int trigPin, int echoPin) {
104    digitalWrite(trigPin, LOW);
105    delayMicroseconds(2);
106
107    digitalWrite(trigPin, HIGH);
108    delayMicroseconds(10);
109    digitalWrite(trigPin, LOW);
110
111    long duration = pulseIn(echoPin, HIGH);
112    return duration * 0.034 / 2;
113  }
```

Figure 6.23: Update LEDs

Firebase Data Update

```
354   if (currentMillis - previousMillis >= interval) {
355     previousMillis = currentMillis;
356
357     Firebase.setFloat(firebaseData, "/Parking_Slots/Slot_01", slot1);
358     Firebase.setFloat(firebaseData, "/Parking_Slots/Slot_02", slot2);
359     Firebase.setFloat(firebaseData, "/Parking_Slots/Slot_03", slot3);
360     Firebase.setFloat(firebaseData, "/Parking_Slots/Slot_04", slot4);
361
362     Firebase.setFloat(firebaseData, "/Gate_Status/Gate_01", gate);
363     Firebase.setFloat(firebaseData, "/Gate_Status/Gate_02", gate);
364
365   }
366 }
```

Figure 6.24: Firebase data update

In this part, Full code is in the GitHub

6.2 Implementation of Web Application

6.2.1 User interface of the web application.

- Home Page

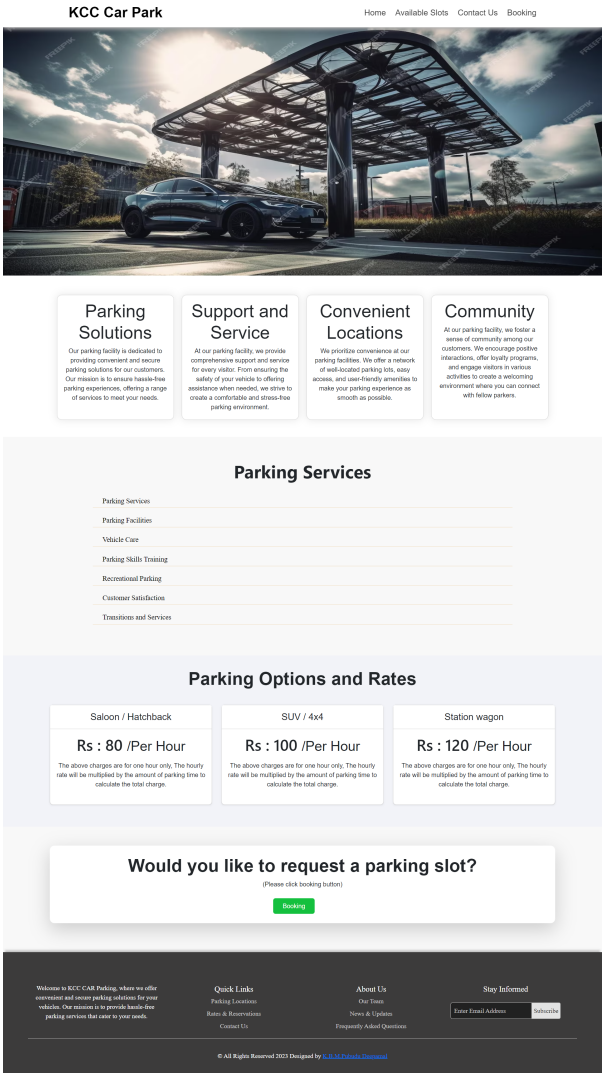


Figure 6.25: Home Page

This is the home page of the KCC car park web application. This web page is responsive to all mobile and desktop screen sizes.

- Available Slots Page

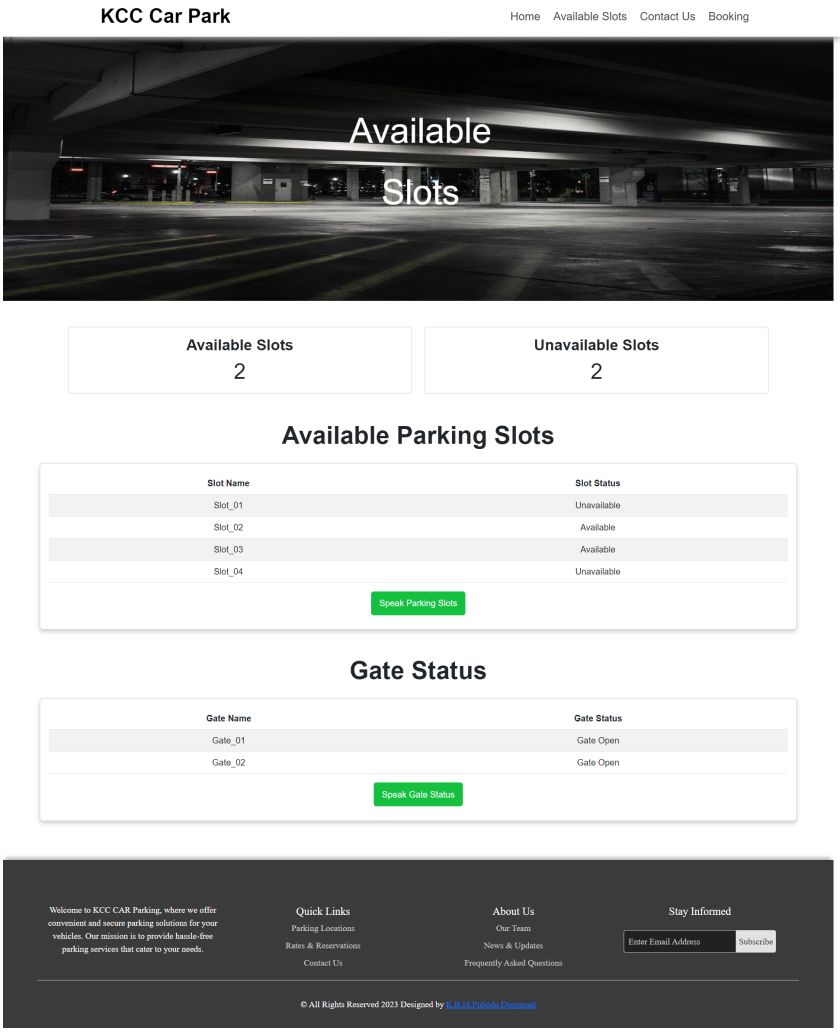


Figure 6.26: Available Slots

This is the Available Slots Page of the KCC car park web application. This is a more important part of this web application. Because this page displays all parking slot details and gate details for users. Another important thing is this all data are updated in real time. If necessary, facilities are also provided on this page for the user to Listen to the data available.

- Contact Us Page

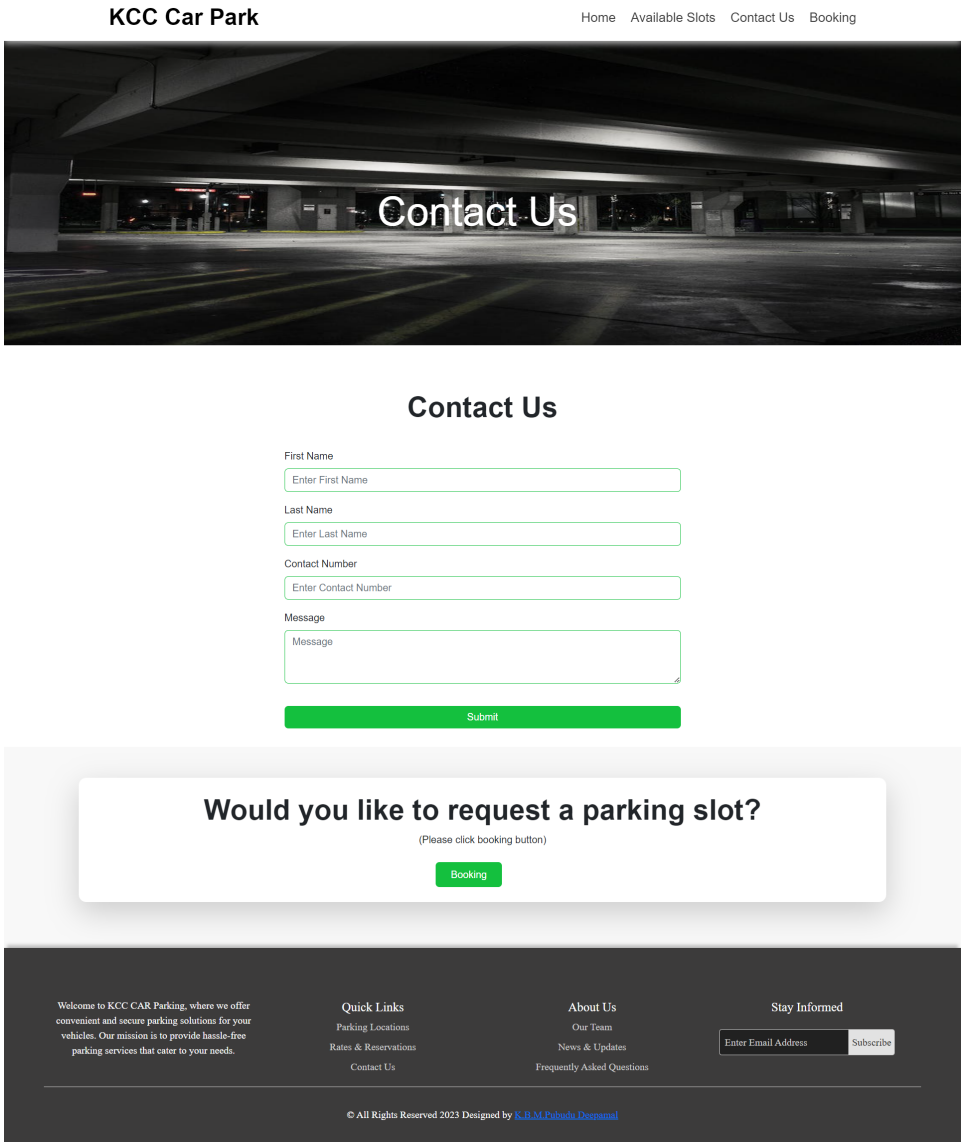


Figure 6.27: Contact Us Page

This is the Contact Us Page of the KCC car park web application. This page includes the Contact Us form. This form can be used for the users to communicate with the admin members.

- Booking Page

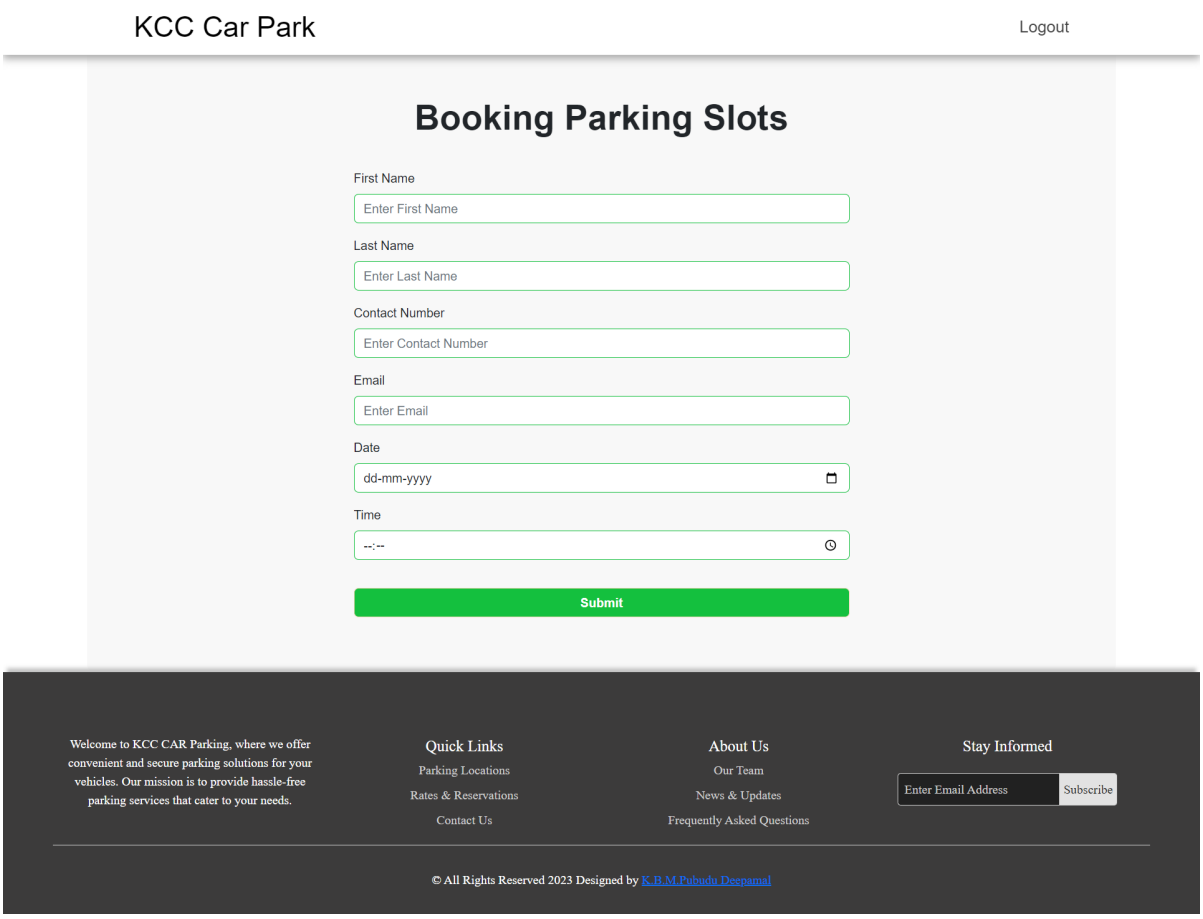


Figure 6.28: Booking Page

This is the Booking Page of the KCC car park web application. users can use the booking page request to parking slots at a specific time and date.

- Login Page

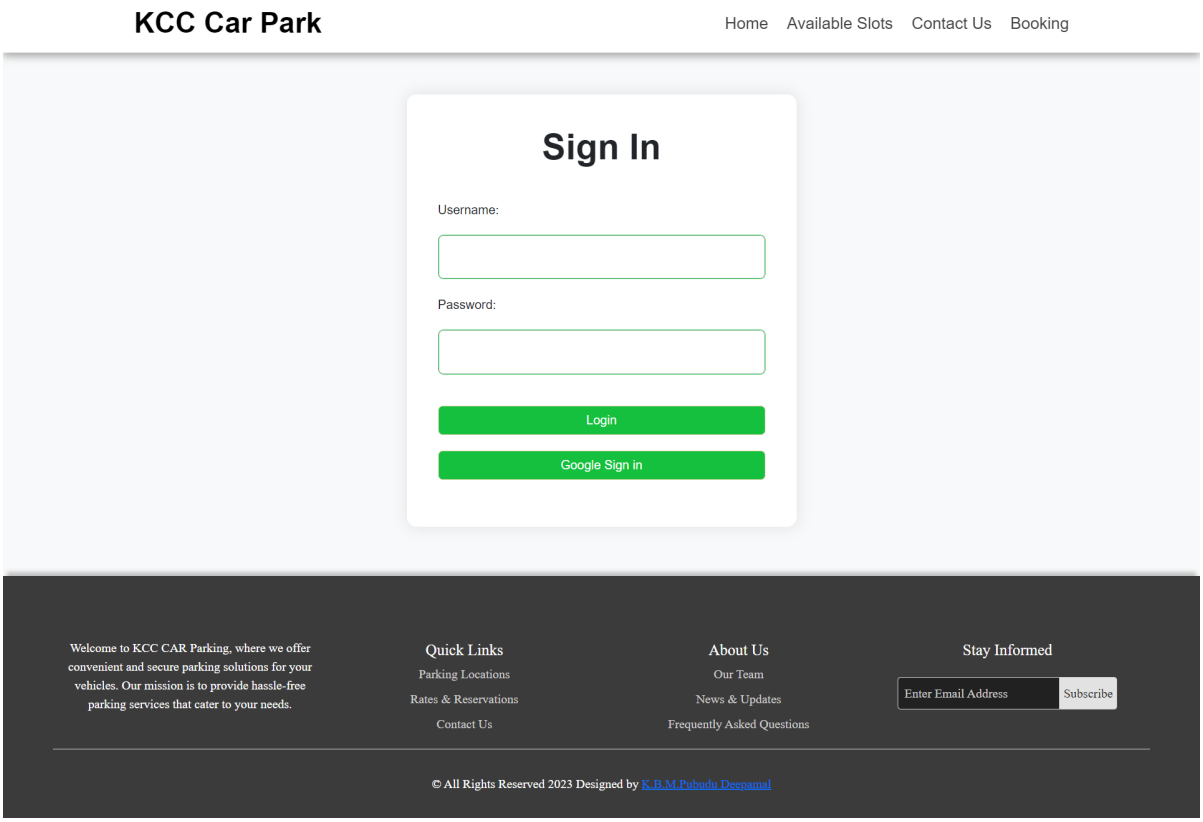


Figure 6.29: Login Page

This is the Login Page of the KCC car park web application. This login page includes the main two types of logins. The first way is to add a username and password. The second way is using Google authentication.

6.2.2 Admin interface of the web application.

- Admin Dashboard

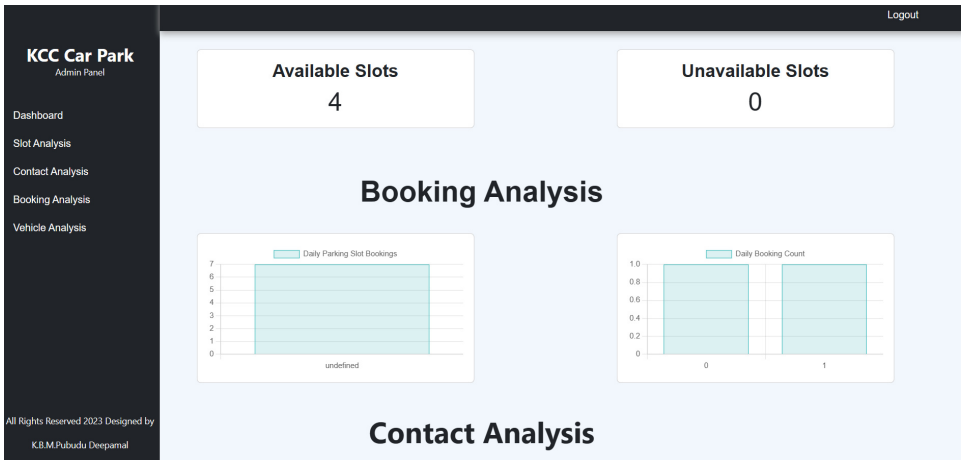


Figure 6.30: Admin Dashboard

