DEVELOPMENT OF SMART PARKING SYSTEM USING MICROCONTROLLER

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours

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To my beloved mother, NUR RIANI, and father, ANUAR,

and

To my loving family

ABSTRACT

The development of a smart parking system integrating microcontroller technology, parking space sensors, and a parking guidance system marks a significant leap forward in urban infrastructure management. This abstract provides an overview of the key components and objectives of such a system. At its core, the system employs a microcontroller unit, serving as the central processing hub, to coordinate inputs from parking space sensors distributed throughout the parking facility. Parking space availability can be accurately monitored thanks to these sensors, which are strategically positioned at each individual space to detect occupancy status in real time. By using an intuitive interface, this system's main goal is to minimise traffic and enable efficient parking space allocation by giving drivers up-to-date information on available spots. Furthermore, the system includes a parking guidance system that helps drivers find available parking spots by providing navigational assistance. Through the integration of these components, the smart parking system maximises the use of parking spaces, improves user convenience, and minimises the amount of fuel and unnecessary driving that contributes to environmental impact. Additionally, the system gives parking facility managers insights into demand trends and parking usage patterns, allowing for more efficient management of parking resources. In conclusion, a major advancement in urban parking management has been made with the creation of a smart parking system that makes use of microcontroller technology, parking space sensors, and a parking guidance system. This system promises advantages for both drivers and parking facility operators.

ABSTRAK

Pembangunan sistem tempat letak kereta pintar yang menggabungkan teknologi mikropemacu, sensor tempat letak kereta, dan sistem panduan tempat letak kereta merupakan satu lonjakan penting dalam pengurusan infrastruktur bandar. Abstrak ini memberikan gambaran keseluruhan mengenai komponen utama dan objektif sistem tersebut. Pada intinya, sistem menggunakan unit mikropemacu sebagai pusat pemprosesan utama, untuk mengkoordinasikan input daripada sensor tempat letak kereta yang tersebar di seluruh fasiliti tempat letak kereta. Sensor ini, diletakkan secara strategik di tempat letak kereta individu, dapat mengesan status kepenuhan secara langsung, membolehkan pemantauan yang tepat terhadap ketersediaan tempat letak kereta. Objektif utama sistem ini adalah untuk menyediakan maklumat kepada pemandu secara tepat pada masanya mengenai tempat letak kereta yang tersedia melalui antara muka yang mesra pengguna, memudahkan pengagihan tempat letak kereta yang cekap dan mengurangkan kesesakan. Selain itu, sistem ini juga menyertakan sistem panduan tempat letak kereta yang menawarkan bantuan navigasi kepada pemandu, mengarahkan mereka ke tempat letak kereta yang terdekat yang tersedia. Dengan menggabungkan komponen ini, sistem tempat letak kereta pintar mengoptimumkan penggunaan tempat letak kereta, meningkatkan keselesaan pengguna, dan mengurangkan kesan alam sekitar dengan mengurangkan pemanduan yang tidak perlu dan penggunaan bahan api. Selain itu, sistem membolehkan operator fasiliti tempat letak kereta untuk mendapatkan maklumat mengenai corak penggunaan tempat letak kereta dan trend permintaan, memudahkan pengurusan sumber tempat letak kereta yang lebih berkesan. Kesimpulannya, pembangunan sistem tempat letak kereta pintar yang menggunakan teknologi mikropemacu, sensor tempat letak kereta, dan sistem panduan tempat letak kereta merupakan satu lonjakan penting dalam pengurusan tempat letak kereta bandar, menjanjikan faedah kepada pemandu dan operator fasiliti tempat letak kereta.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Currently, the majority of current car parks lack a systematic approach. The majority of them are manually handled and rather inefficient. The most common issue in the car park is wasting time looking for available parking places [1]. Users will keep going around the parking lot until they come across a vacant space. The creative smart parking system is an example of a concept that makes use of sensors and real-time data to efficiently manage parking spots. We no longer must waste time and petrol circling around in search of a sport. This state-of-the-art method does not save time. simultaneously promotes a more environmentally conscious and sustainable environment and reduces stress. Sensors are used by the parking system's operating mechanism to ascertain whether parking spaces are available. To determine whether a space is occupied or empty, these sensors are placed strategically along roadsides and in parking lots. Driver updates are produced by processing the data that these sensors have gathered and sending to a server. Vehicles can now easily and efficiently find parking spot thanks to this. Maximising the use of parking spaces is one of the parking system's primary features. The system ensures optimal use of each parking space by providing information about available spots. This does not reduce congestion. Improves income generating for parking lot operators. Furthermore, this innovative method can help to reduce carbon emissions by lowering the time spent looking for parking, therefore alleviating traffic congestion. With this breakthrough technology, the days of continuous seeking and frustration are over. The future of parking has arrived, and it is smarter than ever before. There is no less traffic as a result. Helps parking lot operators generate more revenue. By reducing the amount of time spent searching for parking and thereby easing traffic congestion, this creative approach can also help to lower carbon emissions. The days of constant searching and frustration are over thanks to this ground-breaking invention. Parking has entered a new era, one that is more intelligent than ever.

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1.2 Problem Statement

The goal of smart parking systems is to solve the problem of finding a place to park in big cities. As population of the city grows the number of cars on the road continue to rise, the demand for parking spaces will exceed the supply. Automobiles reverse to locate available spaces, causing frustration, lost time, and increased traffic. Manual labour is a labour-intensive and frequently inefficient method used in conventional parking systems, such as ticket machines and parking attendants. Due to the lack of real-time information regarding available parking spaces, these technologies make it challenging for drivers to plan ahead for parking. Drivers are also left to locate parking spaces on their own or with their own knowledge because these systems don't offer direction or assistance. With the help of smart parking systems, which improve the parking experience through technology, these problems can be fixed. To track and manage parking spaces, this system makes use of sensors and a parking guidance system. These sensors are present in every parking space and are designed to detect the presence of vehicles before communicating that information to a central computer. Parking guidance systems can utilise this data to give drivers real-time updates on available spaces and direction to the nearest accessible space via digital sign.

1.3 Project Objective

The objective of the project is:

a) To develop parking sensors and microcontrollers to precisely monitor and control parking spots in real time.

b) To create a parking guidance system that directs drivers to the closest available spot, thereby reducing the amount of they spend searching for a spot

c) To detect sensor at entry and exit points to count and display the number of vehicles entering and exiting parking.

1.4 Scope of Project

The scope of a smart parking system project can vary depending on the specific goals and requirements of the project. However, a typical project might include the following:

1. Design and Prototype: Design the smart parking system prototype and test the functionality and usability of the dispenser.
2. Implementation of Parking sensors and Microcontrollers: Using parking sensor and microcontroller to create smart parking system that can monitor and manage parking space.
3. Development of a Parking Guidance system: develop a parking guidance system that direct drivers to the nearest available parking spot. This system aims to reduce time drivers to spend searching parking area.
4. Testing and Optimization: Conduct rigorous testing to validate the system’s functionality, reliability, and security under various conditions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

One significant advancement in addressing urban traffic issues is the introduction of smart parking systems. These systems' primary objectives are to ease traffic congestion, cut down on the amount of time drivers spend looking for parking, and minimise needless traffic movements that pollute the environment and contribute to traffic jams. The majority of parking systems in use today are manual and ineffective, frequently underusing available spaces and escalating motorist annoyance. Shoup (2005) asserts that the scarcity of free parking makes city living challenging, citing research indicating that cars seeking parking account for 30% of city traffic [1]. Not only is it a waste of time to search for a spot like this, but the city's environmental issues are exacerbated by the increased emissions and excessive fuel use. To maximise the usage of parking spaces, smart parking systems make use of cutting-edge technologies including sensors, microcontrollers, and real-time data processing. Usually, the vehicle's presence is detected using ultrasonic and infrared sensors; microcontrollers evaluate this data to provide real-time updates on parking availability. These systems, which reduce search times and improve traffic flow, have traffic guiding features like LED displays or smartphone apps, according to Van Ommeren, Wentink and Rietveld (2012) [2]. Further advantages of smart parking system include better urban planning and management. By obtaining and analysing data on traffic usage patterns, city planners can make well informed decisions about infrastructure development and traffic management. Smart Parking system not only save money and the environment, but they can also save city drivers up to 17 hours a year that they would otherwise spend hunting for a spot [3].

2.2 Study On Parking Duration and Demands

Parking time and demand analysis are critical for understanding urban traffic dynamics and optimising parking infrastructure. By analysing parking session durations and corresponding demand patterns, city planners and decision-makers can inform decision about parking sessions, pricing strategies and the development of alternative mobility options [21]. This study typically collects parking time data, such as how long vehicles remain in specific spaces and forecasts the total demand for parking spaces on a given day or week [21]. One section of the study focuses on determining peak hours when sparking spaces are in high demand [21]. Comprehending peak hours facilitates planners and guarantee sufficient parking spaces during periods of peak demand. In addition, the examination of parking durations provides insights into driver behaviour, including inclination toward particular parking spots and the variables influencing their parking choices. In addition, a variety of factors, such as traffic patterns, economic conditions, land use patterns and geographical features may have an impact on the length and demand for parking. Because business operation and land use differ from residential areas, commercial districts might require different parking arrangements. In a similar vein, the availability of public transportation may affect demand for parking because individual maty favour easily accessible alternative forms of transportation [22]. Studies on parking length and rules generally aid in the creation of more sustainable and effective urban transportation system. Communities can create policies and initiatives that encourage alternative mode of transportation, reduce traffic congestion and maximise the use of parking system by having a thorough understanding of the factors that influence parking behaviour and demand [22].

2.3 Overview of Parking Guidance Systems and Parking Space Sensors

Sensors and parking guidance systems are essential components of contemporary parking management technology. Parking guidance system cut down on both traffic congestion and the amount of time drivers must spend searching for ap spot by giving them access to real-time information about parking availability. Using smartphone apps or digital signs, these systems effectively direct vehicles to open parking spaces. Parking sensors are the primary source of information used by parking guidance systems to determine whether a spot is occupied. Many types of sensors are employed, such as camera-based systems, infrared, and ultrasonic ones. Ultrasonic sensors generate sound waves and time it takes for the echo to return in order to detect the presence of a vehicle. Infrared sensors detect cars by generating infrared light and monitoring any reflection. Camera-based systems collect visual data, which is processed to ascertain the precise number of individuals occupying parking spaces. Since these technologies were combined, parking systems have significantly improved. Reduces time spent hunting for parking benefits drivers by saving time and lowering emissions and fuel consumption. Additionally, better parking management is achieved through the optimised use of parking spaces, which increases process efficiency and user friendliness. The adoption smart parking options is becoming more and more crucial for the sustainable growth of cities as they expand.

2.4 A Sample Project Smart Parking System by Using Microcontroller

Smart Car Parking System, a collaborative effort led by Z. I. M. Yusni, K. N. Rajah, J. K. Milton Johnny, A. F. A. Fakaruddeen, K. H. Yusof, and F. Aman represents an innovative solution to urban parking problems. The main goal of this system is to improve parking problems and it combines cutting-edge technology to improve efficiency and ease of use. At its core is an Arduino Uno microcontroller that monitors inputs from various sensors to provide real-time updates on parking availability. The key role is played by the infrared sensors placed in each parking space, which quickly detect the presence of the vehicle and transmit the operational status to the central unit. This information is carefully processed and stored in a central database that facilitates instant updates of available and reserved parking spaces via an LCD screen. In addition, servo motors operate barrier gates at the entrance, ensuring seamless access based on real-time space availability. The user interface, equipped with information screens, provides drivers with useful information that reduces the time spent looking for a parking space and reduces traffic congestion. Published in the Borneo Engineering and Advanced Multidisciplinary International Journal (BEAM) in 2022, the project highlights the transformative potential of microcontroller technology in modernizing parking management. Combining innovation with practicality, this system ushers in a new era of urban parking solutions, promising greater efficiency, lower environmental impact and greater user satisfaction.

Figure 2.1Circuit Diagram[7]

From the figure, the input of this system is cars going into the car park, and the output of this system is LCD displaying the words and the LEDs. The component consists in this project are Arduino Uno, IR sensor, LCD and servo motor[7].

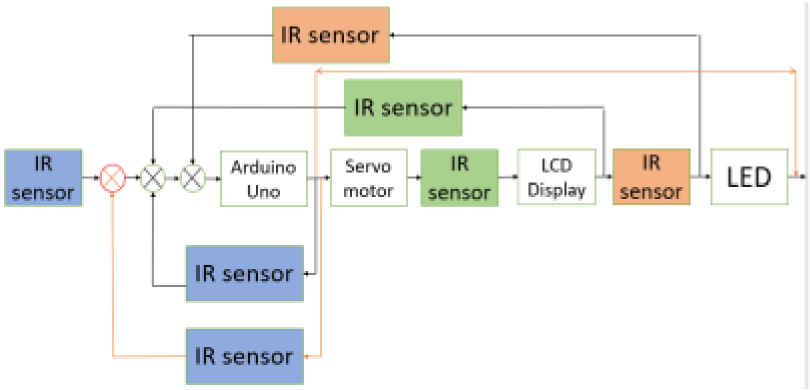


Figure 2.2Block Diagram[7]

Based on the block diagram above, the blue colour boxes and green colour boxes IR sensors are installed at the bar gate. While the red colour boxes IR sensor is installed in the parking space. A blue colour line is, represents the process when the parking lot is full [7].