This is the admin dashboard page. This page shows analysis charts of the contact table and Booking table. It also shows the number of parking spaces with and without vehicles.

- Slot and Gate Analysis Page

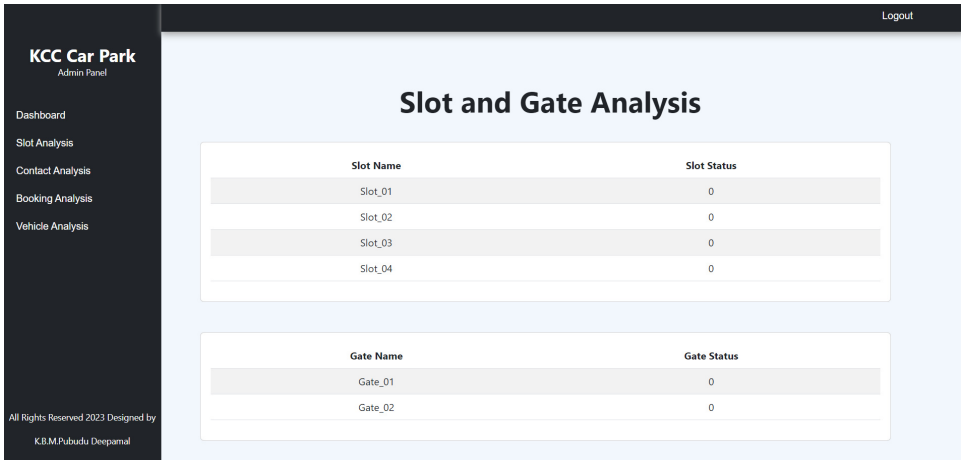


Figure 6.31: Slot and Gate Analysis Page

This is this web application's Slot and Gate Analysis Page. this page displays all parking slot details and gate details for admin.

- Contact Us Analysis Page

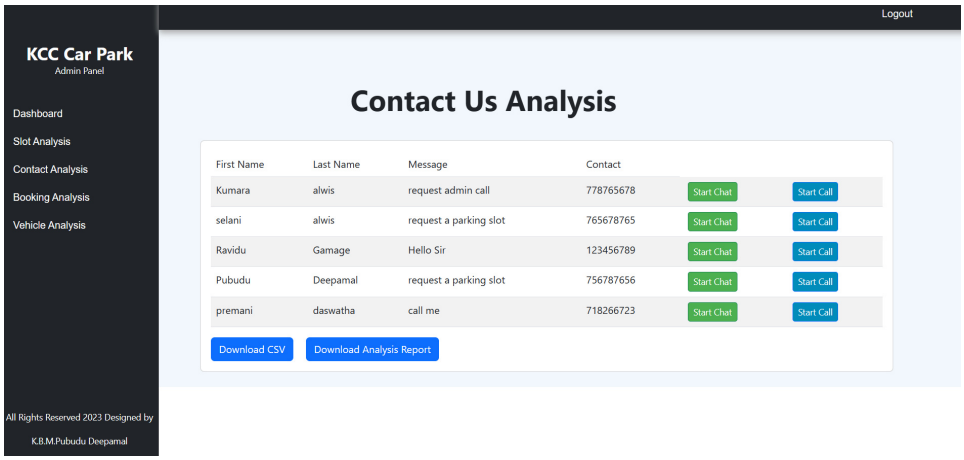


Figure 6.32: Contact Us Analysis Page

This is this web application's Contact Us Analysis Page. this page displays all Contact details for admin. In addition, the data available here is also provided for the administrator to download. Another special feature here is the ability to download an analysis report to the administrator. This table has main two buttons. The first button is the start chat button, second button is the start call button. Admin can use these two buttons to communicate with customers.

- Booking Details Analysis Page

This is this web application's Booking Details Analysis Page. this page displays all Booking Details for admin. In addition, the data available here is also provided for the administrator to download. Another special feature here is the ability to download a Booking details analysis report to the administrator. On this page, the admin is given to access remove the bookings.

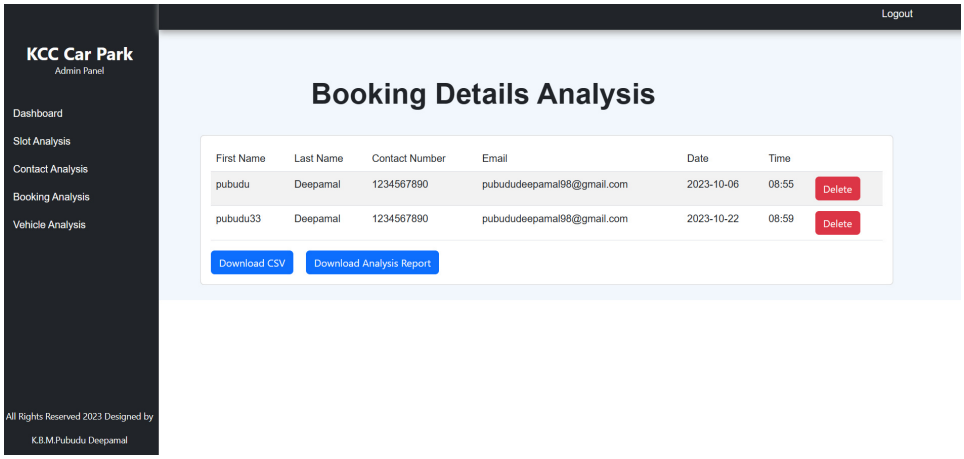


Figure 6.33: Booking Details Analysis Page

- Vehicle count Analysis Page

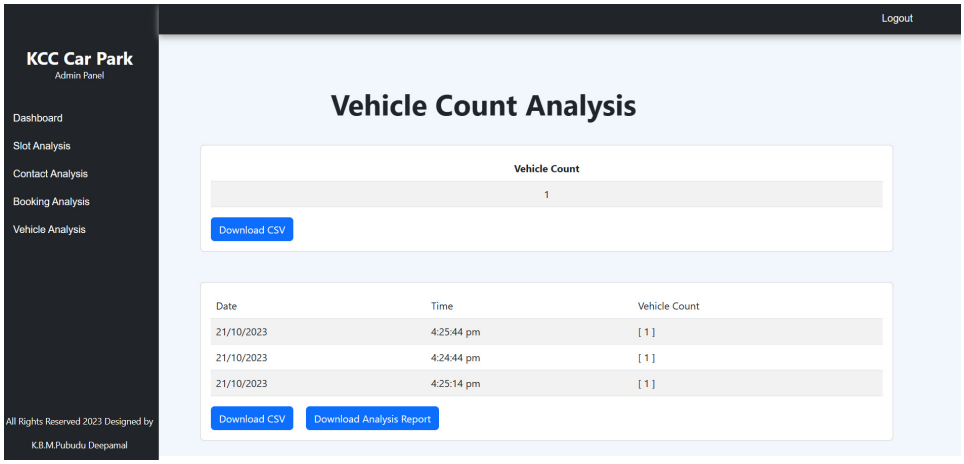


Figure 6.34: Vehicle count Analysis Page

This is this web application's Vehicle Count Analysis Page. Always first table displays the number of cars entering the parking lot in the last twenty-four hours. These tables are automatically updated during that period. The data available here is also provided for the administrator to download. (Since this should be displayed in the presentation, the 24-hour period is designed to work as a minute.) The second table keeps a record of the number of cars entered on each date. (The table is designed to update every 30 seconds as it should be displayed in

this presentation.) The second table data available here is also provided for the administrator to download. Another special feature here is the ability to download a data analysis report to the administrator.

6.2.3 Mobile view interfaces of the web application

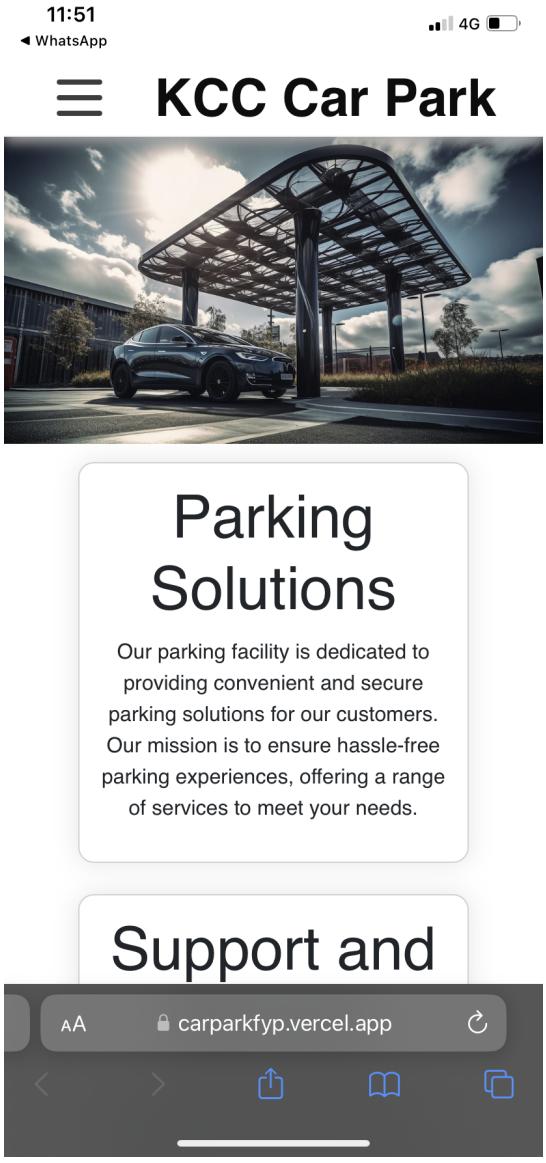


Figure 6.35: Mobile view interfaces of the web application-1

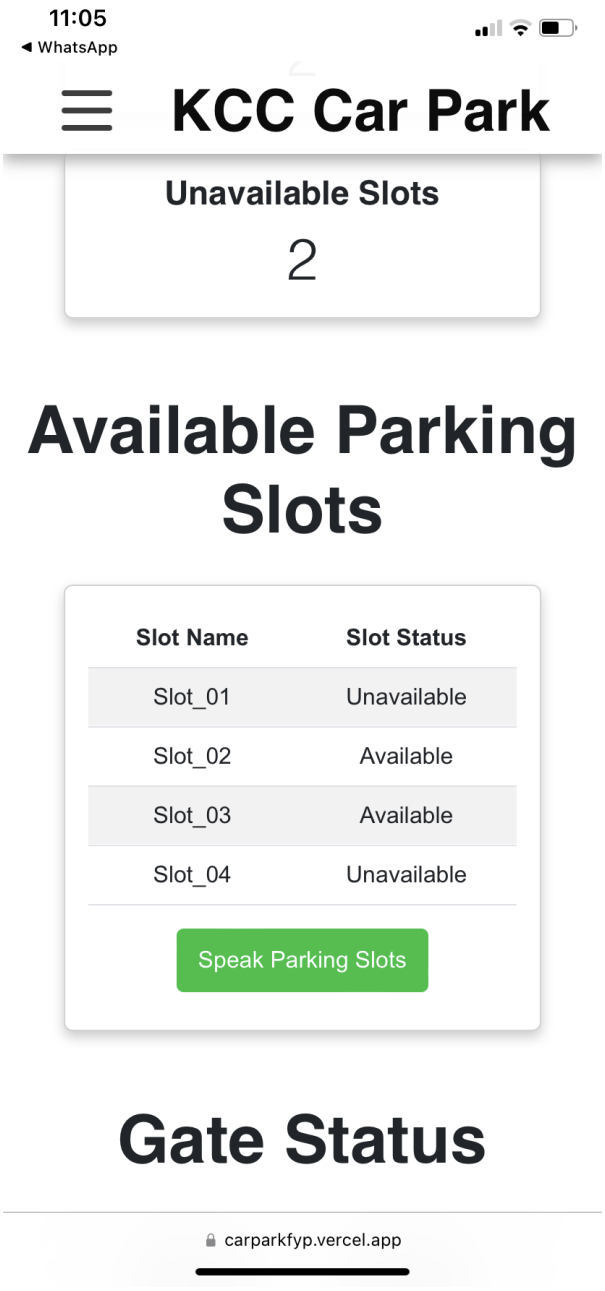


Figure 6.36: Mobile view interfaces of the web application-2

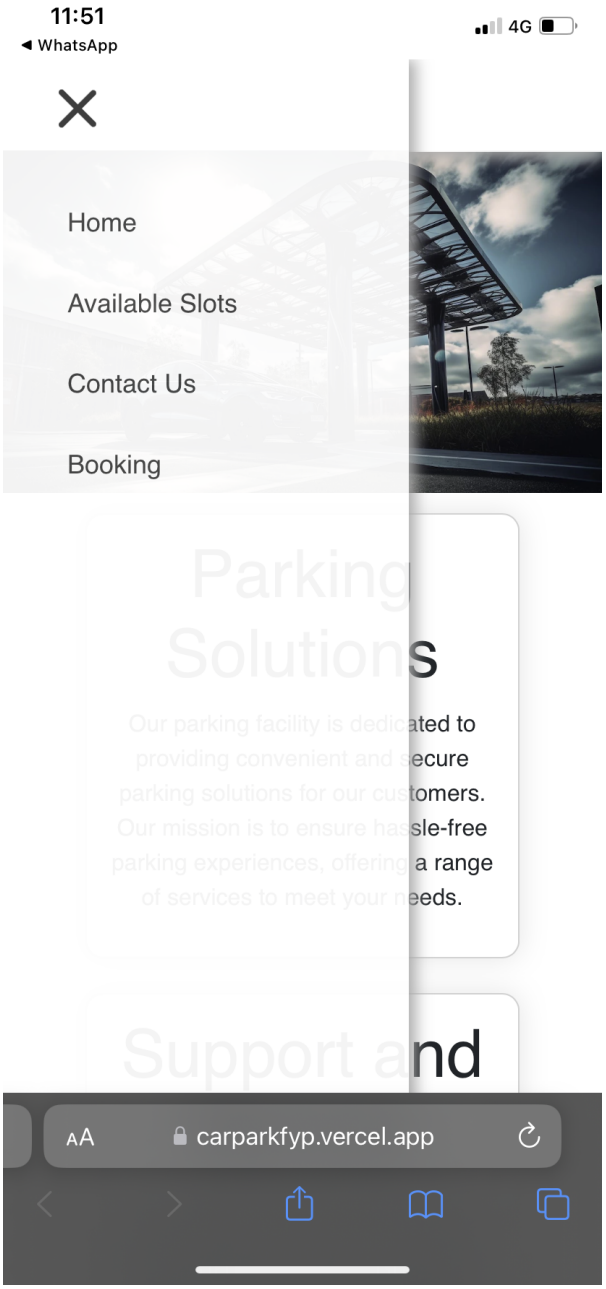


Figure 6.37: Mobile view interfaces of the web application-3

6.2.4 Codes that are used in this Web Application

- Firebase connecting to the web application

```
JS firebaseConfig.js M ×
src > JS firebaseConfig.js > ...
1   import { initializeApp } from 'firebase/app';
2   import { getFirestore } from "firebase/firestore";
3
4   const firebaseConfig = {
5     apiKey: "AIzaSyDWfil-cgu_bPr3BkXW0wzJKDecF6VbaTI",
6     authDomain: "smart-parking-system-acf8a.firebaseapp.com",
7     databaseURL: "https://smart-parking-system-acf8a-default-rtdb.firebaseio.com",
8     projectId: "smart-parking-system-acf8a",
9     storageBucket: "smart-parking-system-acf8a.appspot.com",
10    messagingSenderId: "1012120949318",
11    appId: "1:1012120949318:web:08edd146ca80508aacf047",
12    measurementId: "G-FFPDVV50TN"
13  };
14
15  const firbaseApp = initializeApp(firebaseConfig);
16
17  const db = getFirestore()
18  export default db
19
```

Figure 6.38: Firebase connecting to the web application

This code is used to connect web applications and Firebase together. This code includes all Firebase configurations. for example, API Key, auth domain, and database URL.

- Displaying details of parking slot and gate

This code is used to display Firebase data in the KCC web application. Here the data is transmitted to the web applications using the API. For that, the Axios library has been used.

```
<div class="row">
  <h1 class="display-4 mb-4" id="GateStatus">Gate Status</h1>
  <div class="col">
    <div class="card">
      <div class="card-body">
        <table class="table table-striped table-mobile-responsive table-mobile-sided">
          <thead>
            <tr>
              <th scope="col" style="text-align: center;"><b>Gate Name</b></th>
              <th scope="col" style="text-align: center;"><b>Gate Status</b></th>
            </tr>
          </thead>
          <tbody>
            <tr v-for="(status, gate) in gateStatus" :key="gate">
              <td style="text-align: center;">{{ gate }}</td>
              <td style="text-align: center;">{{ status == 0 ? 'Gate Open' : 'Gate Close' }}</td>
            </tr>
          </tbody>

        </table>
        <button @click="speakTableData('gateStatus')">Speak Gate Status</button>
      </div>
```

Figure 6.39: Displaying details of parking slot

```
<div class="row">
  <h1 class="display-4 mb-4" id="GateStatus" style="margin-top: 50px;">Available Parking Slots</h1>
  <div class="col">
    <div class="card">
      <div class="card-body">
        <table class="table table-striped table-mobile-responsive table-mobile-sided">
          <thead>
            <tr>
              <th scope="col" style="text-align: center;"><b>Slot Name</b></th>
              <th scope="col" style="text-align: center;"><b>Slot Status</b></th>
            </tr>
          </thead>
          <tbody>
            <tr v-for="(slotStatus, slotName) in parkingSlots" :key="slotName">
              <td style="text-align: center;">{{ slotName }}</td>
              <td style="text-align: center;">{{ slotStatus == 0 ? 'Available' : 'Unavailable' }}</td>
            </tr>
          </tbody>
        </table>
        <button @click="speakTableData('parkingSlots')">Speak Parking Slots</button>
      </div>
    </div>
```

Figure 6.40: Displaying details of gate

- Display details of Vehicle Count

```
getData() {
  this.getVehicleCount();
},
getVehicleCount() {
  axios
    .get('https://smart-parking-system-acf8a-default-rtdb.firebaseio.com/Vehicle_Count.json')
    .then((response) => {
      this.vehicleCount = response.data;

      this.csvDataUrl = this.generateCSVDataUrl();
    })
    .catch((error) => {
      console.error('Error fetching vehicle count data:', error);
    });
},
```

Figure 6.41: Display details of Vehicle Count

```
<template>
  <div style="background-color: #f1f7fc;">
    <br /><br /><br />
    <div class="container">
      <div class="section-title">
        <h3 class="faqsection" style="font-size: 45.8px; font-weight: bold; margin-top: 60px;">
          Vehicle Count Analysis
        </h3>
      </div>
      <div class="row">
        <div class="col">
          <div class="card">
            <div class="card-body">
              <table class="table table-striped table-mobile-responsive table-mobile-sided">
                <thead>
                  <tr>
                    <th scope="col" style="text-align:center"><b>Vehicle Count</b></th>
                  </tr>
                </thead>
                <tbody>
                  <tr v-for="(count, vehicleType) in vehicleCount" :key="vehicleType">
                    <td style="text-align:center">{{ count }}</td>
                  </tr>
                </tbody>
              </table>
              <a :href="csvDataUrl" download="vehicle_count_data.csv" class="btn btn-primary">Download CSV</a>
            </div>
          </div>
        </div>
      </div>
    </div>
    <br />
  </div>
</template>
```

Figure 6.42: Display details of Vehicle Count

- Displaying the amount of available and unavailable parking slots

```
<template>
<div style="background-color: #f1f7fc;">
    <br><br><br>
    <div class="container mt-5">
        <div class="row justify-content-center mt-4">
            <div class="col-md-6">
                <div class="card text-center">
                    <div class="card-body">
                        <h3 class="card-title" id="fontfamily"><b>Available Slots</b></h3>
                        <p class="card-text display-4" id="fontfamily" style="font-size: 40px;">{{ availableSlots }}</p>
                    </div>
                </div>
            </div>
            <div class="col-md-6">
                <div class="card text-center">
                    <div class="card-body">
                        <h3 class="card-title" id="fontfamily"><b>Unavailable Slots</b></h3>
                        <p class="card-text display-4" id="fontfamily" style="font-size: 40px;">{{ unavailableSlots }}</p>
                    </div>
                </div>
            </div>
        </div>
    </div>
    <br><br>
  </div>
</template>
```

Figure 6.43: Displaying the amount of available and unavailable parking slots

```
<script>
export default {
    data() {
        return {
            availableSlots: 0,
            unavailableSlots: 0
        };
    },
    mounted() {

        fetch('https://smart-parking-system-acf8a-default-rtdb.firebaseio.com/Parking_Slots.json')
            .then(response => response.json())
            .then(data => {

                for (const slotId in data) {
                    if (data[slotId] === 0) {
                        this.availableSlots++;
                    } else if (data[slotId] === 1) {
                        this.unavailableSlots++;
                    }
                }
            });
    }
};
</script>
```

Figure 6.44: Displaying the amount of available and unavailable parking slots

- Speak Table Data Function code

```
speakTableData(type) {
    let msg = new SpeechSynthesisUtterance();
    let content = '';

    if (type === 'parkingSlots') {
        content = "Parking Slots Status: ";
        for (let slot in this.parkingSlots) {
            let statusText = this.parkingSlots[slot] == 0 ? 'Available' : 'Unavailable';
            content += `${slot} is ${statusText}. `;
        }
    } else if (type === 'gateStatus') {
        content = "Gate Status: ";
        for (let gate in this.gateStatus) {
            let statusText = this.gateStatus[gate] == 0 ? 'Gate Open' : 'Gate Close';
            content += `${gate} is ${statusText}. `;
        }
    }