2.5 A Sample Project of Android Smart Parking mobile application

The main goal of designing and implementing the Android Smart Parking mobile application is to provide users with a smooth and efficient way to find and reserve parking spaces in urban areas. This application attempts to address typical parking congestion issues by leveraging mobile technologies to optimise parking space utilisation and improve user experience. The primary function of the Android Smart Parking mobile app is to deliver real-time information on available parking spaces in approved places. Thanks to the integration of IoT sensors and parking management systems, the application receives information about parking space availability and displays it to users in a simple and friendly interface. Users can simply search for parking spots depending on their present location or destination, examine specific information like parking costs and time limits, and reserve parking spaces ahead of time. Furthermore, the programme contains elements that simplify the parking procedure, such as navigation directions to the next free parking space, mobile payment choices for quick and easy transactions, and notifications/alerts about parking expiration or changing availability status. Users can also use past data and analytics to track their parking history, expenditure, and usage habits to help them plan and make better decisions. Additionally, customers can communicate with customer service representatives report parking violations or issues and send comments to parking lot operators with ease thanks to the Android Smart Parking mobile application. This two-way communication system ensures that parking issues are resolved quicky and increase user participation [12].

Figure 2.3Mobile app Diagram [12]

2.6 A Sample Project of Smart Parking Using Internet of Things (IoT)

Using Internet of Things (IoT) technologies to reduce urban parking congestion, the articles describe an IoT-based smart parking system that aims to revolutionise traditional parking management [16] The main objective of this project is to provide a comprehensive solution that uses real-time monitoring and management of parking spaces to improve user experience, reduce traffic jam and increase parking efficiency. In order to determines whether a parking space is occupied, an IoT-based smart parking system deploys IoT sensors to each one. Parking availability can be tracked in real time thanks to these sensors wireless communication with a central system. A user-Friendly mobile app or web interface provides driver with up-to-date information about parking spaces nearby, empowering them to make informed decisions and maximise parking resources [16]. To further enhance the parking experience and boost customer comfort, the system offers features like parking reservations, navigation instruction for available parking spaces, and mobile payment options. Parking lot managers and local government representative can also benefit from system since it offers crucial information on demand trends, and parking usage pattern, analysing data produces by Internet of Things devices allows users to improve the effectiveness of parking management. Technology additionally makes proactive parking infrastructure maintenance and monitoring possible, which reduces operating expenses and boosts service dependability. All things considered, an Internet of Things (IoT)-based smart parking system is a major advancement in parking technology and provides a scalable and effective answer to urban parking issues. Utilizing IoT technology, this system not only improves the parking experience of drivers, but also contributes to the development of a smarter and more sustainable urban environment [16].

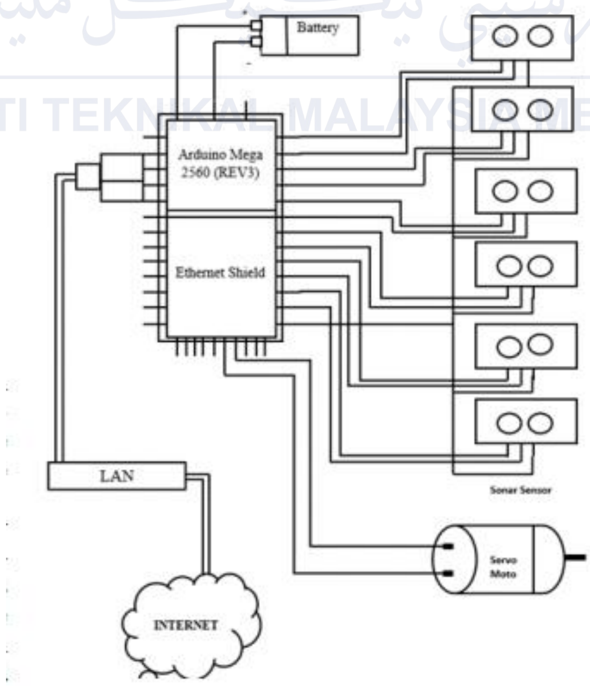


Figure 2.4Circuit Diagram Parking Lot [16]

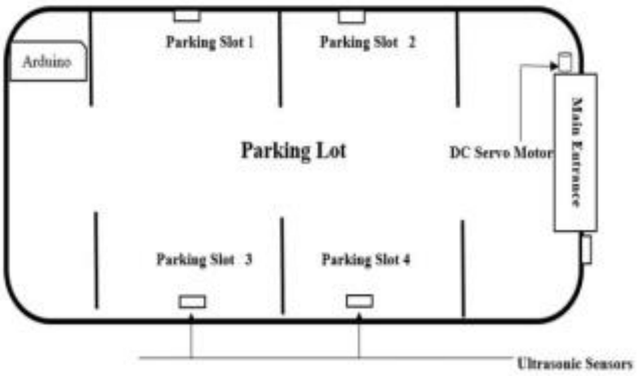


Figure 2.5Block Diagram Parking Lot [16]

2.7 Comparison of Sample projects that related with project

Table 2.1 Comparison of the sample projects.

Article Title and Author	Main Component	Method	Advantages	Disadvantages
"Development of A Smart Car Parking System by Using Arduino Uno" Yusni, Z. I. M., Rajah, K. N., Milton Johnny, J. K., Fakaruddeen, A. F. A., Yusof, K. H., Aman, F.	Arduino Uno microcontroller, infrared sensors, LCD screen, and servo motors.	Infrared sensors detect the presence of a vehicle and update the LCD screen to show available and reserved parking spaces. Servo motors drive the barrier gates.	This system provides real-time updates on parking availability, reducing time spent searching for parking spaces and reducing traffic congestion.	The accuracy of the system depends on the correct operation of the sensors, which may require regular maintenance.
Alkhuraiji, Samar. *"Design and Implementation of an Android Smart Parking Mobile"*	Mobile application integrated with IoT sensors and parking management systems	The app provides real-time information about parking availability, allowing users to search, view information, book spaces, navigate to parking spaces, make mobile payments and receive notifications.	Improve the user experience by offering a wide range of features such as reservations and mobile payments.	Users must have smartphones on which the application is installed, which may limit its usability.
Rahman, Saidur and Bhoumik, Poly. *"IoT Based Smart Parking System "*	IoT sensors, centralized system, and user-friendly mobile/web interface.	Internet of Things sensors are installed in the parking spaces that detect presence and communicate wirelessly with a centralized system.	Offers complete solutions for parking management, including real-time tracking, reservation and mobile payments.	Implementation and maintenance costs can be high due to the widespread use of IoT sensors and the need for a reliable wireless network.

2.8 Summary

These previous projects focused on new ways to transform urban traffic management. Smart parking systems use microcontroller technology that integrates sensors to detect vehicle presence and provide real-time updates on the availability of parking spaces. Coordinated by a central processing unit such as the Arduino Uno, the system reduces search times and optimizes the use of space, improving the efficiency and flexibility of the user. In an effort, Smart Parking Android mobile app uses the power of smart technology to provide users with the best parking solutions. The integration of GPS and IoT allows drivers to find, reserve and pay for parking spaces, simplifying the parking process, and reducing traffic congestion. Finally, smart parking projects using Internet of Things (IoT) technology will introduce dynamic traffic management through the deployment of sensors. IoT servers monitor space availability in real-time, and real-time systems can provide users with information about traffic availability. Optimize space allocation and improve user experience by managing navigation instructions and phone costs. These prototypes demonstrate various technological applications to solve urban traffic problems and create smarter, more efficient and sustainable urban environments.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology refers to the systematic, theoretical analysis of methods applied in a research field. It includes the principles and procedures that guide the research and development processes. Essentially, methodology describes how research is conducted and details the strategies, tools, and techniques used to collect and analyze data. It acts as a blueprint for the researchers and ensures that the research is structured, consistent and repeatable. A well-defined methodology is crucial because it provides a clear road map for research that allows others to follow and understand the steps taken to reach conclusions. This includes selection of appropriate tools and techniques, design of experiments or studies, methods of data collection and data analysis. The methodology would explain how to choose and install sensors, how to programme a microcontroller to process data, and how to show users real-time information in the context of design project like the create of smart parking system. Methodology encompasses not only the technique s employed but also rationale behind their applicability to research. This guarantees the validity and reliability of the research findings as well its foundation in logical, repeatable procedures. The methodology enhances the scientific rigour and credibility of research by a systematic approach, thereby making it a crucial component of any scientific or technical undertaking.

3.2 Methodology

Creating a smart parking system requires a methodical approach that integrates different hardware and software elements to guarantee a seamless, effective and user-friendly parking experience. An Arduino Mega microcontroller server as the main process unit of the system a. In order to detect vehicles, infrared sensors a first installed in each parking lot. The Arduino Mega receives the data from these sensors and processes it in real time. Drivers can view the most up-to-date information about available spaces on an LCD screen at the parking lot entrance once the data has been processed. Servomotors, which are automated based on operational data received, are another means of operating the gates. If parking is available, the gate opens to allow entry; otherwise, it remains closed. Combining these components enables the system to more accurately and efficiently regulate the availability of parking spots, reducing driver search times and enhancing the overall parking experience. In order to create a dependable and scalable smart parking system, this method focuses on automatic control, user interaction, and real-time data processing.

3.3 Elaboration of Process Flow

3.3.1 Flowchart

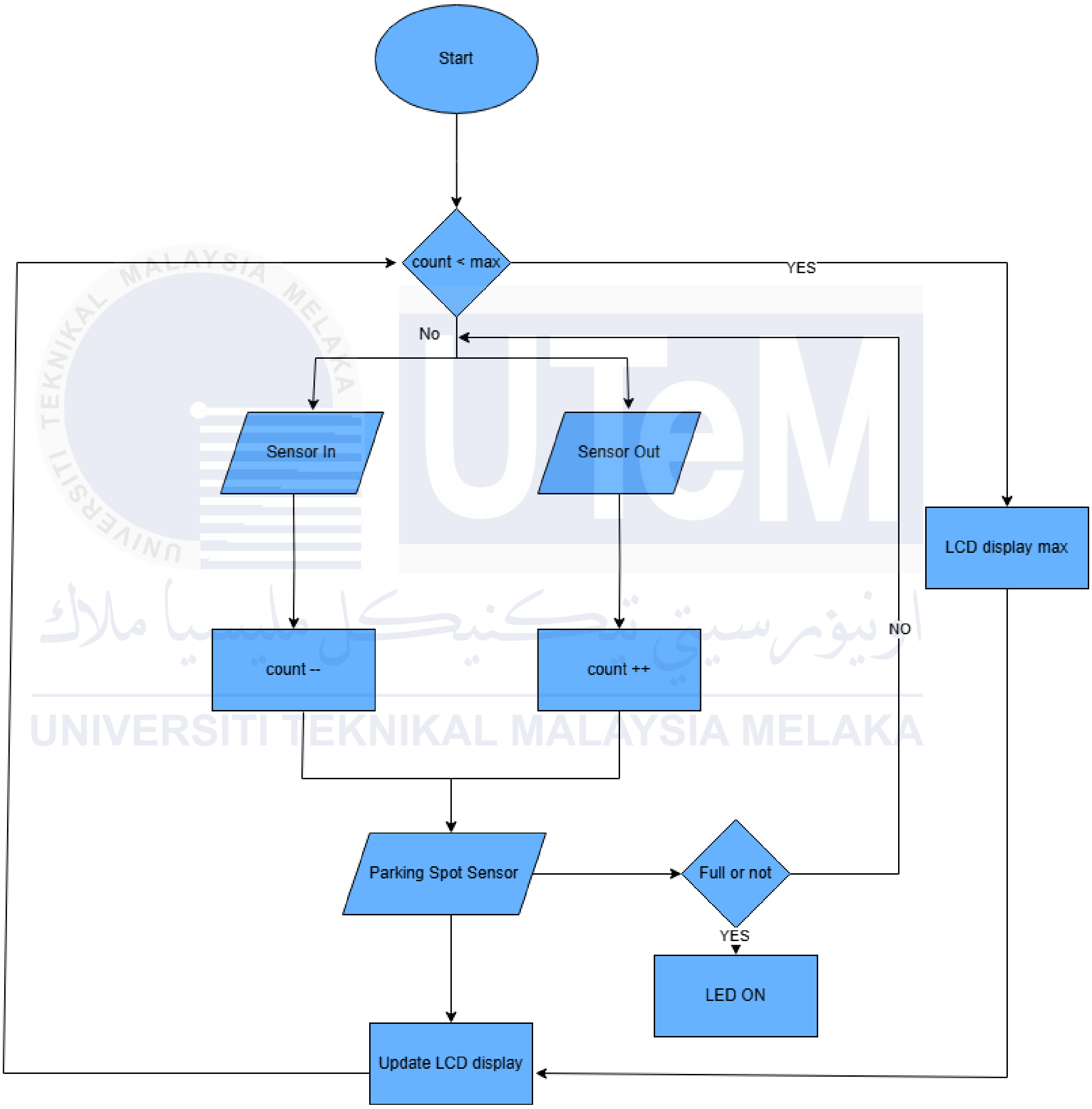


Figure 3.1Flowchart Smart Parking System

3.3.2 Block Diagram

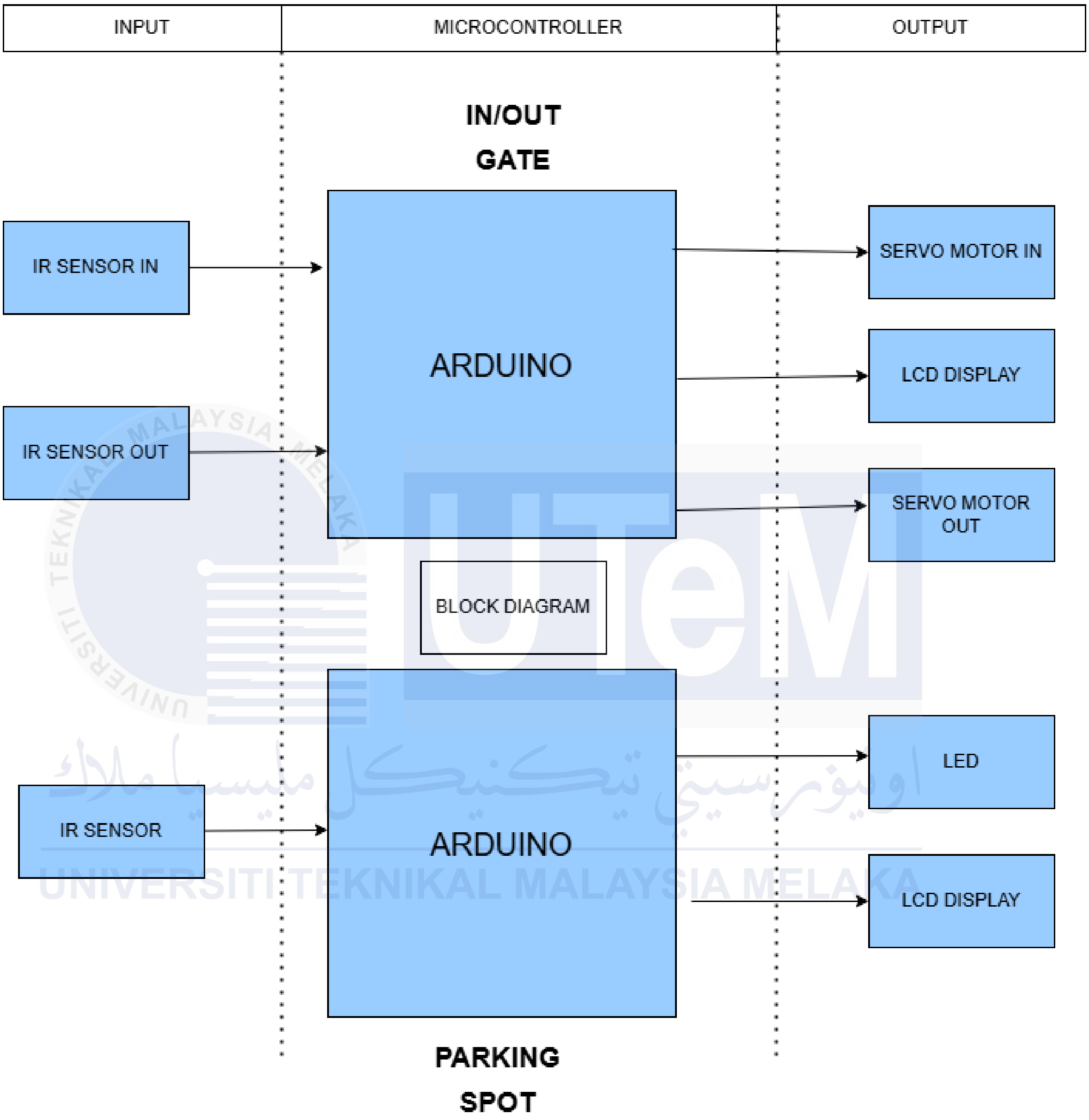


Figure 3.2Block diagram Smart Parking System

The In and Out Gate and the parking spot are the two main parts make up the block diagram of the smart parking system. An Arduino microcontroller serves as the primary processing unit in each part.

In/Out Gate:

Vehicle entrance and exit are manged by In/Out Gate. It detects the presence of vehicles at the gate using two infrared sensors, designated IR Sensor IN and IR Sensor OUT. AN Alert sent is to the Arduino by the ‘IR Sensor IN’ when the cars get close. The Arduino opens the gate to let the car in if there are parking spots available by turning on the Servo Motor In function. The status of available will be displayed on the LCD by Arduino simultaneously. The Servo Motor Out opens the exit gate when IR Senor Out detects vehicle leaving and sends a signal to the Arduino.

Parking Spot:

An infrared sensor controls each parking lot by determining whether the area is occupied. The Arduino receive the data from this sensor, process it, and then turns on LED indicator. The Arduino makes sure that the corresponding LED Illuminates to show that a parking space is reserved. However, LED won’t turn on if the parking lot are available. When combined, these parts form an effective system that controls entry and exit gates and manages parking availability in real time, optimising and reducing time for the driver to search parking.

3.3.3 Block Diagram Parking lot

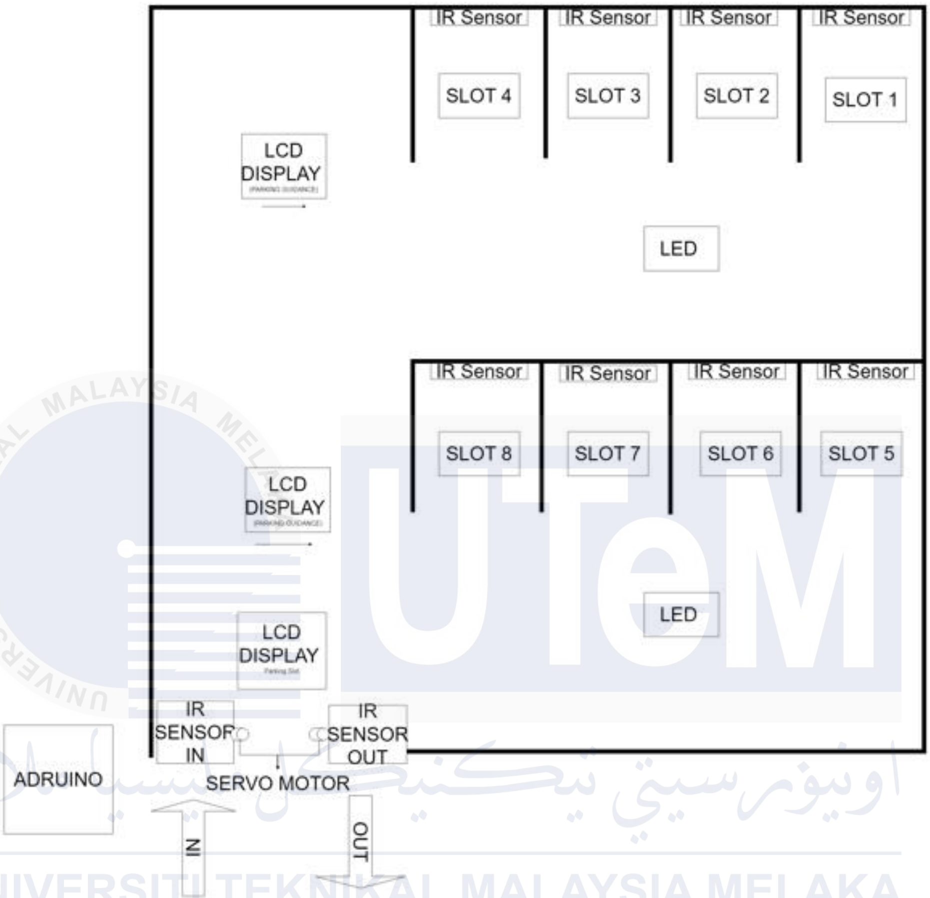


Figure 3.3Parking lot of Block diagram

3.4 Hardware and Software

3.4.1 Hardware Equipment

Table 3.1 Bill of Material (BoM)

NO	ITEM	DESCRIPTION	QUANTITY	COST/ITEM	COST
1	Arduino Mega R3	Uno Compatible (CH340) with USB Cable, ATmega2560	1	RM78.00	RM78.00
2	IR Sensor	Adjustable IR Infrared Range Finder Obstacles Avoid Distance Digital Sensor Module	15	RM1.90	RM28.50
3	Servo Motor	SG90 Micro Servo	2	RM6.50	RM13.00
4	Jumper	Female to Male (FM) 40pcs Dupont Jumper Wire DIY Experiment Breadboard Rainbow Cable 40p 10cm 20cm 30cm for Arduino	3	RM2.00	RM6.00
5	LCD	16x2 Character LCD, I2C Address: 0x27 Backlight (White character on blue background), enable or disable by a mini jumper at the back of the LCD	3	RM12.00	RM36.00
6	LED	LED LEDs 3MM 5MM Light Emitting Diode Bulb	2	RM1.00	RM2.00
				TOTAL COST	**RM163.50**

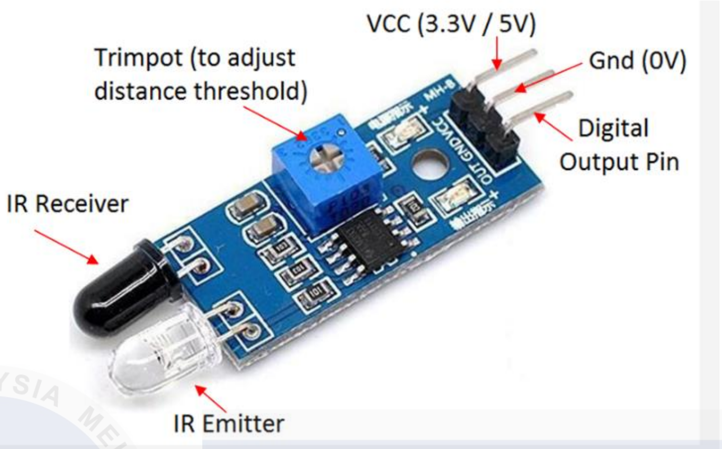
3.4.2 Arduino Mega

Figure 3.4Arduino Mega

For projects requiring a lot of processing power and connectivity, The Arduino Mega is a potent microcontroller board. It features an ATmega2560 microcontroller, sixteen analogue inputs, an astounding 54 digital I/o pins, and a sizable 256kb of flash memory for code storage. The Mega allows smooth communication with a variety of devices, including sensors, display and motors thanks to its adaptable range of Prestwich includes USB, UART SPI, and I2C. Mega IS programming language that is perfect for both beginners and experts, supporting C and C++ among the other language, so it is usable by a wide range of programmers. Its ability to work with Arduino software (IDE) simplifies the coding process and allows for quick testing prototyping. Morevover, Mega Sturdy Construction guarantee longevity and its small size make it possible to incorporate it into a variety of project, such as interactive installation, robotic and automation. Because of its unmatched efficiency and versatility, The Arduino Mega allows you to realise your idea, whether you’re a professional engineer taking on challenging tasks or just a hobbyist tinkering at home.

3.4.3 IR Sensor

Figure 3.5 IR sensor



A sensor That Detects and measures infrared radiation in its surrounding is known as an infrared sensor (IR) sensor. Depending on their temperature, object release infrared radiation, which is invisible to the human eye. IR sensors are extensively employed in many different applications such as object, motion and proximity detection. The two primary parts of an infrared sensor are and infrared transmitter and a detector. Infrared light is producing an IR emitter, which typically a light emitting diode (LED) or laser diode. Nearby objects refracted infrared slight is detected by an infrared detector, which typically a photodiode or phototransistor. The emitted Infrared light is reflected to the detector when an object approaches it, setting off the sensor's reaction. These are two categories of these sensors: active and passive. While passive Infrared (PIR) sensors, also referred to as passive infrared sensors, only detect infrared radiation emitted by other sources and generally used in motion detection application, active infrared (IR) sensors emit and detect infrared light on their own. Because Of their affordability, simplicity and dependability, infrared sensors are recommended. They are incorporated into a number of applications, including smart parking system, robotic obstacle detection, remote controls and automated lighting systems. They are appropriate for a variety of industrial and consumer electronic applications due to their non-contact nature and ability to function well in low light.