    msg.text = content;
    window.speechSynthesis.speak(msg);
}
```

Figure 6.45: Speak Table Data

Reading the web application to the driver while traveling in the car is a very difficult task. Therefore, this section is designed for the driver to listen to current information.

In this project, Full code is in the GitHub

6.3 Implementation of Firebase Database

6.3.1 Firebase Realtime Database

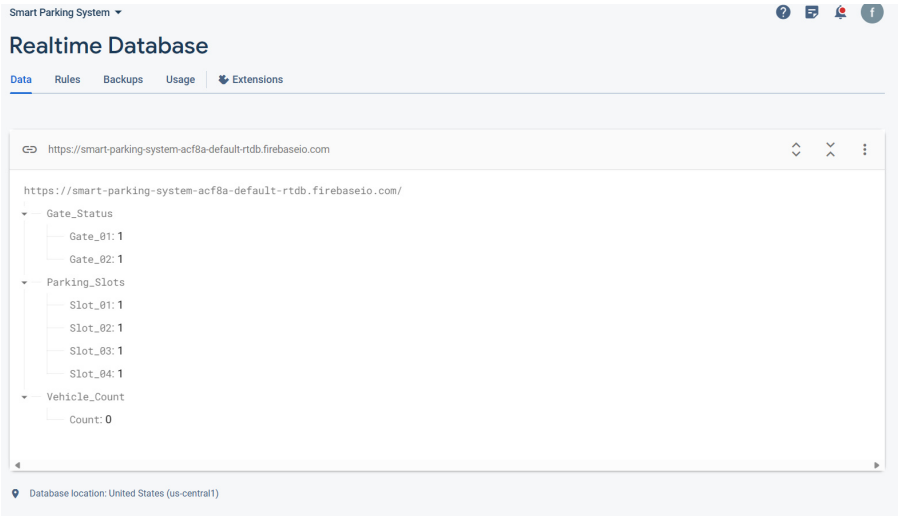


Figure 6.46: Firebase Realtime Database

6.3.2 Firebase Firestore Database

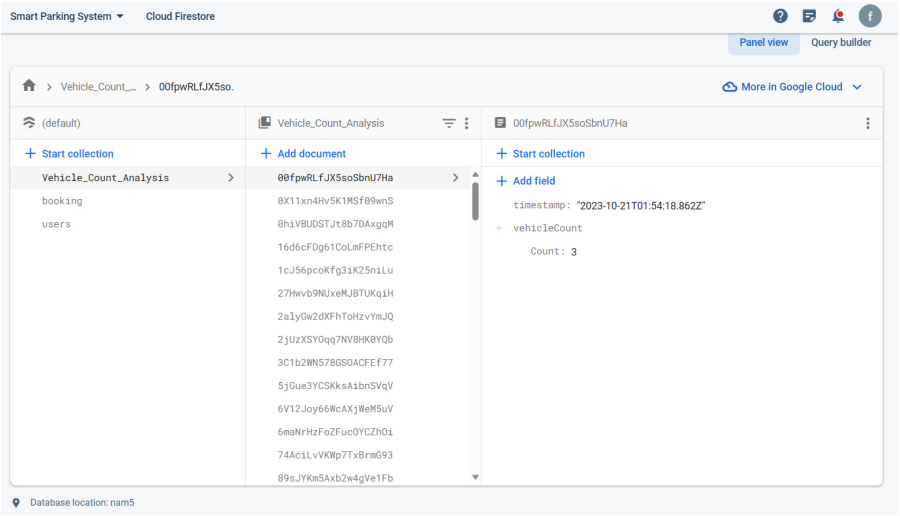


Figure 6.47: Firebase Firestore Database

Chapter 7

Testing and Evaluation

7.1 Justification of the Smart Parking System Prototype

IoT-based Smart Parking System prototype is successfully implemented. This is evident from the proper functioning of all sensors and all other electronic devices that have been used to create this system. IR sensor and Ultrasonic Sensors are mainly used in this system and these sensors are used for different functions. IR sensor are used to count the number of vehicles entering the car park and Ultrasonic Sensors are used to monitor the presence of vehicles in parking lots. 4 Ultrasonic Sensors are used in this system as the prototype has four parking spots. The success of this entire system depends on the accuracy of the data obtained by these sensors. Another feature of this system is to close the entry gates when all the stops are full of vehicles. This prevents congestion due to excessive vehicles entering the parking lot. Additionally, LCD screens and web applications show car park users whether or not a car is available at each parking spot.

The system created above has been able to offer solutions for a large number of problems in the current system in the KCC car park. The new method has made

it quite simple to find a spot to park a car in the car park, which was previously a very tough process.

According to the current system in the parking lot, even when the parking lot is full of vehicles, it can be seen that there will be unnecessary traffic because the vehicles will enter the parking lot. The proposed new method has also offered a solution to this.

Another problem with the old system is that there is no proper understanding of the number of vehicles entering the car parking each day. The main reason is currently no automatic calculation system in the car park. With the new system, a system has been set up to automatically calculate the number of vehicles entering the car park, and thus, an understanding of busy days in the car park can be obtained.

Data is shown on LCD panels in the prototype. However, using LED displays as the primary choice in this design is recommended. The ease of connecting the LCD screen prototype compared to LED screens has led to the use of LCD display for the original model.

Another problem with the prototype is that the sensors used here capture things other than vehicles. It can cause this system to fail and therefore it is essential to use sensors that can distinguish the cars in this real-world implement design.

7.2 Testing of the Smart Parking System Prototype

Table 7.1: Testing of the Smart Parking System Prototype

Test case	Testing	Expected result	Actual result	Action
1	Ultrasonic sensors detect the vehicle.	Detecting whether a vehicle is parked in the parking lot or not.	Worked properly	Success
2	Gate open and close	Gates must be closed if all spots are full.	Worked properly	Success
3	LCD display works	LCD display showing Available and unavailable parking slots.	Worked properly	Success
4	Lighting the bulbs in the circuit	When the car is parked in a parking lot, the corresponding bulbs should be lit.	Worked properly	Success
5	IR sensors detect the vehicle.	When a vehicle enters, the total number of vehicles increases.	Worked properly	Success
6	ESP32 Wireless Communication Protocol is working properly.	Updating the database correctly.	Worked properly	Success

7.2.1 IR and ultrasonic sensor test results

```
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 1     Vehicle Count: 1
Slot 1 : 1      Slot 2: 1       Slot 3: 1       Slot 4: 1       Seconds : 3     Vehicle Count: 1
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 7     Vehicle Count: 1
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 1       Seconds : 9     Vehicle Count: 1
Slot 1 : 0      Slot 2: 1       Slot 3: 0       Slot 4: 0       Seconds : 12    Vehicle Count: 1
Slot 1 : 0      Slot 2: 1       Slot 3: 0       Slot 4: 0       Seconds : 15    Vehicle Count: 1
Slot 1 : 0      Slot 2: 1       Slot 3: 1       Slot 4: 0       Seconds : 19    Vehicle Count: 1
Slot 1 : 1      Slot 2: 1       Slot 3: 1       Slot 4: 1       Seconds : 26    Vehicle Count: 1
Slot 1 : 1      Slot 2: 1       Slot 3: 1       Slot 4: 1       Seconds : 30    Vehicle Count: 1
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 1
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 1
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 1
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 2
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 2
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 2
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 2
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 3
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 3
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 40    Vehicle Count: 3
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 41    Vehicle Count: 3
Slot 1 : 0      Slot 2: 0       Slot 3: 0       Slot 4: 0       Seconds : 41    Vehicle Count: 3
```

Figure 7.1: IR and ultrasonic sensor test results

7.3 Testing of the Web Application

Mainly Used automation testing method and manual testing method to test KCC web applications. Manual Testing is manually testing the program by humans. Automation testing is a software testing technique. Testers use a lot of technologies and testing tools to do automation testing. Automation testing is reducing a lot of human errors. Developers do testing frequently combine manual testing and automated testing.

Table 7.2: Testing of the Web Application

Test case	Testing	Expected result	Actual result	Action
1	Contact Us form testing.	In this operation and validation are working correctly.	Worked properly	Success
2	Booking form testing	In this operation and validation are working correctly.	Worked properly	Success
3	Login form testing	In this operation and validation are working correctly.	Worked properly	Success
4	Multiple devices with responsive design	The website is fixed in all screen sizes	Worked properly	Success
5	Multiple browser testing.	The website is fixed in all browser.	Worked properly	Success
6	Database testing	Updating the database correctly.	Worked properly	Success

7.3.1 Automation testing using the Lighthouse plugin

Lighthouse is a plugin used for testing web application automation. It mainly tests Performance, Accessibility, and SEO in web applications.

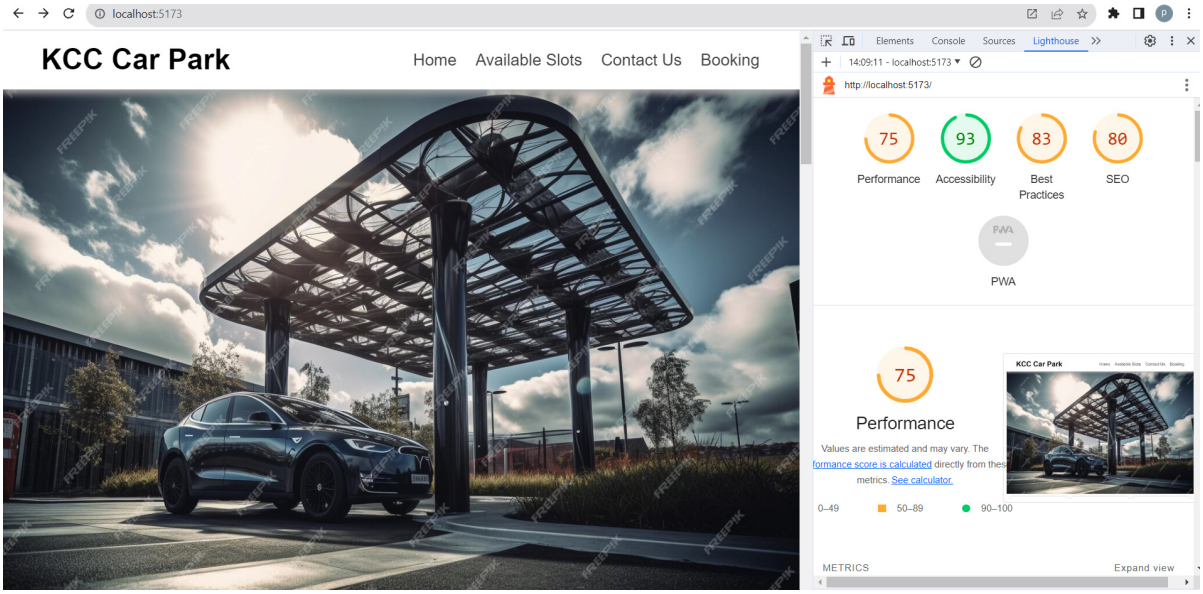


Figure 7.2: Automation test results 1

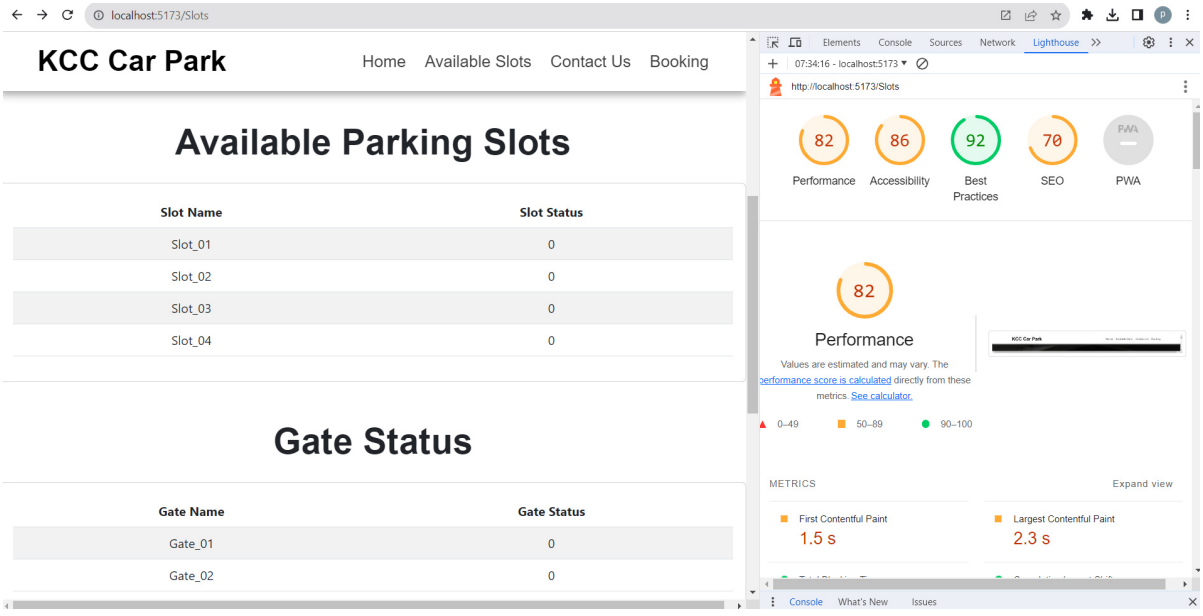


Figure 7.3: Automation test results 2

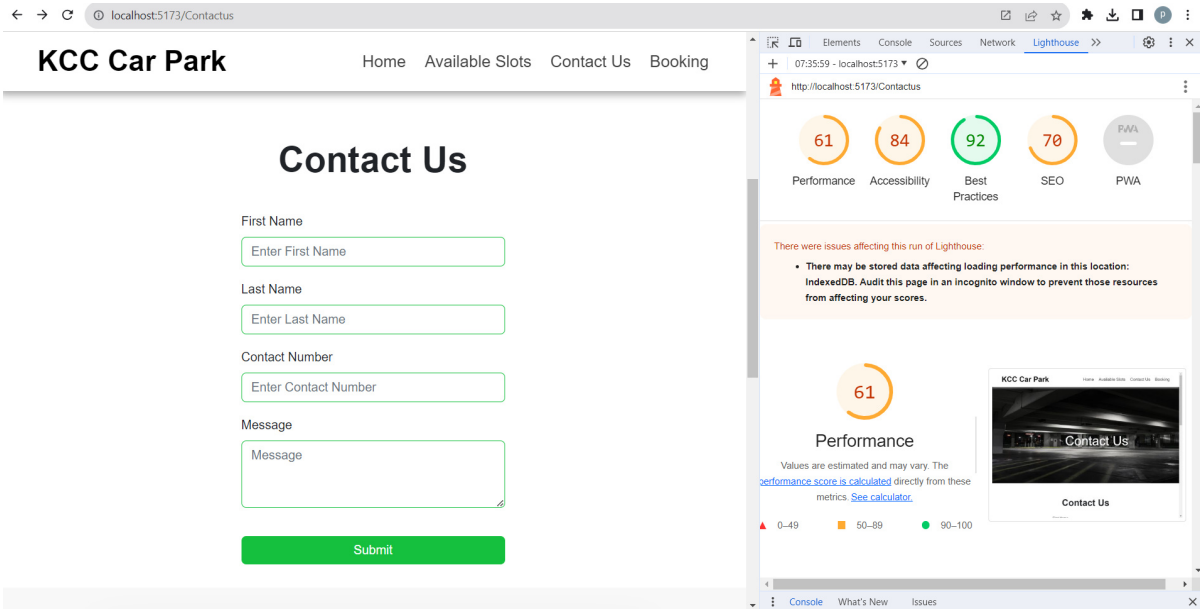


Figure 7.4: Automation test results 3

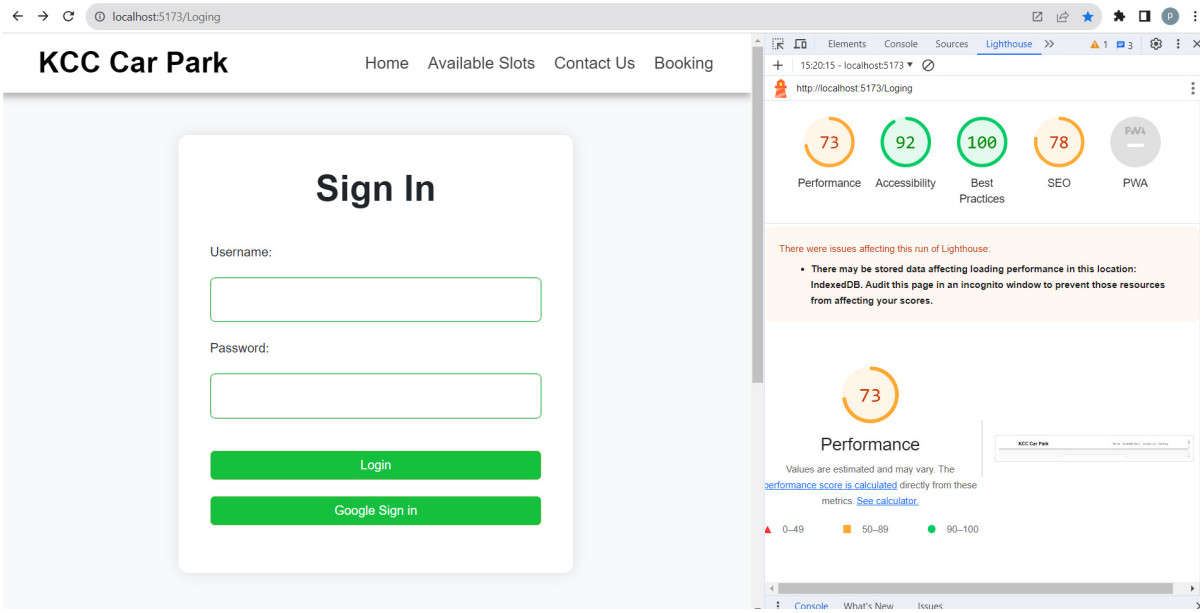


Figure 7.5: Automation test results 4

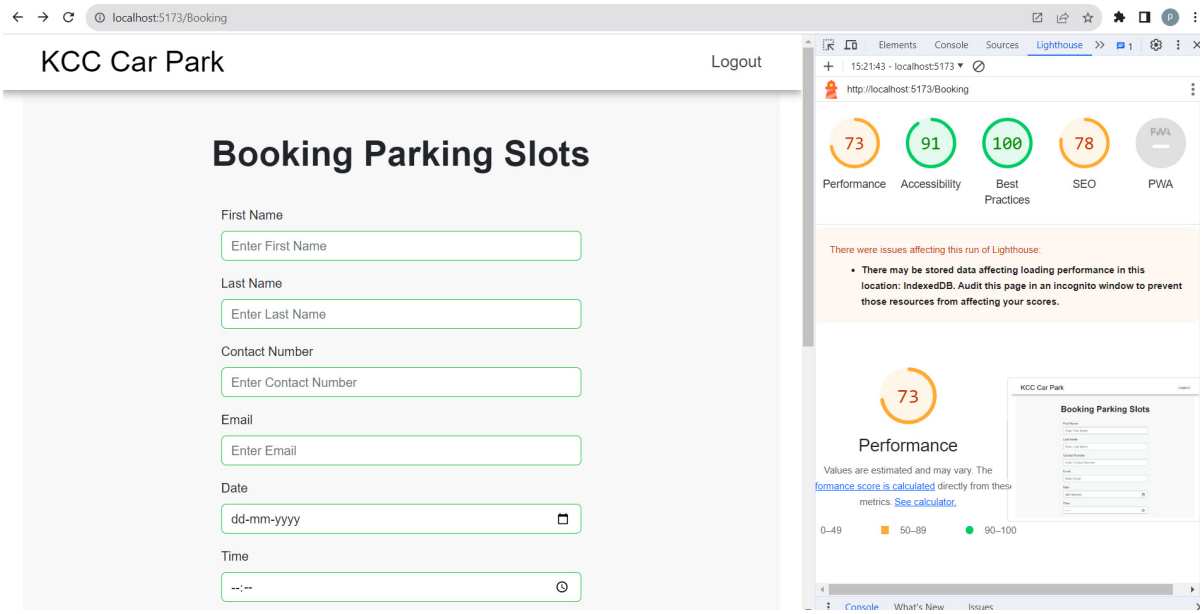


Figure 7.6: Automation test results 5

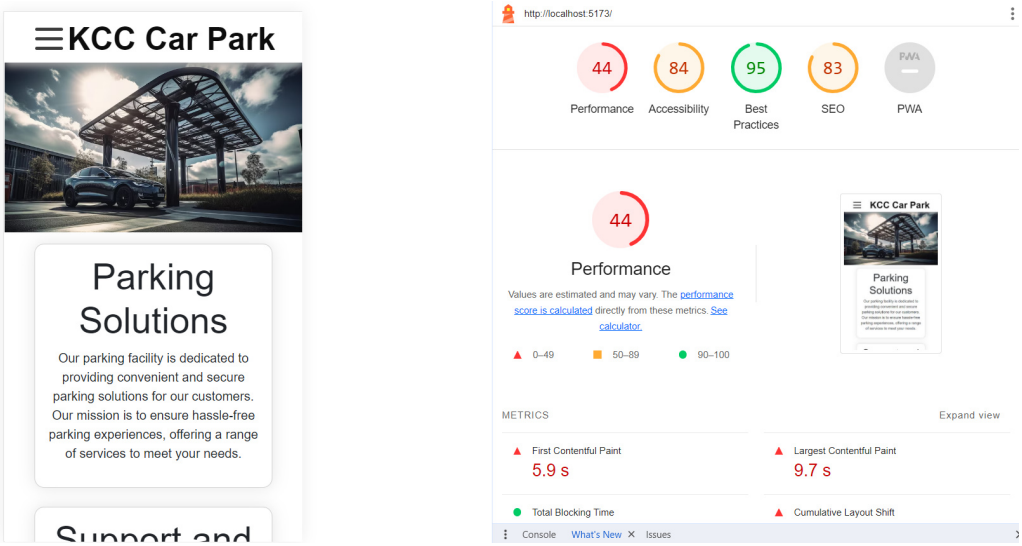