3.4.4 Servo Motor

Figure 3.6 Servo motor

A servo motor is a linear or rotary drive that enables accurate control over acceleration, speed, and angular position. It's made up of a gear box, a control circuit, and a motor coupled to a position feedback sensor. The Servo motor can obtain a control signal from the control circuit that specified the desired output shaft position. Because servo motors are usually compact and strong, they are perfect for application like robotic, conveyor belts and remotely operated vehicles that call for precise motion control. They use pulse width modulation (PWM) to operate, where the motor shaft's position is determined by the length of the pulse. High torque, quick response times and accurate positioning are servo motors key characteristic, They are frequently utilised in system that require precise motion control, like automated manufacturing control systems m, robotic arms and CNC machines to guarantee dependable and accurate performance.

3.4.5 Jumper Wires

Figure 3.7 Jumper wires

In electronic prototyping, jumper wires are crucial components because they enable flexible and rapid connections between various circuit components without the need for solder. These cables often connector both ends, which can be male or female, and are covered sturdy plastic insulation. Male-to male (M-M) jumpers are used to join two female headers or leads on a breadboard. They Have pins on both ends. A male pin of a component can be connected to connector using Male-Female (M-F) jumpers, which have a single pin and socket. In order to connect two male contacts, female-female (F-F) wires features sockets on both ends. In complicated circuits, jumper wires which come in a variety of colours and lengths are useful for organising and separating connection. And indispensable tool for enthusiast, engineers, and educator to effectively design alter and debug electronic circuits are their versatility, reusability, and user friendly

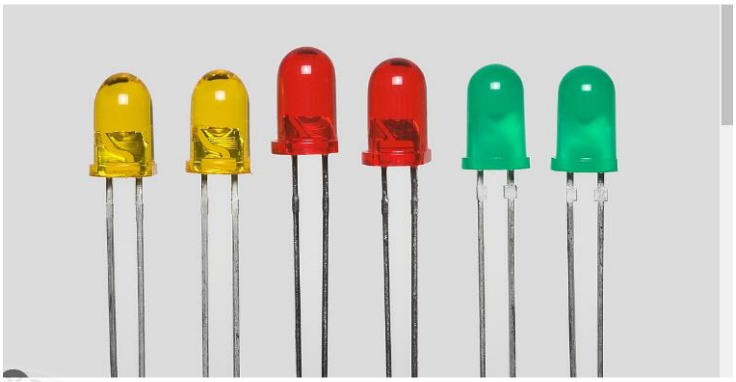
3.4.6 2x16 LCD (Liquid Crystal Display)

Figure 3.8 2x16 LCD (Liquid Crystal Display)

A common alphanumeric display module the 2x16 LCD (Liquid Crystal Display) can display 32 characters in a row on tow 16-character line. Since it makes use of a standard Hitachi HD44780 controller, it works with the majority of the development platforms and microcontrollers. The display uses very little power and has a backlight for visibility in low light. It is perfect for use in embedded system, DIY projects and electronic devices just need basic text printing. Wirth its adjustable contrast for improve reality, The 2x16 LCD is simple to operate, typically through an 8-bit or 4-bit parallel interface.

3.4.7 Light Emitting Diode (LED)

Figure 3.9 LED



A semiconductor device known as a light-emitting diode (LED) releases light when an electric current flows through it. LEDs com in range of colours and sizes, are highly efficient and convert majority of light into heat. They are employed in many different applications, such as lighting, displays, and indicators, and have an extended service life. LEDs are appropriate for battery operated devices because of their low voltage and current requirements. They can tolerate frequent cycling and are robust and long-lasting. LED are a crucial component of modern electronics and lighting system because of their small size and high energy efficiency.

3.4.8 Software Equipment

Figure 3.10 Arduino IDE Platform

Code can be written, built, and loaded onto Arduino boards using the open-source Arduino Integrated Development Environment (IDE). Because of tis user-friendly design, even beginner users will find it easy to use, and expert's user will find it to have enough features. The IDE comes with a simplified version of the manipulation-base wire language and supports the programming languages C and C++. The Arduino IDE has a straightforward user interface with standard features like a text console, message area, code editor, and toolbar with buttons for common operation like uploading and checking code. Additionally, it comes with a powerful library manager that enables users to import manage libraries that enhance Arduino project functionality. When debugging and keeping an eye on real-time data sent from Arduino board, the serial monitor function comes in quite handy. The Arduino Ide works with numerous Arduino board and clones and is compatible with Window, MacOS, and Linux. Its community support, comprehensive documentation, and ease of use make it an indispensable tool for developing and prototyping a wide range of electronic projects.

3.5 Experimental setup

3.5.1 Connections

Arduino Mega

Arduino Mega Pins	Connected To	Reason
D2	Entry IR Sensor	To detect cars entering parking area.
D3	Exit IR Sensor	To detect cars exiting parking area.
D4-11	Slot Sensor (8 total)	To monitor the availability of parking slots.
D12	Entry Servo Motor	To open the entry gate.
D13	Exit Servo Motor	To open the exit gate.
D22	LED Indicator for Slots 5-8	To indicate whether slots 5-8 are full.
D24	LED Indicator for Slots 1-4	To indicate whether slots 1-4 are full.
I2C SDA (Pin 20)	LCD SDA Line	To send data to the LCDs for displaying messages and parking slot status.
I2C SCL (Pin 21)	LCD SCL Line	To provide the clock signal for LCD communication.

Table 3.2 Explanation of Arduino Mega connection with Components

3.5.2 Equipment

The proposed system's hardware should be utilized or incorporated based on minimum requirements. This table provide a comprehensive breakdown of the system's needs, including the functionality with each individual component.

Table 3.3 Hardware details

No	Hardware	Functionality
1	Arduino Mega	The microcontroller for this project is an Arduino Mega
2	IR Sensors (Entry/Exit)	To detect cars entering or exiting the parking area

3	Servo Motors	Operates entry and exit gates
4	Parking Slot Sensors	To detect the status of each parking slot whether its empty or occupied.
5	LED indicators	Shows the availability parking slot for each group.
6	LCD Display 1 (Gate)	Display message welcome and available slots
7	LCD Display 2 (Slots 1-4)	Display the status of parking slots 1-4 (F for Full, E for Empty)
8	LCD Display 3 (Slots 5-8)	Display the status of parking slots 5-8 (F for Full, E for Empty)
9	Resistor 1k	To connect with LED to prevent damage, ensure consistent brightness and protect the circuit

Table 3.4 Software details

No	Hardware	Functionality
1	Arduino IDE	Used to create and upload irrigation system programming

3.5.3 Simulation

IR Sensor and Servo Motor Entry/Exit

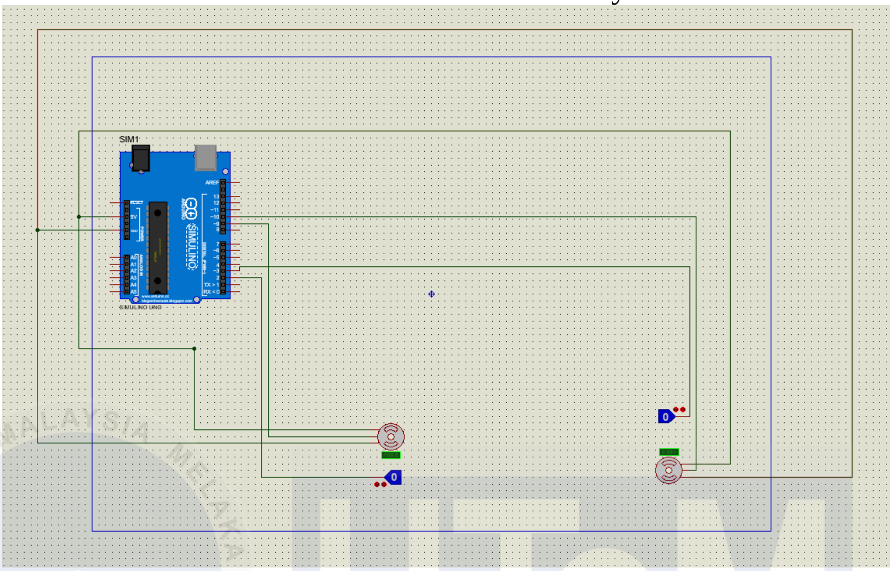


Figure 3.11 Simulation IR Sensor and Servo Motor using Proteus

Using Proteus, a virtual system modelling tool, Figure 3.12 shows how to integrate and simulate a servo motor and an infrared (IR) sensor. The IR sensor in this configuration serves as a proximity detector to detect the presence of an object, usually a car in parking applications. Upon detecting an object, the IR sensor transmits a signal to a microcontroller, like an Arduino, which subsequently processes the input to initiate the servo motor. In this simulation, the servo motor is in charge of moving a gate or barrier. Upon receiving the signal from the microcontroller, the servo motor rotates to a specific angle, lifting the gate to allow the vehicle to pass. Once the vehicle has passed and the IR sensor no longer detects its presence, the microcontroller sends another signal to the servo motor to return to its original position, closing the gate. This simulation is very important to test the functionality and interaction of IR sensor and servo motor without physical components. It ensures the correct operation of the system under real conditions by controlling the logic and timing of sensor detection and motor response. In addition, Proteus allows real-time monitoring and modification of circuits, which facilitates troubleshooting and optimization of system performance.

IR Sensor and LCD Display

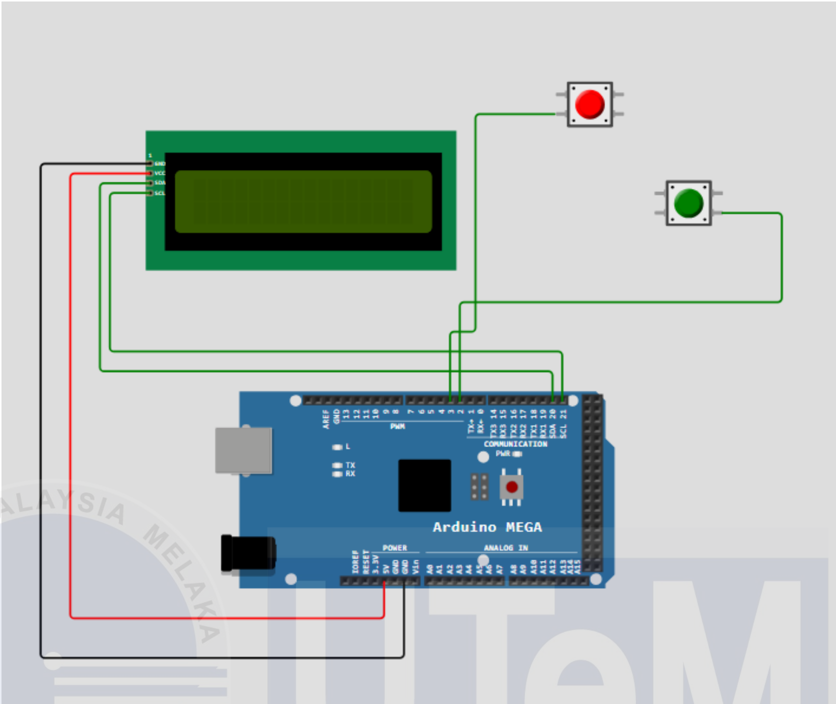


Figure 3.12 Simulation IR Sensor and LCD Display using Wokwi

Figure 3.13 illustrates the simulation of a system integrating a push button and an LCD display using Wokwi, an online Arduino and electronics simulator. In this setup, the push button acts as a manual input device, replacing the IR sensor in the original configuration. This configuration is frequently employed to mimic human interaction or manual event triggering. A button's press transmits a digital signal to the Arduino microcontroller. After analysing this data, the Arduino modifies the LCD. A button can be used to change the status message, simulate reserving a parking space, or increase and decrease the counter displayed

on the LCD screen. Real-time information is displayed on the LCD screen using a visual feedback mechanism in response to button presses. This could include textual information such as a counter increment or messages like "Parking full" or "Parking Slot". The LCD interface's ability to monitor and control the system's response to button input can be useful for a variety of applications, including user interface testing, training demonstrations, and early prototyping. Using Wokwi in this simulation has several advantages. This allows for extensive testing and debugging of both hardware and software components without requiring physical components. Developers can write and test Arduino code to make sure the logic handling button presses and updating the display is working as it should.

Furthermore, iterative development and optimisation are supported by the Wokwi simulation environment, which facilitates simple circuit and code modification and real-time feedback.

3.6 Summary

This chapter presented the process flow of the Smart parking system, flowchart and the block diagram of the component how will there operate. We also show the equipment description of the hardware and the software that we use for building the project. In this chapter we put the Arduino code and demonstrate in simulation. We use proteus to simulation the IR sensor and Servo Motor. The results of the simulation show that IR sensor will give signal to servo motor when the sensor detect movement. After getting the signal the servo motor will automated open the gate and go in. We also use Wokwi to simulate the IR sensor and LCD. Based on the simulation, show that the push button acts as a manual input device, replacing the IR sensor and LCD will show the display and content the message that will be show in result.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The outcomes and analysis of a smart parking system built with Arduino microcontrollers are presented in this chapter. Its main objective is to assess system performance through the use of sensor data and user input. In order to determine the precision and dependability of infrared sensors in identifying the presence of vehicles, the chapter starts with a thorough examination of sensor data. It also assesses the system's efficiency in data processing and LCD display, as well as its response time. Comparisons with other smart parking technologies highlight the benefits of both the current system and upcoming improvements. Through the use of real-world case studies, the system's applicability in a variety of scenarios is made clear. By analysing user feedback obtained from surveys and interviews, the system's usability and user satisfaction are evaluated.

4.2 Results and Analysis

Results on the development of the Smart Parking System are described through the analysis of figures 4.1 to figures 4.9, presenting the functionality and performance of the system. Each figure represents main issues about the system which is entry and exit gates operation, status of the LCD display updating, and LEDs on, which will show parking availability. These views present the integration and coordination of the system components, which in turn, validate and integration of the Arduino Mega microcontroller, IR sensors, servo motors, LCD screens, and LEDs to develop an operative smart parking solution. The findings pinpoint that the system will improve the usage of parking space, reduce the search time by drivers and ensure smooth traffic flow within the parking facility.

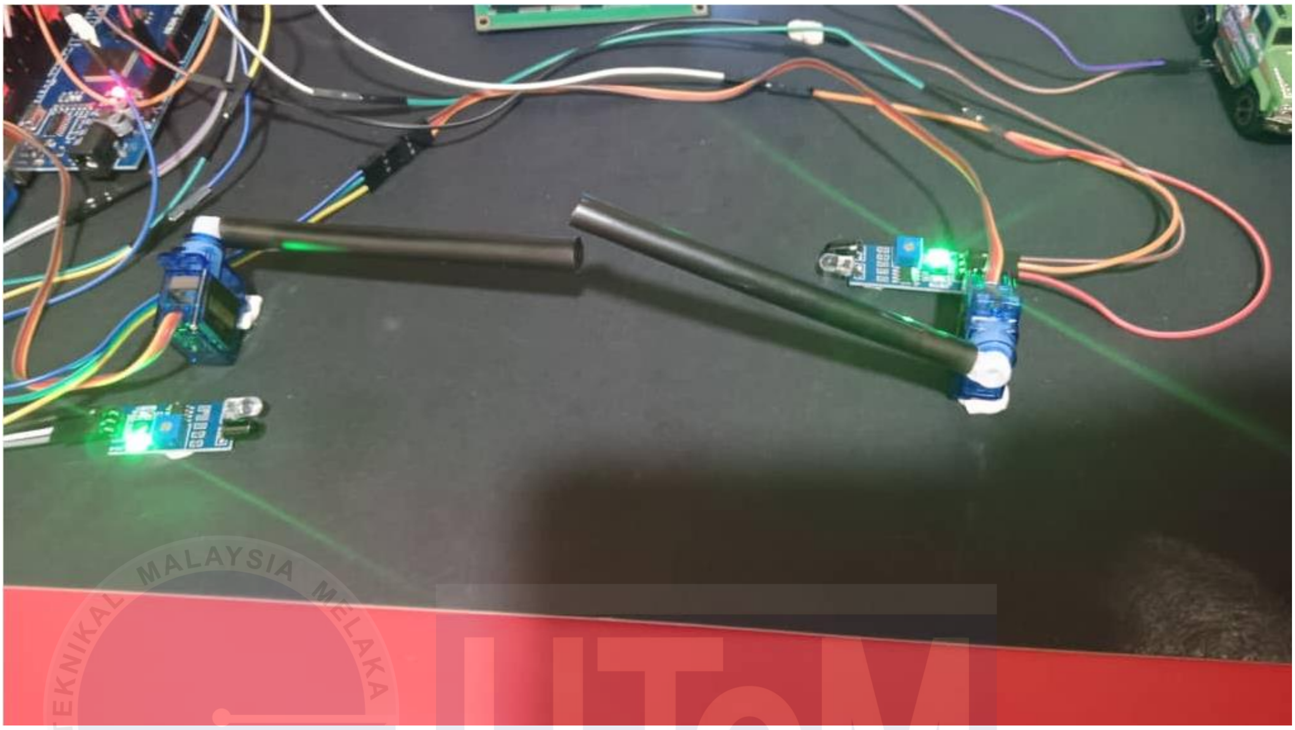


Figure 4.1 Entry and Exit Gate

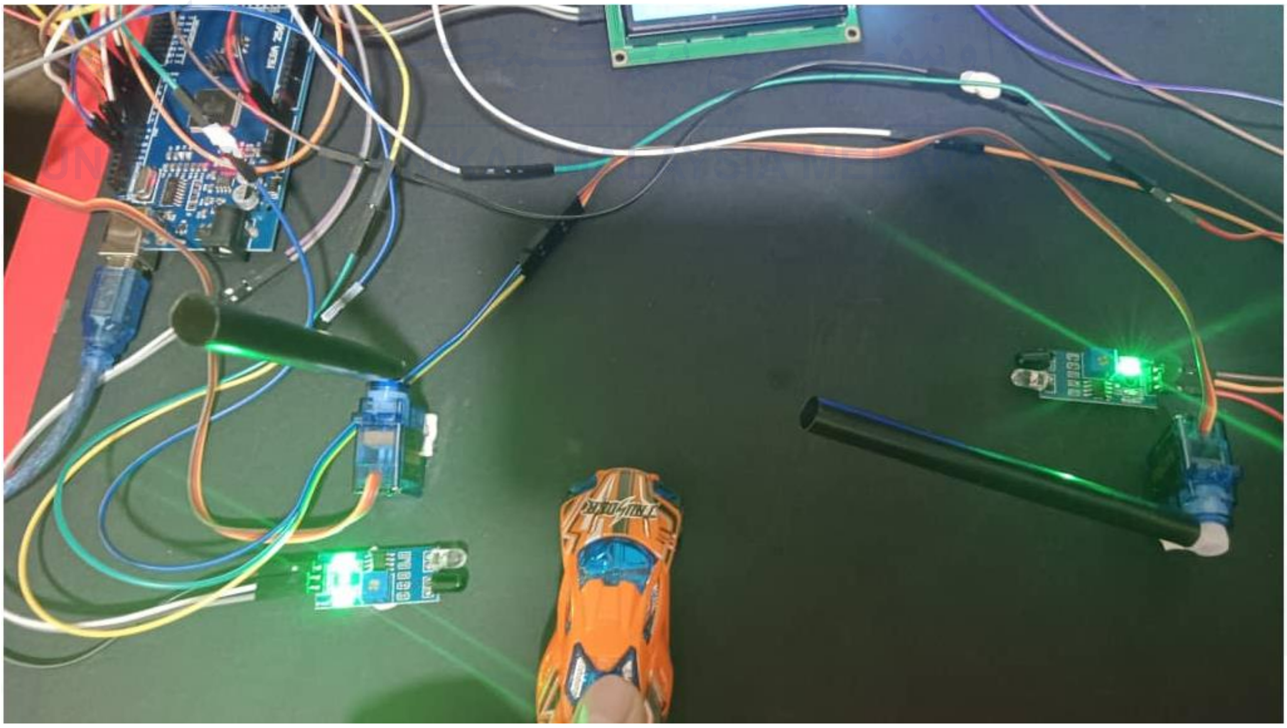


Figure 4.2 Entry Open Gate

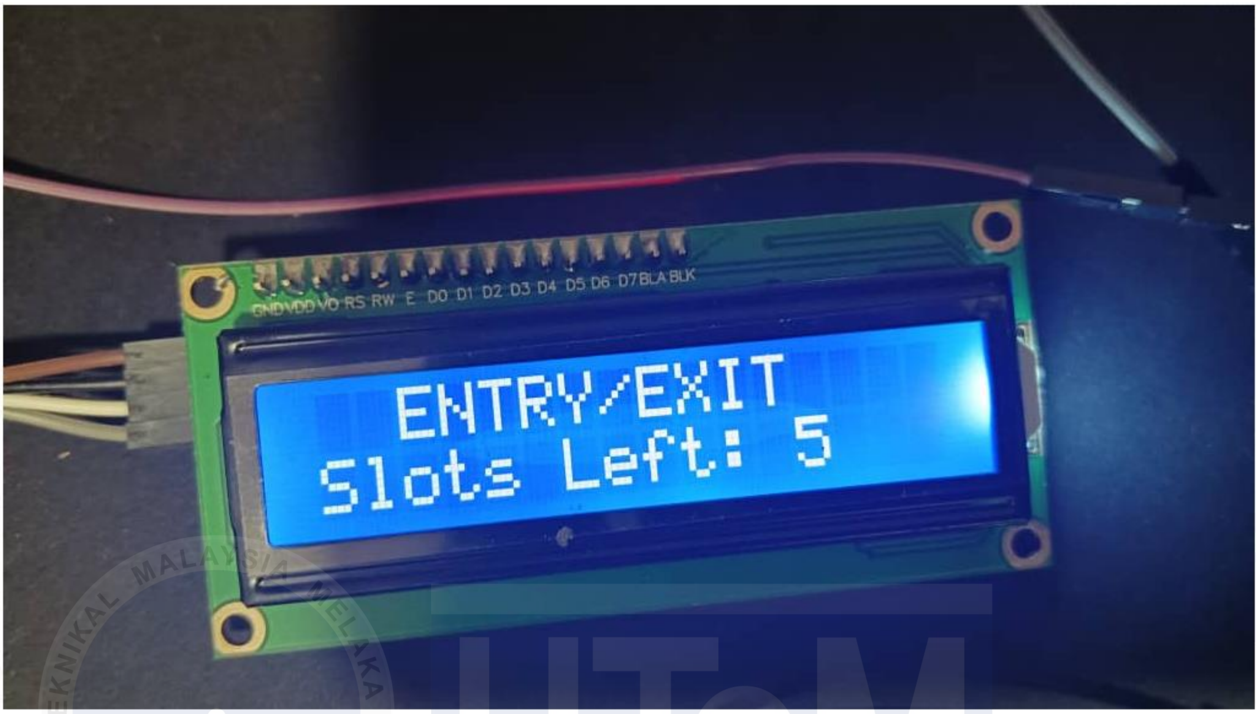


Figure 4.3 LCD Display- “Entry/Exit Slot Left: 5”

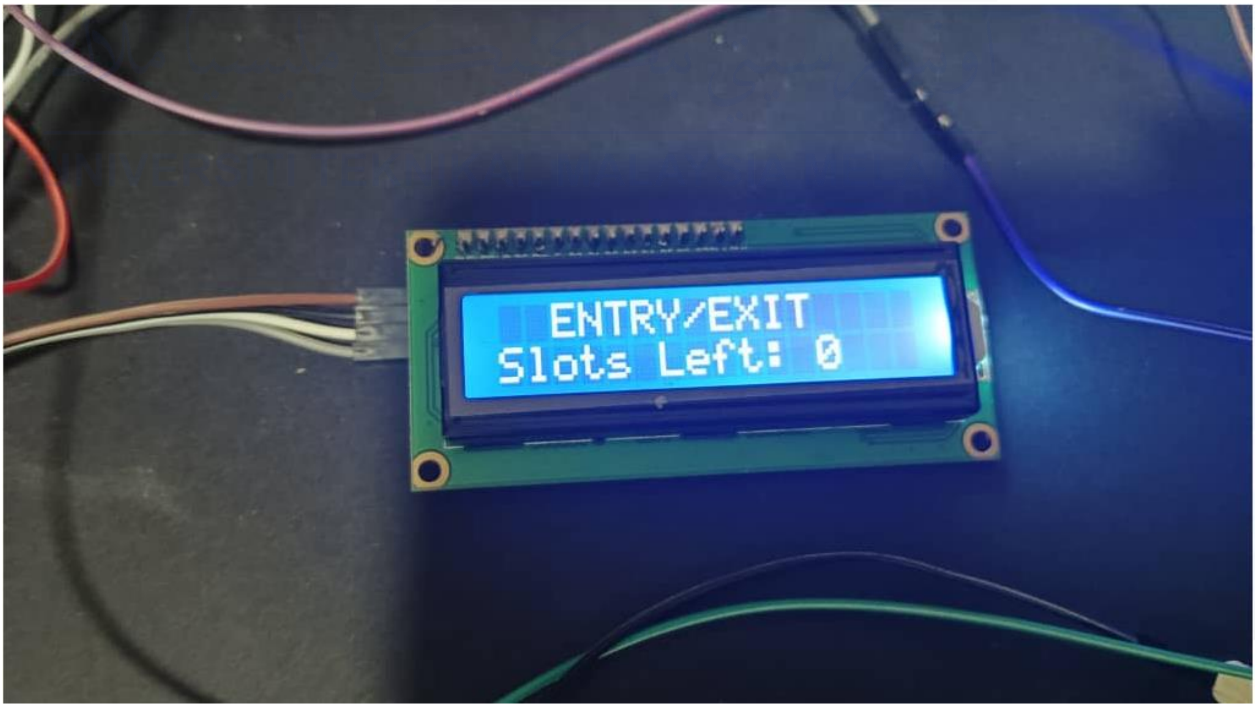


Figure 4.4 LCD Display – “Slot left=0”