Figure 7.7: Automation test results 6

Chapter 8

Conclusion and Future Enhancement

8.1 Conclusion

With rapid urbanization, there is a need for an efficient and high-tech vehicle parking system in urban areas. This was revealed in a survey conducted in Kandy city. For this survey, information has been collected from forty people through Google Forms and information has been obtained by interviewing ten more people. Here, A large percentage of those who participated in the survey said that the weaknesses of the current system of the KCC car park, which is the main car park in Kandy, should be identified and a new high-tech system should be presented.

The inefficiency of the system and the difficulty in locating parking spaces are two issues with the existing system in the KCC car park that were noted in this research. In order to address these issues, a novel IoT smart parking system is presented in this study. Many of the issues with the existing system in the KCC car park have been addressed in this new IoT smart parking system, the new system is much more user-friendly.

as it provides real-time data on parking availability in parking slots, congestion reduction, and space utilization. This system has a high initial cost and maintenance cost. This can be stated as a major problem faced during the creation of the system.

The hardware part collects detailed information and displays the information through the web application. There are two main systems in the hardware section and one section prepares a record of the number of vehicles arriving at the parking lot. The other part sends real-time information to the database about whether Parking slots are available or not. It is always essential to take care of the performance of the system. Reasons for that include the possibility of errors in the electronics used to build the system and the privacy of the data collected by the system.

8.2 Limitation and Key Challenges

- Lack of knowledge about IoT: Before starting this IOT project, had limited knowledge about IoT. That knowledge is not enough to continue this project.
- The proposed system uses Ultrasonic Sensors and IR Sensors to detect cars, and it is accuracy is not one hundred percent.
- Transmitting the real-time information obtained from the sensor to web applications.

8.3 Future Enhancement

- Introduce a mobile app for users to find and reserve parking spaces, mobile payment options and Show directions to the parking spot.
- Show the directions to the parking spot using the LCD displays and web applications.

- Setting up a system to allocate parking spaces through web applications. (The basic part required for this has already been developed in web applications.)
- Add an Online payment system to a web application.
- Using advanced sensors to detect vehicles. For example, LIDAR and radar.

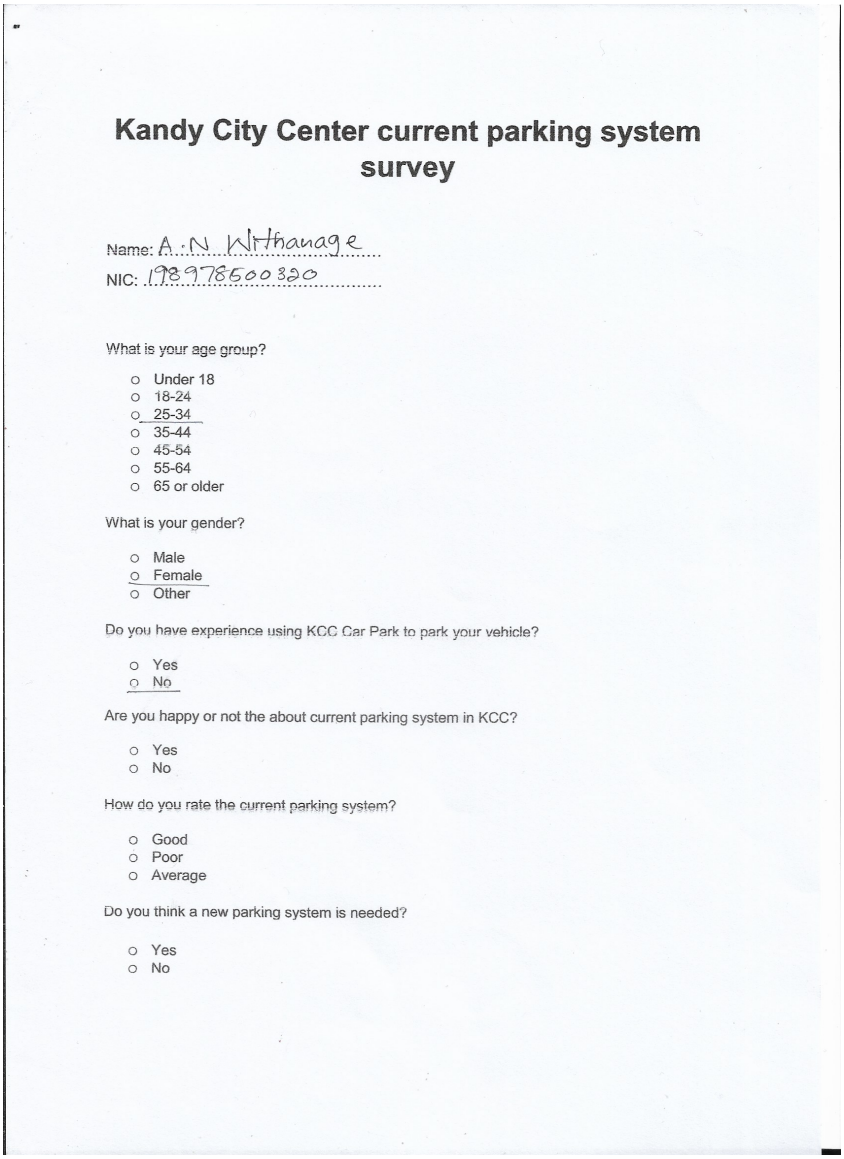
Appendix A

Appendix

A.1 Important links

- Web application hosting link Click here.
- In this project Iot part Full code is in the GitHub.
- In this project web application Full code is in the GitHub.
- Web application and hardware project implementation videos Click here.

A.2 Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: A.N Withanage

NIC: 198978500390

What is your age group?

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or older

What is your gender?

- Male
- Female
- Other

Do you have experience using KCC Car Park to park your vehicle?