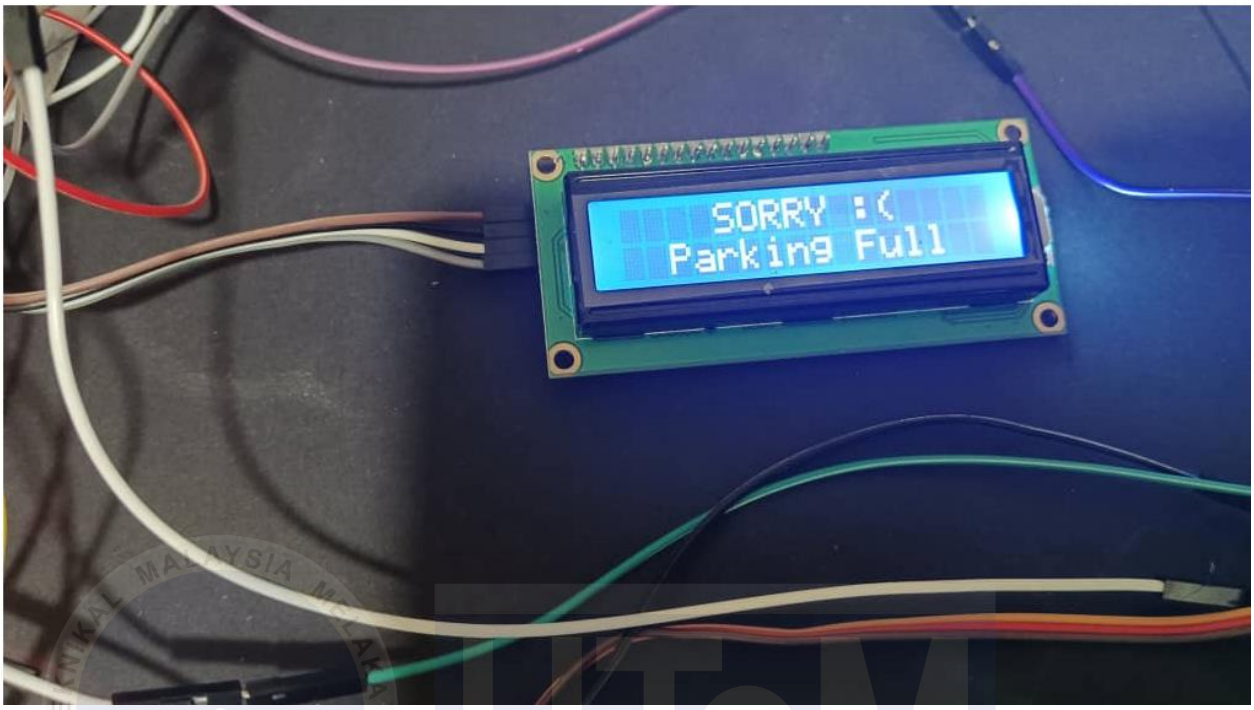


Figure 4.5 LCD Display – "Sorry Parking Full"

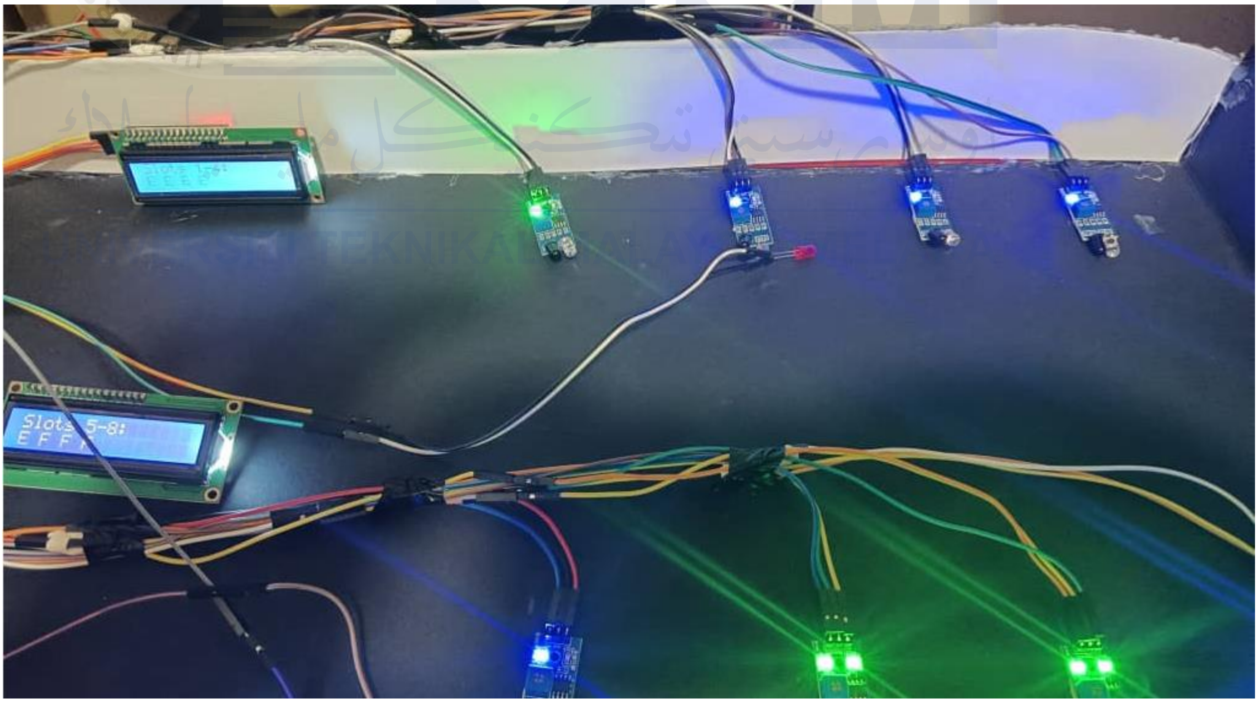


Figure 4.6 LCD Display Show Guidance and Parking Slot

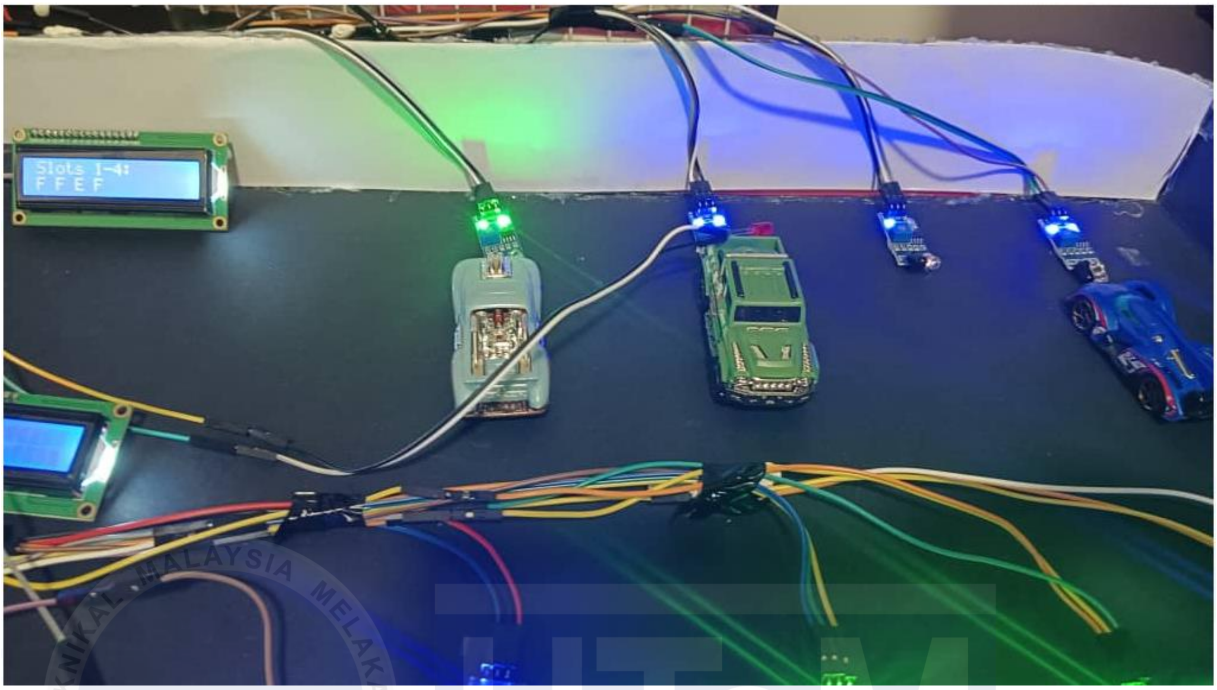


Figure 4.7 LCD Display shows that “Slot 1-4: F F E F” and LED is still Off because the parking is not FULL.

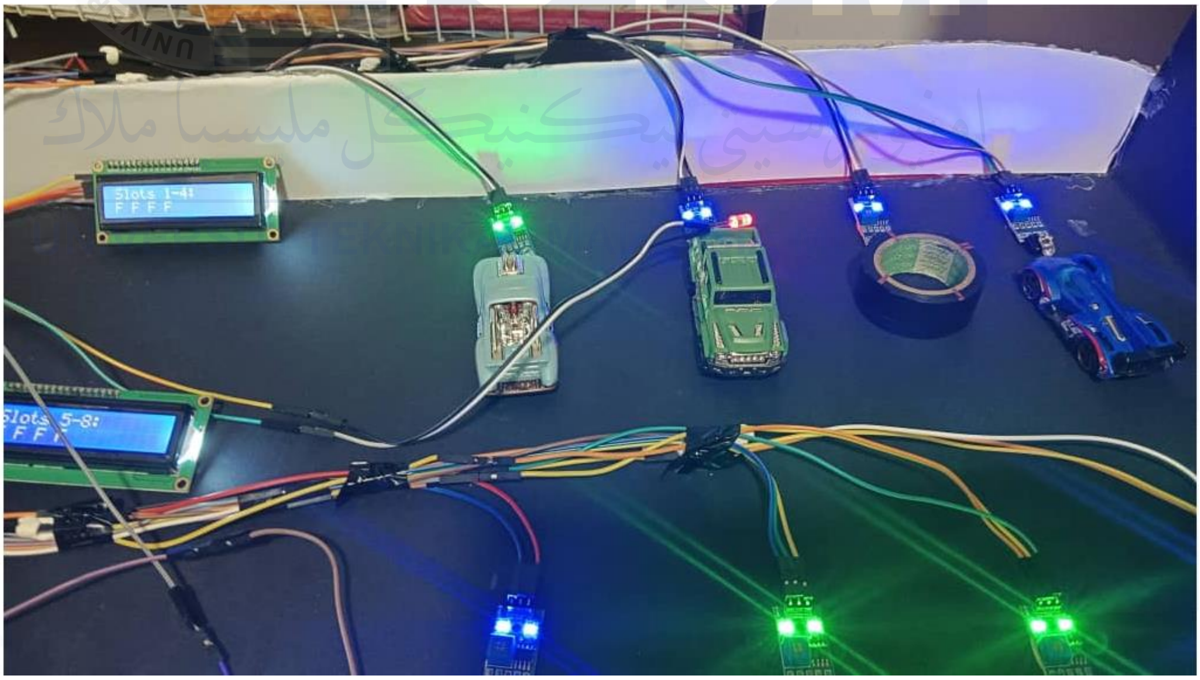


Figure 4.8 Parking Slot 1-4 Full, LED will light ON

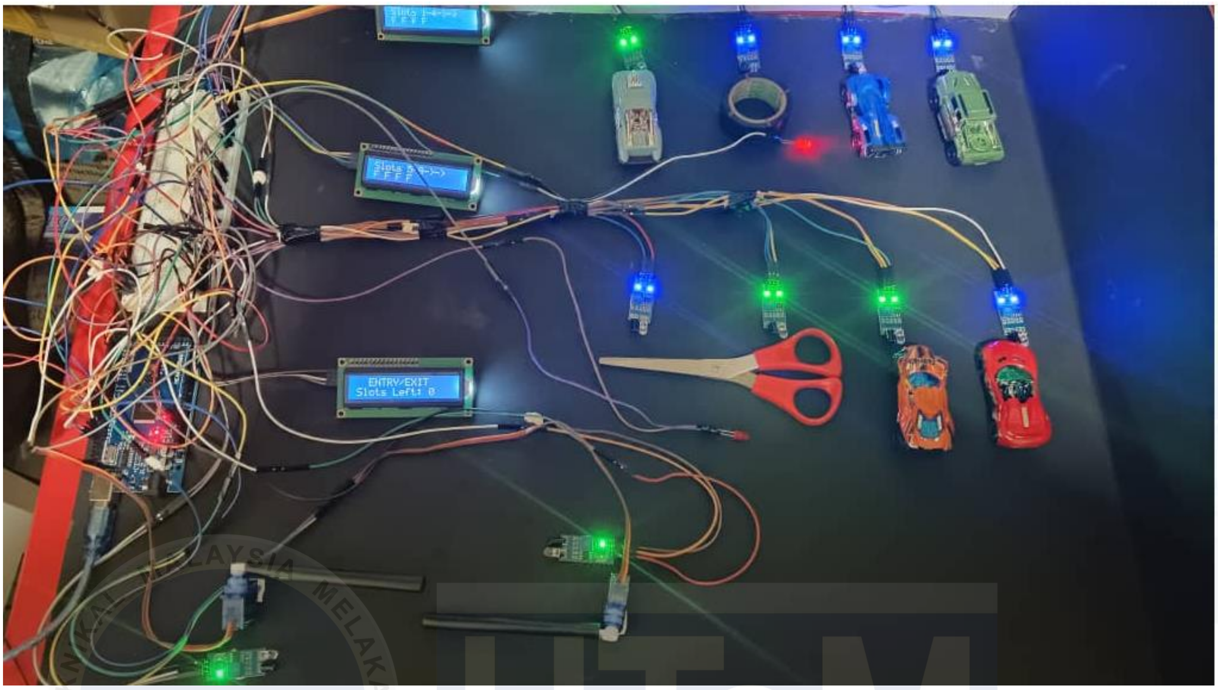


Figure 4.9 Parking Slot 1-8 Full, LED will light ON and Entry cannot Open the Gate

Figures 4.1 and 4.2 show the operation of the system entry and exit gates, respectively. Servo motors interface with IR sensors for input work effectively to control the flow of vehicles by opening or closing the gates depending on slot availability. Figures 4.3 to figures 4.5 give the LCD displays that provide current information on the availability of parking space. Message displayed include “Entry/Exit Slot Left:5” and “Sorry parking Full”; this keeps driver updated about parking availability status for convenience and elimination of confusion. Lastly, Figures 4.6 through figure 4.9 depict LED indication and detailed monitoring of the parking slot. The LEDs indicate when certain groups of parking slots, for example, slot 1-4 have reached their full capacity, and no more entries should be allowed. The LCD displays also further break down the status of individual slots using “F” for full and “E” for empty, hence enabling precise and user-friendly parking management.

4.2.1 Data Analysis

In this section, collected sensor data had been analyzed to understand the accuracy and response time of the Smart Parking System. Response Timetable is showing the time taken by every slot sensor detecting a vehicle. Response times recorded in the readings range form 48 ms to 65 ms, averaging about MS. This proves that the system can update in real time in very little time, hence enhancing smooth parking management and ensuring minimal delays for drivers who enter or leave the facility.

Parking Slot	Response Time(ms)
Slot 1	50
Slot 2	48
Slot 3	60
Slot 4	52
Slot 5	65
Slot 6	49
Slot 7	55
Slot 8	53

Table 4.1 Response Time and Parking Slot 1-8

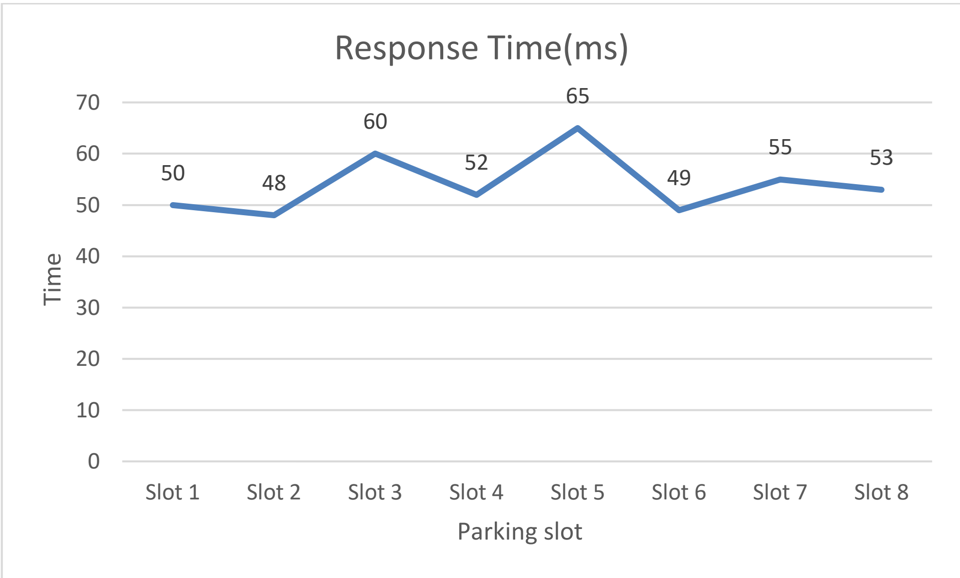


Figure 4.10 Sensor Detection Response Time

Table 4.2 gives the detection accuracy of each sensor in showing system's realiability. Most of the parking slots reached a 100% accuracy rate, indicating consistency in vehicle detection. However, minor deviations include the 60% accuracy recorde for slot 5. These are the factors that may bhave resulted form misalignment, interference due to enviromental causes, or the need for calibration. These would enchance the precison and reliablity of the system.

Parking Slot	Detection Accuracy (%)
Slot 1	100
Slot 2	100
Slot 3	80
Slot 4	100
Slot 5	60
Slot 6	100
Slot 7	100
Slot 8	100

Table 4.2 Parking Slot With Detection Accuracy

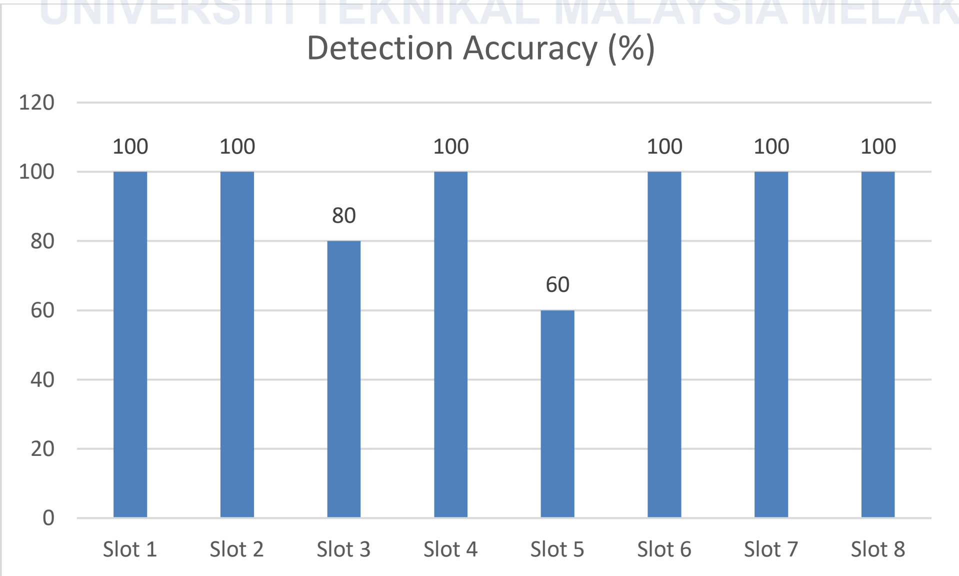


Figure 4.11 Performance For Detection Sensor and Parking Slot

These are further reflected in the performance analysis graphs on sensor response time and detection accuracy rates across all slots. The data reflects the ability of the system to constantly detect and update the status of parking slot availability efficiently. By these metrics, the Smart Parking System proves effective in handling parking operations, optimizing slot utilization, and reducing driving search time. That means the entire system works just fine, with great response times and high reliability for object detection. However, these anomalies do prove periodic maintenance, good sensor placement, and calibration to be quite crucial to its optimal workability. In such a way, the system will keep operating without any hitches under most conditions as an effective and handy option for modern car parking management.

4.3 Prototype Design

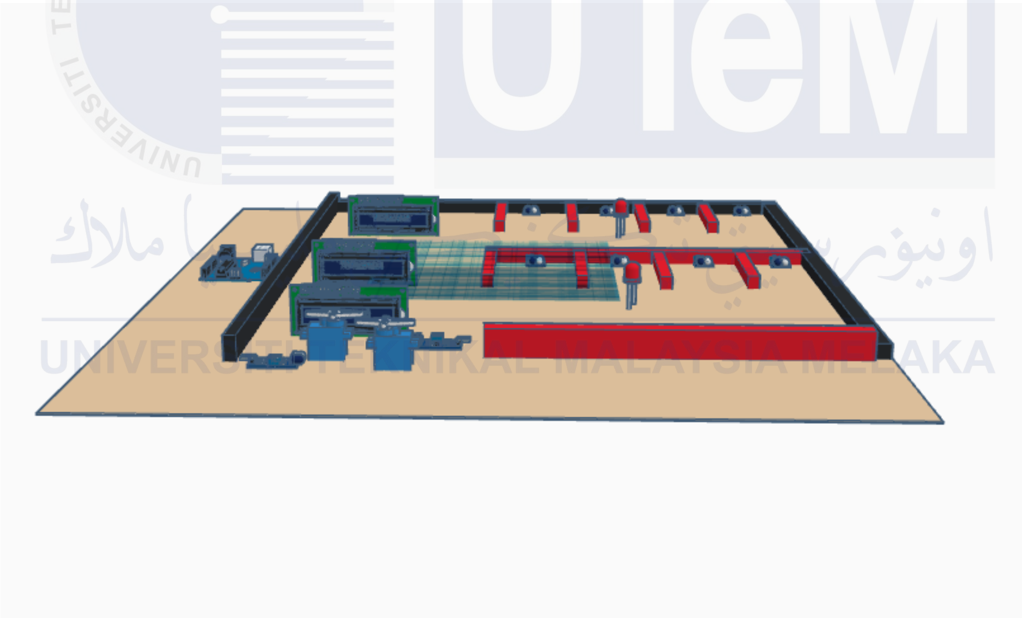


Figure 4.12 Smart Parking System (FRONT)

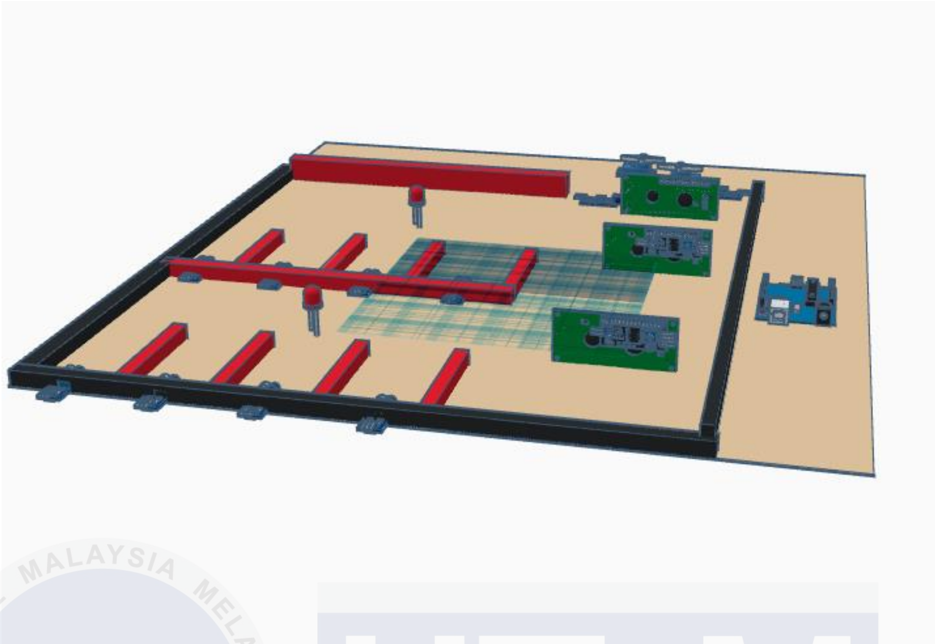


Figure 4.13 Smart Parking System (BACK)