- Yes
- No

Are you happy or not the about current parking system in KCC?

- Yes
- No

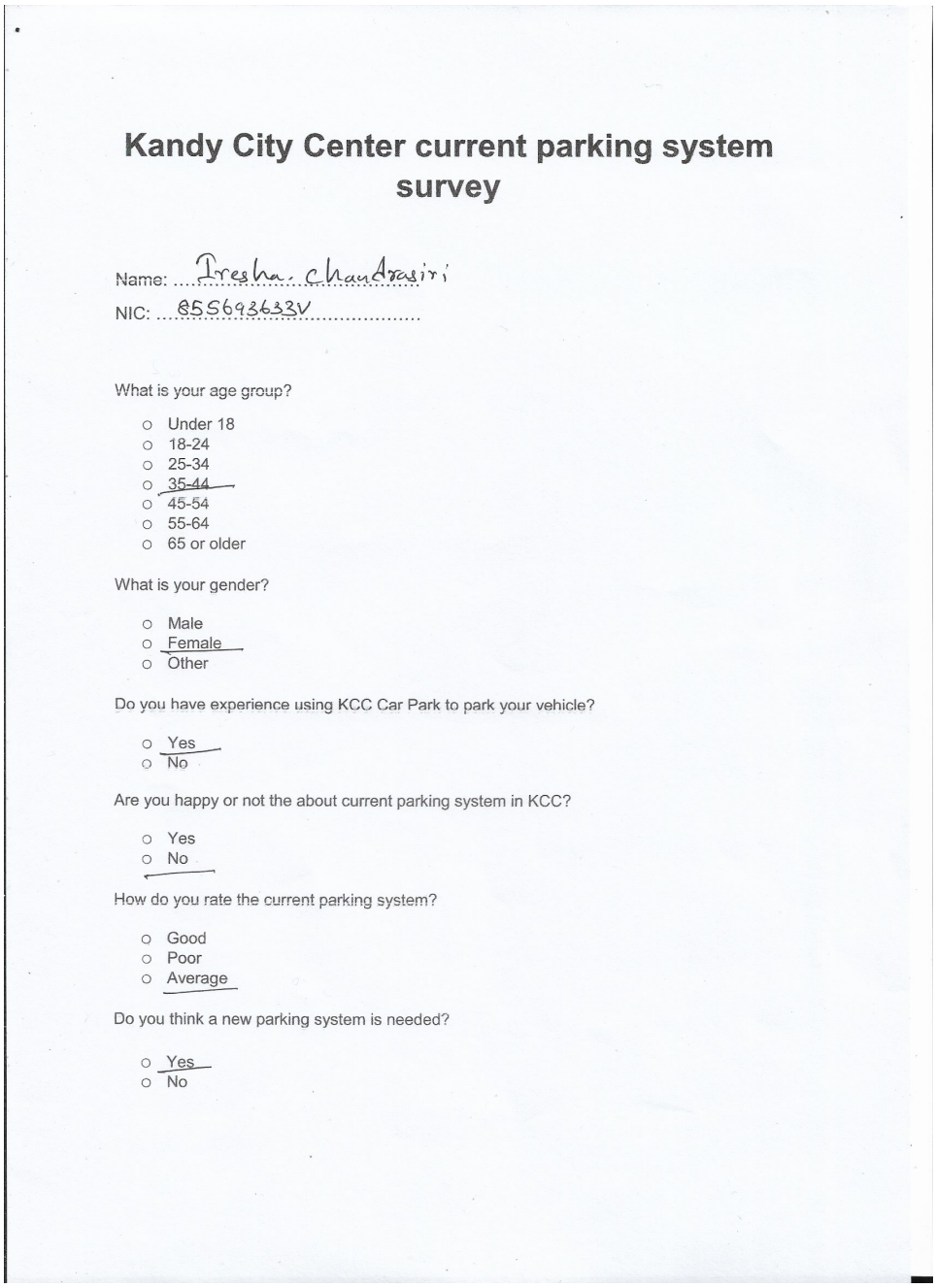
How do you rate the current parking system?

- Good
- Poor
- Average

Do you think a new parking system is needed?

- Yes
- No

Figure A.1: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: Tresha. chandrasiri

NIC: 855693633V

What is your age group?

- ○ Under 18
- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65 or older

What is your gender?

- ○ Male
- ○ Female
- ○ Other

Do you have experience using KCC Car Park to park your vehicle?

- ○ Yes
- ○ No

Are you happy or not the about current parking system in KCC?

- ○ Yes
- ○ No

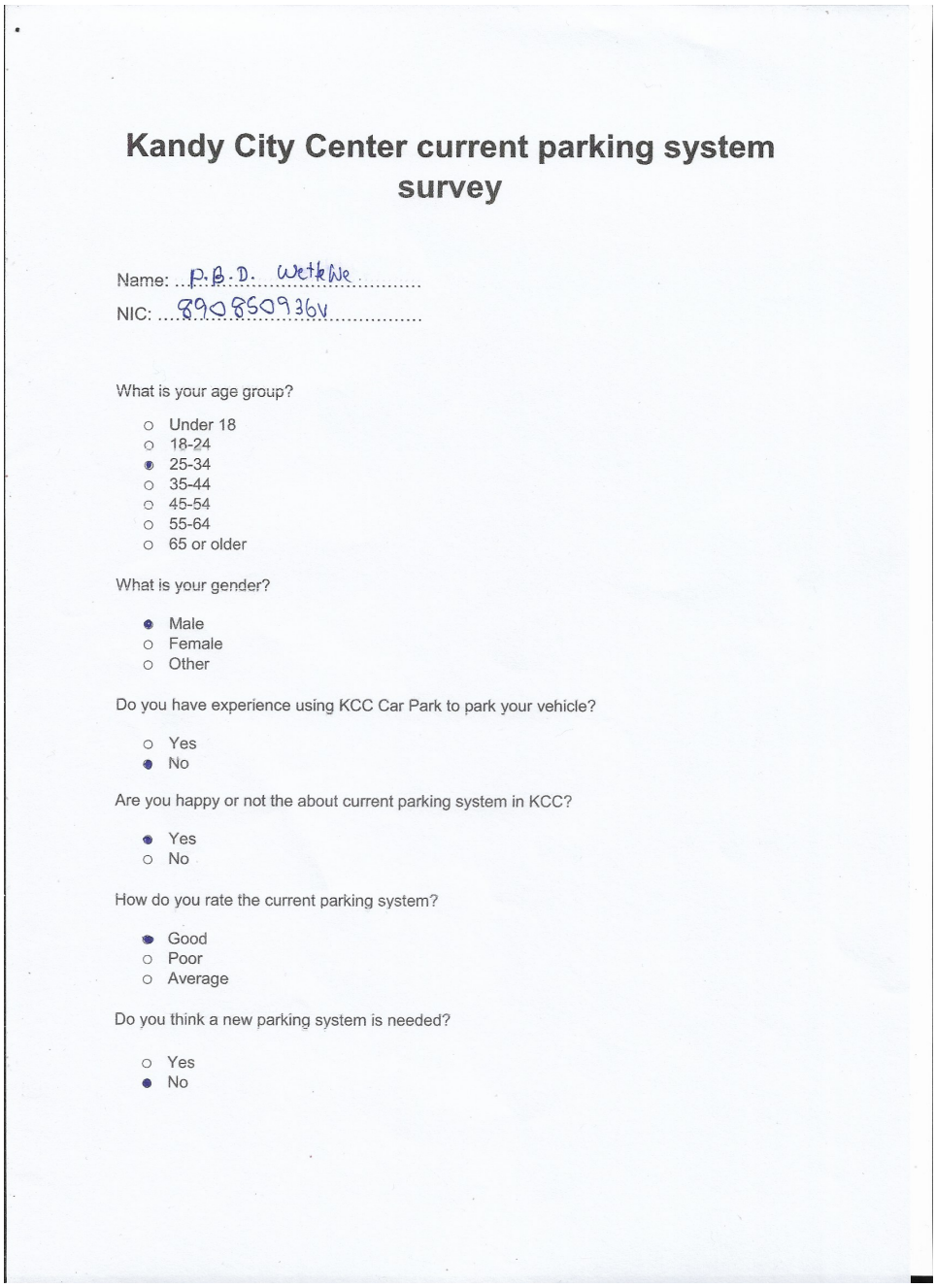
How do you rate the current parking system?

- ○ Good
- ○ Poor
- ○ Average

Do you think a new parking system is needed?

- ○ Yes
- ○ No

Figure A.2: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: P.B.D. Wetkine

NIC: 890850936V

What is your age group?

- ○ Under 18
- ○ 18-24
- ● 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65 or older

What is your gender?

- ● Male
- ○ Female
- ○ Other

Do you have experience using KCC Car Park to park your vehicle?

- ○ Yes
- ● No

Are you happy or not the about current parking system in KCC?

- ● Yes
- ○ No

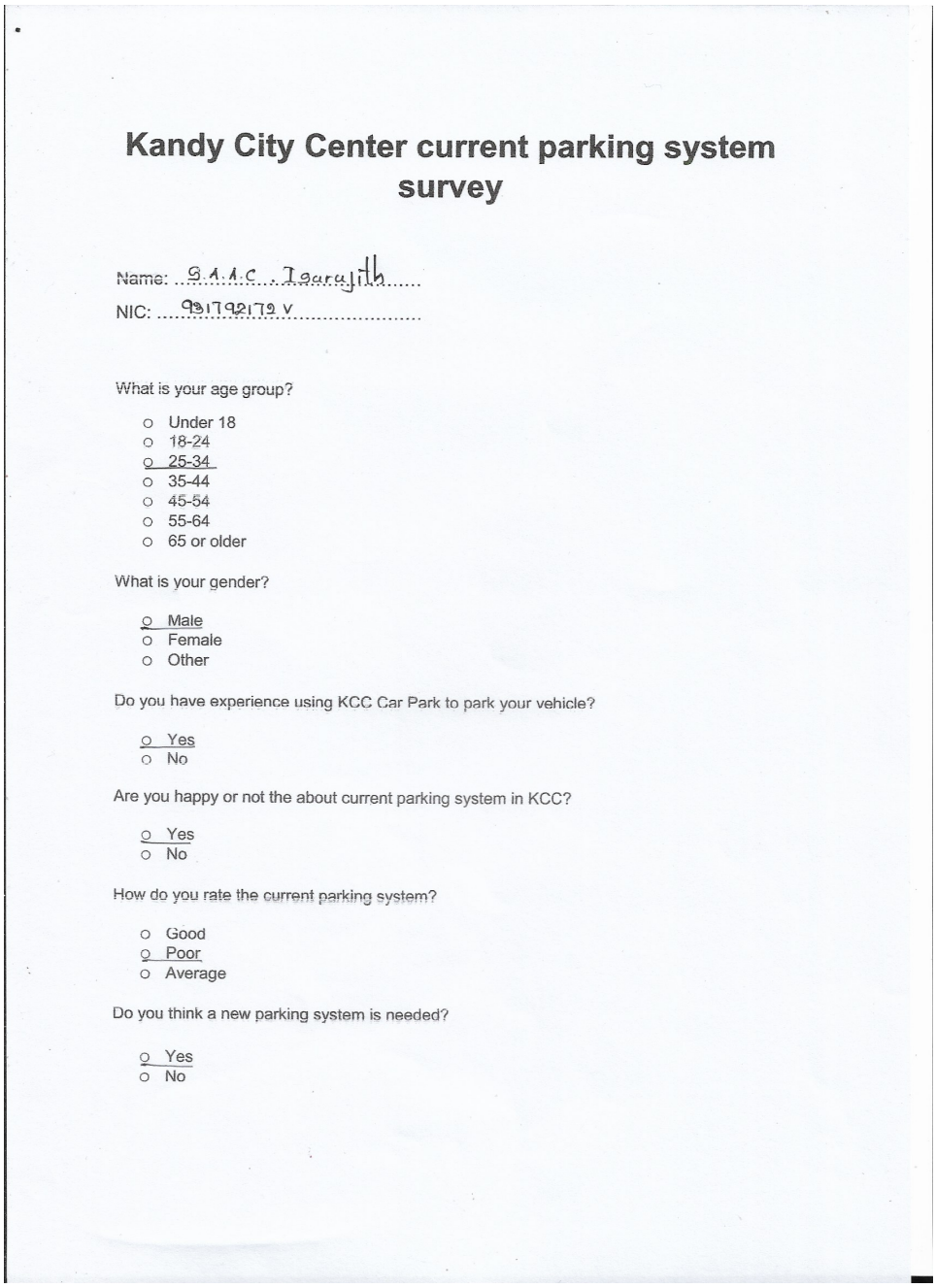
How do you rate the current parking system?

- ● Good
- ○ Poor
- ○ Average

Do you think a new parking system is needed?

- ○ Yes
- ● No

Figure A.3: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: S.A.A.C. Isaraji th

NIC: 931792172 V

What is your age group?

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or older

What is your gender?

- Male
- Female
- Other

Do you have experience using KCC Car Park to park your vehicle?

- Yes
- No

Are you happy or not the about current parking system in KCC?

- Yes
- No

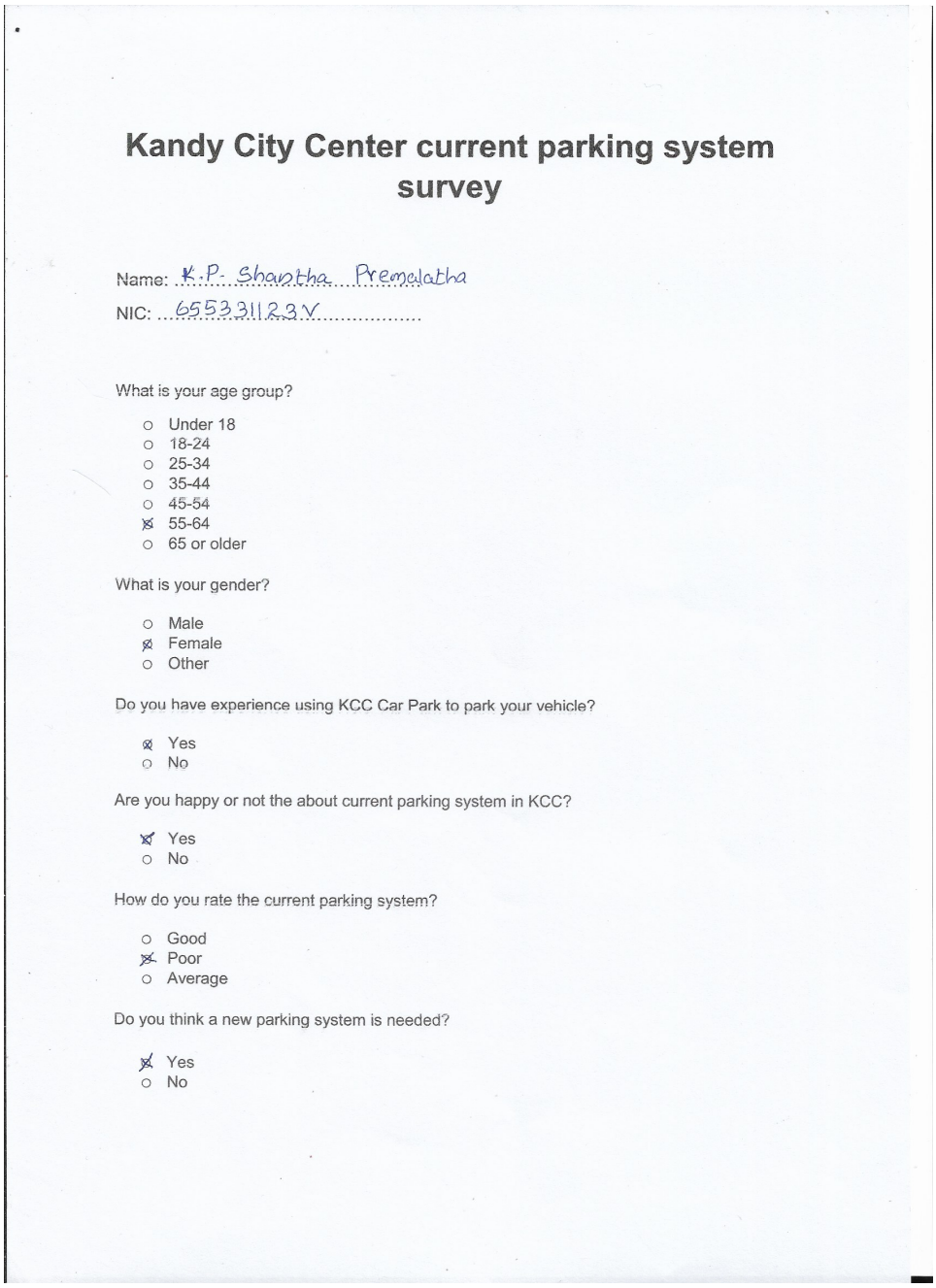
How do you rate the current parking system?

- Good
- Poor
- Average

Do you think a new parking system is needed?

- Yes
- No

Figure A.4: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: K.P. Shantha Premalatha

NIC: 655331123V

What is your age group?

- ○ Under 18
- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ☒ 55-64
- ○ 65 or older

What is your gender?

- ○ Male
- ☒ Female
- ○ Other

Do you have experience using KCC Car Park to park your vehicle?

- ☒ Yes
- ○ No

Are you happy or not the about current parking system in KCC?

- ☒ Yes
- ○ No

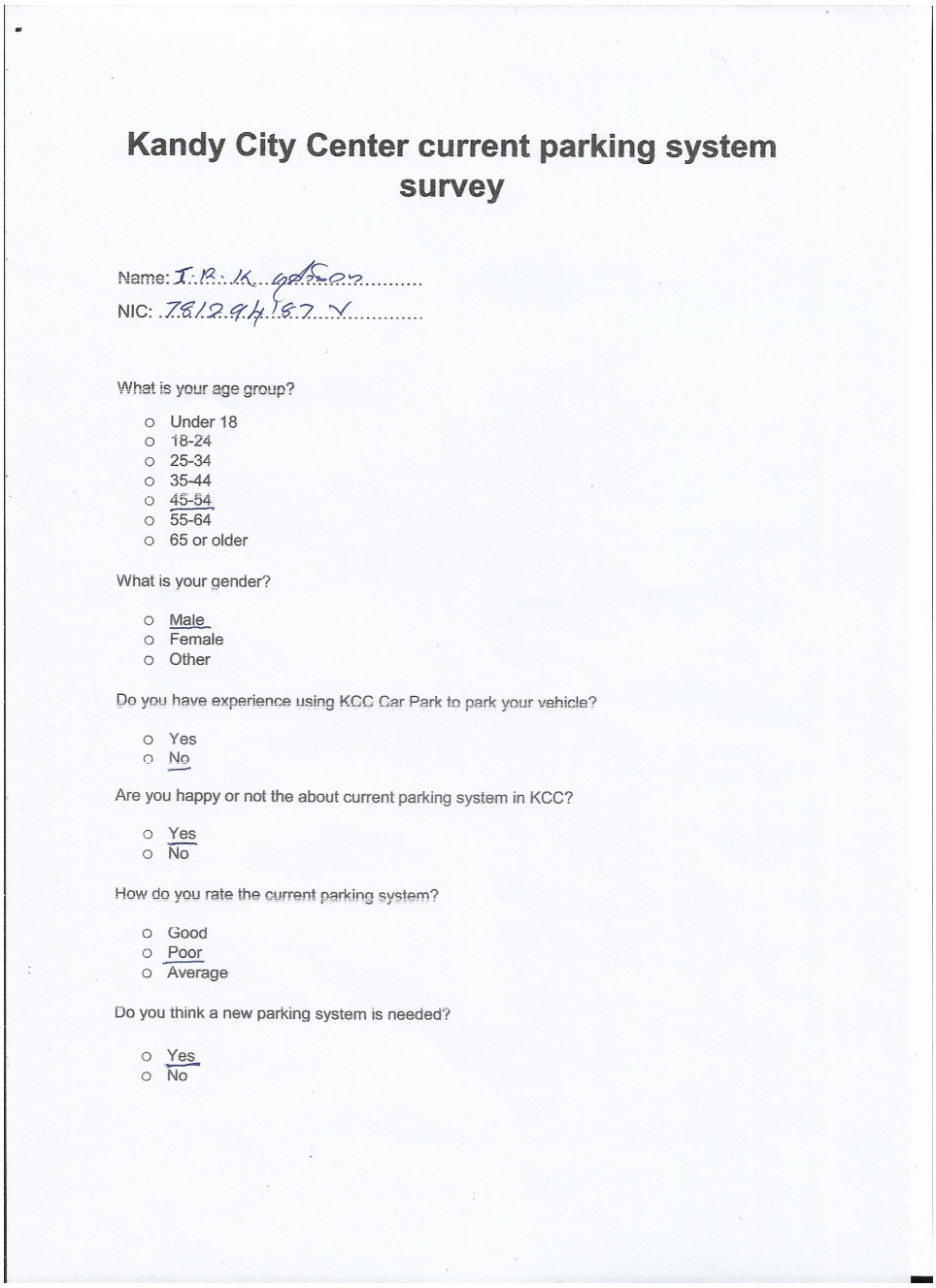
How do you rate the current parking system?

- ○ Good
- ☒ Poor
- ○ Average

Do you think a new parking system is needed?

- ☒ Yes
- ○ No

Figure A.5: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: I.R.K. ...

NIC: 781294187V

What is your age group?

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or older

What is your gender?

- Male
- Female
- Other

Do you have experience using KCC Car Park to park your vehicle?

- Yes
- No

Are you happy or not the about current parking system in KCC?

- Yes
- No

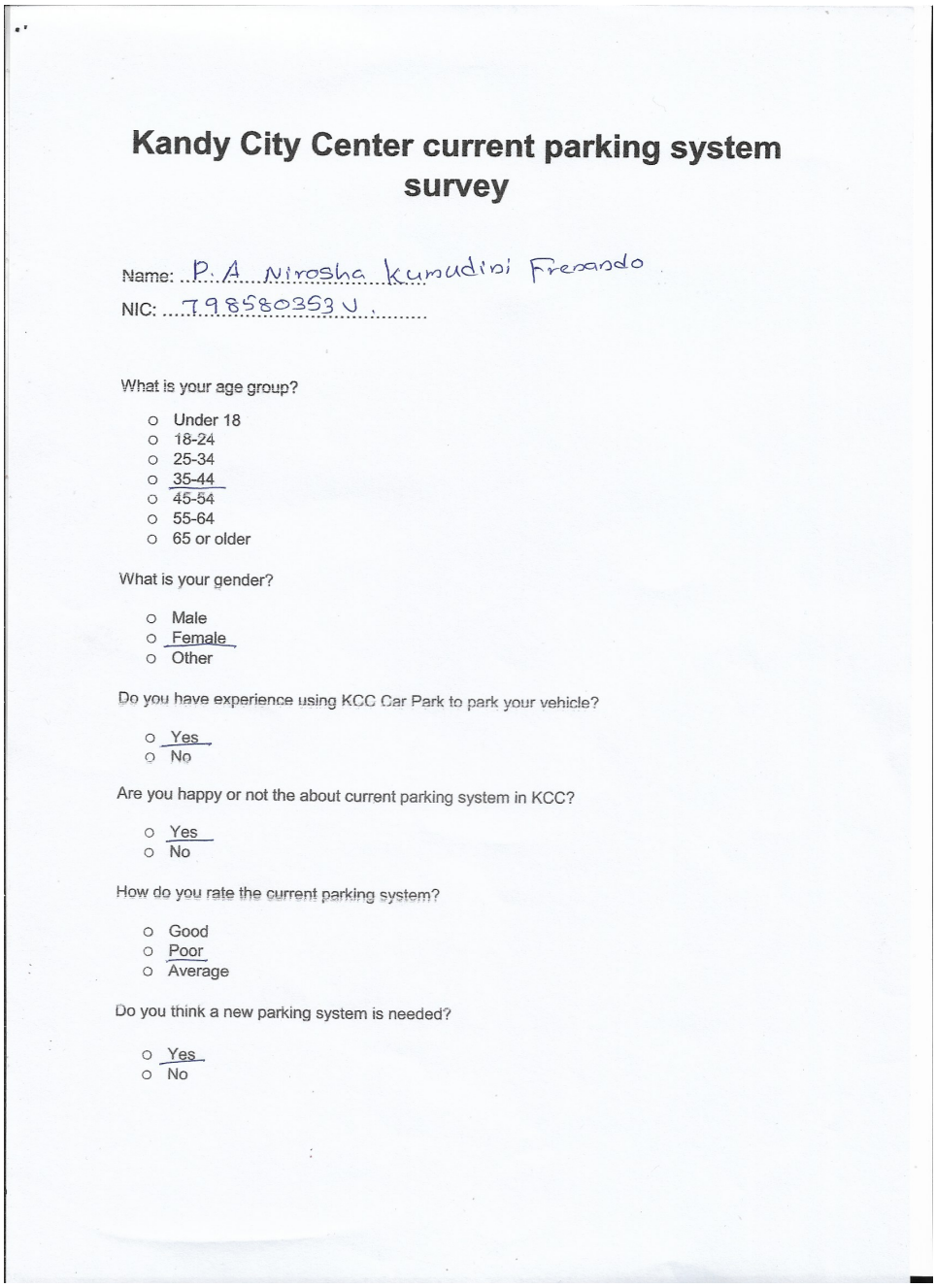
How do you rate the current parking system?

- Good
- Poor
- Average

Do you think a new parking system is needed?

- Yes
- No

Figure A.6: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: P.A Nirosha kumudini Fernando

NIC: 798580353V

What is your age group?

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or older

What is your gender?

- Male
- Female
- Other

Do you have experience using KCC Car Park to park your vehicle?

- Yes
- No

Are you happy or not the about current parking system in KCC?

- Yes
- No

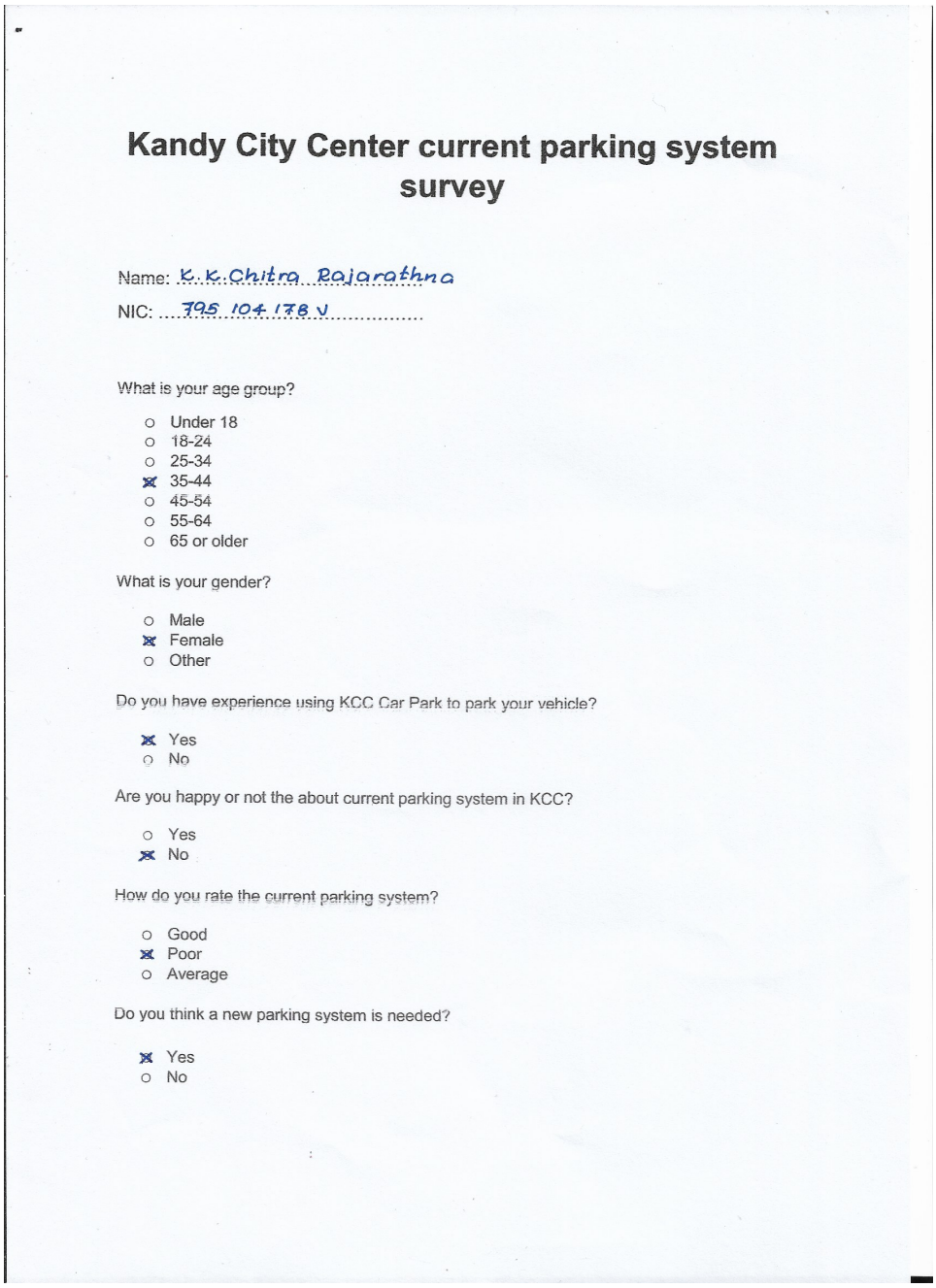
How do you rate the current parking system?

- Good
- Poor
- Average

Do you think a new parking system is needed?

- Yes
- No

Figure A.7: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: K.K.Chitra Rajarathna

NIC: 795 104 178 V

What is your age group?

- ○ Under 18
- ○ 18-24
- ○ 25-34
- ☒ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65 or older

What is your gender?

- ○ Male
- ☒ Female
- ○ Other

Do you have experience using KCC Car Park to park your vehicle?

- ☒ Yes
- ○ No

Are you happy or not the about current parking system in KCC?

- ○ Yes
- ☒ No

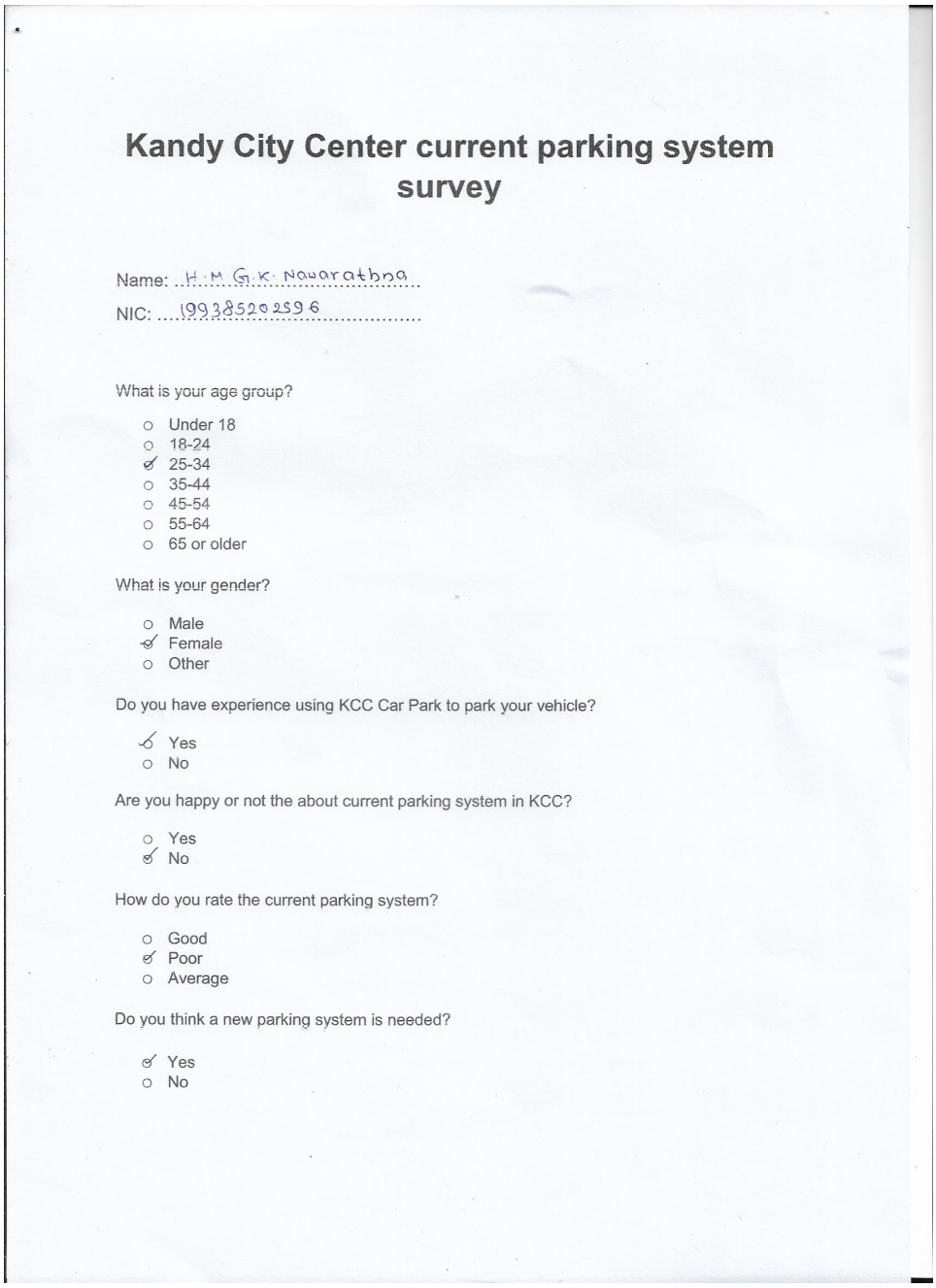
How do you rate the current parking system?

- ○ Good
- ☒ Poor
- ○ Average

Do you think a new parking system is needed?

- ☒ Yes
- ○ No

Figure A.8: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: ..H.M G.K. Nawarathna.....

NIC: ....199385202596.....

What is your age group?

- ○ Under 18
- ○ 18-24
- ✓ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65 or older

What is your gender?

- ○ Male
- ✓ Female
- ○ Other

Do you have experience using KCC Car Park to park your vehicle?

- ✓ Yes
- ○ No

Are you happy or not the about current parking system in KCC?

- ○ Yes
- ✓ No

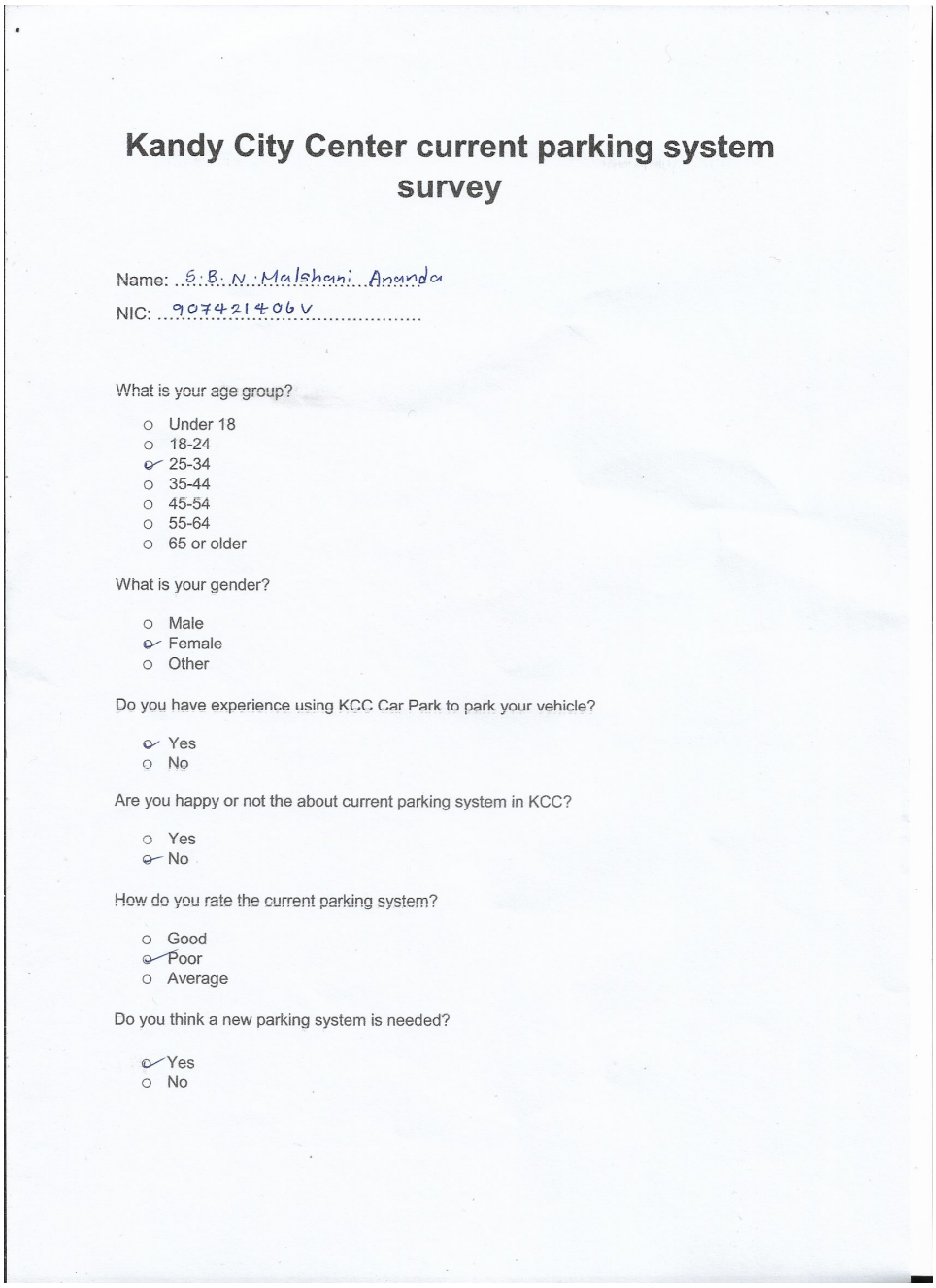
How do you rate the current parking system?

- ○ Good
- ✓ Poor
- ○ Average

Do you think a new parking system is needed?

- ✓ Yes
- ○ No

Figure A.9: Kandy City Center current parking system survey Documents



Kandy City Center current parking system survey

Name: G.B.N. Malshani Ananda

NIC: 907421406V

What is your age group?

- ○ Under 18
- ○ 18-24
- ✓ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65 or older

What is your gender?

- ○ Male
- ✓ Female
- ○ Other

Do you have experience using KCC Car Park to park your vehicle?

- ✓ Yes
- ○ No

Are you happy or not the about current parking system in KCC?

- ○ Yes
- ✓ No

How do you rate the current parking system?

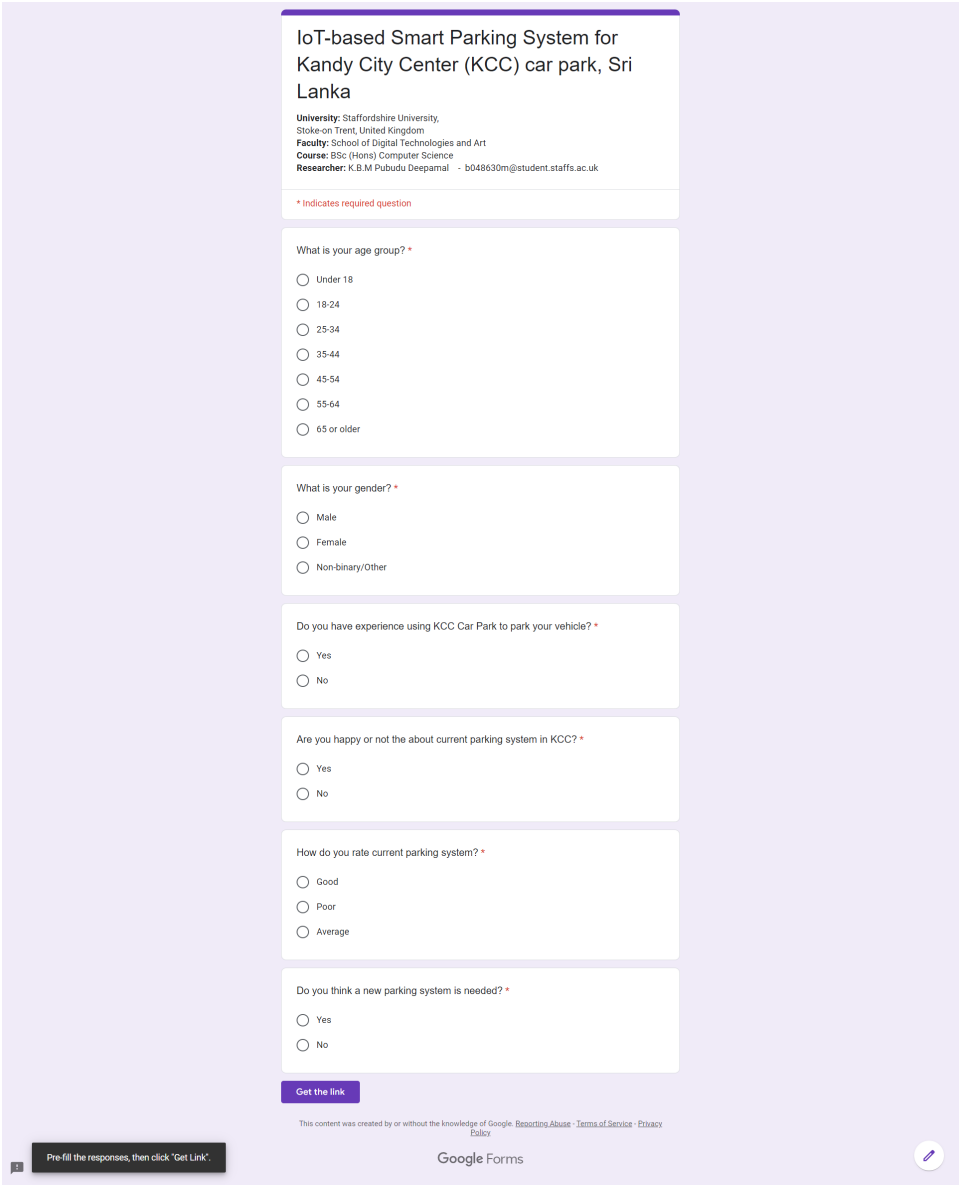
- ○ Good
- ✓ Poor
- ○ Average

Do you think a new parking system is needed?

- ✓ Yes
- ○ No

Figure A.10: Kandy City Center current parking system survey Documents

A.3 Kandy City Center current parking system survey Google Form



IoT-based Smart Parking System for Kandy City Center (KCC) car park, Sri Lanka

University: Staffordshire University,
Stoke-on Trent, United Kingdom
Faculty: School of Digital Technologies and Art
Course: BSc (Hons) Computer Science
Researcher: K.B.M Pubudu Deepamal - b0486630m@student.staffs.ac.uk

* Indicates required question

What is your age group? *
- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or older

What is your gender? *
- Male
- Female
- Non-binary/Other

Do you have experience using KCC Car Park to park your vehicle? *
- Yes
- No

Are you happy or not the about current parking system in KCC? *
- Yes
- No

How do you rate current parking system? *
- Good
- Poor
- Average

Do you think a new parking system is needed? *
- Yes
- No

Get the link

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Google Forms

Pre-fill the responses, then click "Get Link".

Figure A.11: Kandy City Center current parking system survey Google Form

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