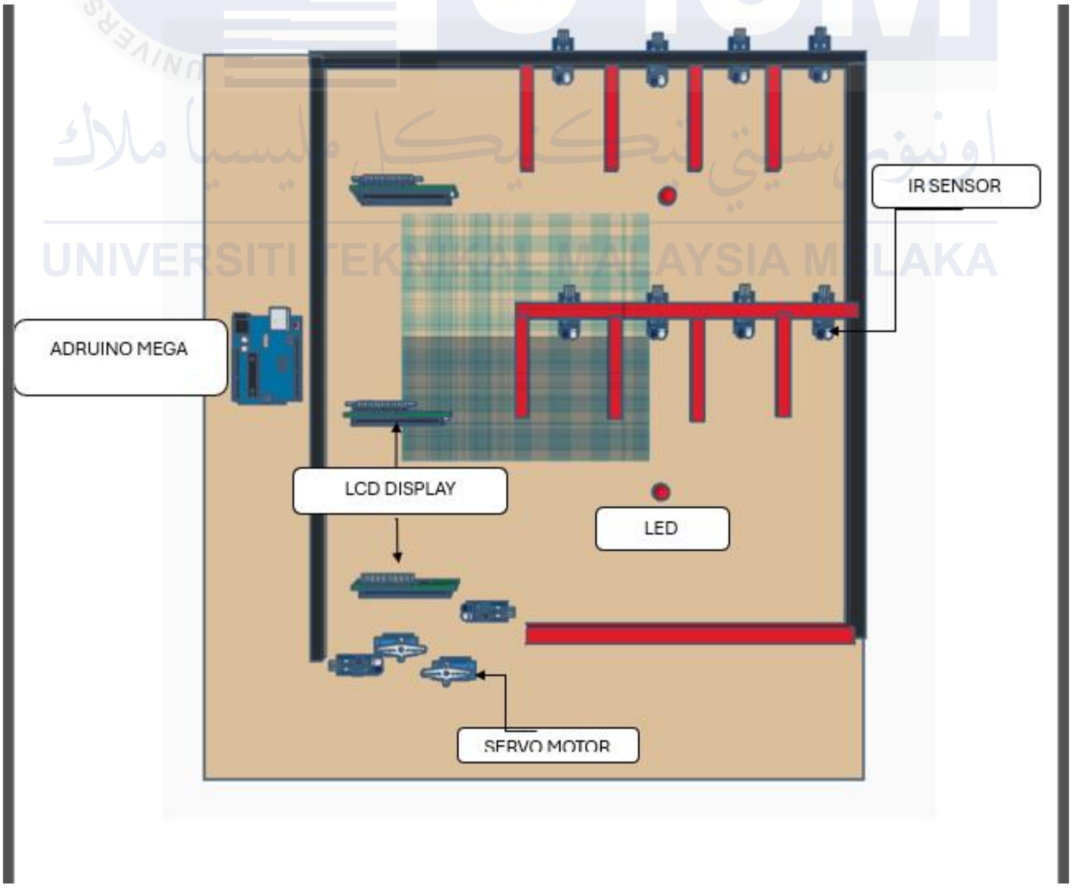


Figure 4.14 Smart Parking System

Figure 4.15 Final Prototype Design (Front)

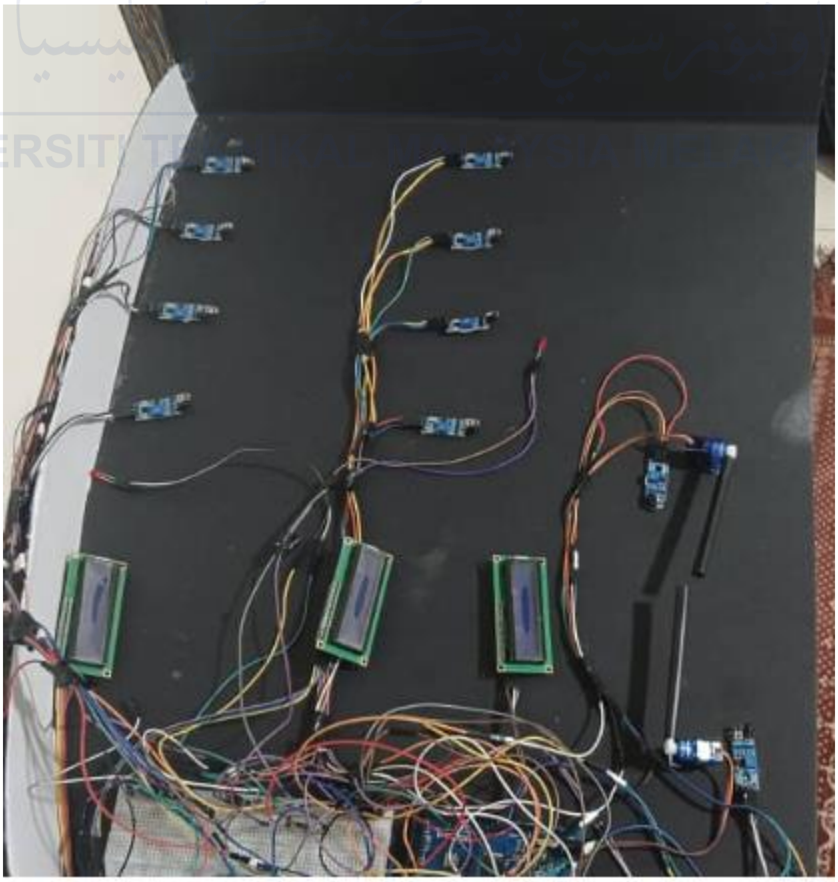


Figure 4.16 Final Prototype Design (Side)

4.4 Project coding

4.4.1 LCD and Servo

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Servo.h>

// Initialize LCDs
LiquidCrystal_I2C lcdGate(0x27, 16, 2);
LiquidCrystal_I2C lcdSlots1(0x25, 16, 2);
LiquidCrystal_I2C lcdSlots2(0x24, 16, 2);


Servo entryServo;
Servo exitServo;
```


The code starts with inclusion of libraries that it will use, namely: Wire.h, LiquidCrystal_I2C.h, and Servo.h is for communication with the I2C devices; its's used for the LCD screens. LiquidCrystal_12C.h helps interact with LCD screens using I2C interface. Lastly, Servo.h will help in creation of parking system where the opening and closing of gates will be implemented through servo motors.

The code initializes three LCD objects, ldcGate, lcdSlot1, and lcdSlots2, for different LCD screens with I2C addresses 0x27, 0x25, and 0x24, respectively. These are used to disp;ay information regarding the parking system, such as the number of available slots. Then, two servo objects, entryServo and exitServo, are created for controlling the entry and exit gates of the parking system. Such Servos to open or close the gates if there is the entrance or exit of a car on either side in parking.

4.4.2 Entry and Exit Sensor with Servo

```
void loop() {

  updateFreeSlots();


  if (carDetected(entryIR)) {
    if (Slots > 0) {

      entryServo.write(0);
      delay(1500);
      entryServo.write(90);
      Slots--;

      lcdGate.clear();
      lcdGate.setCursor(0, 0);
      lcdGate.print("   WELCOME!    ");
      lcdGate.setCursor(0, 1);
      lcdGate.print("Slots Left: ");
      lcdGate.print(Slots);
      delay(2000);
    } else {

      lcdGate.clear();
      lcdGate.setCursor(0, 0);
      lcdGate.print("    SORRY :(    ");
      lcdGate.setCursor(0, 1);
      lcdGate.print("  Parking Full  ");
      delay(2000);
    }
  }
```

In the program, entry logic was implemented to continuously check car detection using an entry IR sensor known as entryIR. If there was a detected car, then first of all it checks availability in parking slots. It opens the entry gate by rotating the entryServo to 0-degrees when slots are available, waits for 1.5 seconds to allow the passage of the car, and then closes the gate by rotating the servo back to 90-degrees. After that, decrease the number of available slots by 1 and update the LCD screen with "WELCOME" and the refreshed count slots are available. If there is no slot available, it displays "Parking Full" in the LCD and keeps the gate in a closed state.

```
if (carDetected(exitIR)) {


    exitServo.write(0);
    delay(1500);
    exitServo.write(90);
    Slots++;



    lcdGate.clear();
    lcdGate.setCursor(0, 0);
    lcdGate.print("   THANK YOU!   ");
    lcdGate.setCursor(0, 1);
    lcdGate.print("Slots Left: ");
    lcdGate.print(Slots);
    delay(2000);
  }
```


In the exit logics, the program checks if a car has been detected by the exit IR sensor(exitIR). When the car is detected, the exit gate opens at 0-degree movement of the exitServo, waits for 1.5 seconds, then closes the gate back to 90-degree movement of the servo. This will then increase the variable available_slots by 1 when a slot gets freed. Update the LCD display in "THANK YOU" plus new count of available slot. It therefore provides an appropriate way of the entrance and exit into the car park while keeping track of the number of parking slots left.

4.4.3 LCD Display with IR Sensor

LCD will display the current status of the particular parking slot whether it is Empty or Full based on reading from its IR sensors associated with a particular parking slot. In general, each IR sensor connected with the system detects if the car is in parking space or not. If there is a detection, a HIGH signal at the output means slot FULL. If no car is detected, the sensor outputs a LOW signal, meaning that the slot is Empty.

The code checks on the status of the slots and then displays it on two LCD screens, lcdSlots1 and lcdSlots2. In the first LCD, lcdSlots1, it will display the status of the slots from 1 to 4, while on second LCD, lcdSlots2, the status of the slots from 5 to 8 is displayed. This code runs a for loop for each slot sensor reading its state and then displaying 'E' for Empty or 'F' for Full.

Code:

```
lcdSlots1.clear();
  lcdSlots1.setCursor(0, 0);
  lcdSlots1.print("Slots 1-4->->");
  lcdSlots1.setCursor(0, 1);
  for (int i = 0; i < slotsPerLCD; i++) {
    if (digitalRead(slotSensors[i]) == LOW) {
      lcdSlots1.print("F");
    } else {
      lcdSlots1.print("E");
    }
    lcdSlots1.print(" ");
  }


  // Display slot status on the second LCD (Slots 5-8)
  lcdSlots2.clear();
  lcdSlots2.setCursor(0, 0);
  lcdSlots2.print("Slots 5-8->->");
  lcdSlots2.setCursor(0, 1);
  for (int i = slotsPerLCD; i < totalSlots; i++) {
    if (digitalRead(slotSensors[i]) == LOW) {
      lcdSlots2.print("F"); // F for Full
    } else {
      lcdSlots2.print("E"); // E for Empty
```

```
    }
    lcdSlots2.print(" ");
  }

  delay(500);
}
```

4.4.4 LED Updates

The system will provide indications of parking slot availability using LEDs within two groups which slots 1-4 and slots 5-8. LEDs will connect to two different pins, respectively: ledSlots1 and LedSlots5to8. If all the slots within a group are occupied that is, the sensors for each of the group read HIGH, then the LED turn ON, showing that particular group is full. If there is at least one empty slot in the group or parking slot, any sensor in the group read LOW and LED turn OFF to signify that there are still available space within that slot.

```
  bool slots1To4Full = true;
  for (int i = 0; i < slotsPerLCD; i++) {
    if (digitalRead(slotSensors[i]) == HIGH) {
      slots1To4Full = false;
      break;
    }
  }
  if (slots1To4Full) {
    digitalWrite(ledSlots1, HIGH);
  } else {
    digitalWrite(ledSlots1, LOW);
  }
  bool slots5To8Full = true;
  for (int i = 4; i < slotsPerLCD ; i++) {
    if (digitalRead(slotSensors[i]) == HIGH) {
```

```
    slots5To8Full = false;
    break;
  }
}
if (slots5To8Full) {
  digitalWrite(ledSlots5To8, HIGH);
} else {
  digitalWrite(ledSlots5To8, LOW);
}
```

4.5 Summary

This chapter has presented the results and analysis of the Smart Parking System. The main elements of the system were IR sensors, servo motors, LCD displays, and LEDs, interface using an Arduino Mega microcontroller to establish the working of the system. The results show smooth working of entry and exit gates, accurate real-time update of parking availability, and efficient indication through LEDs about the occupancy of a slot. Data analysis confirmed the system's high detection accuracy and rapid response time, validating its effectiveness in optimizing parking space and reducing time driver to search. The finding suggests the system successfully addresses common parking, paving the way for impro in smart parking system.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The project was successfully achieved in the main objective of the proposal, which was to design a smart parking system using microcontroller technology in order to help eliminate inefficiencies found in manual parking management. It integrated parking sensor, servo motors, and LCD displays that would enable real-time monitoring, parking guidance, and automated gate operation. This installation proved that these components could reduce parking management inefficiencies through minimum search time for drivers and reduce congestion, as seen from results.

This value addition is further enhanced with infrared sensors and real-time processing to increase system performance and reliability. The vehicle presences detection by the sensors was highly accurate, and the response times of the system facilitates smooth functionality of the system, confirming its practicality for the real-world application. The prototype also showed crystal clarity in the LCD interface regarding slot availability and user management. This integration of automated features into the system augured well in addressing practicality and usability. Moreover, the project underlined the role of smart technologies in modernizing urban infrastructure. While the system optimized parking space utilization, it not only brought convenience to users but also contributed to reducing environment impacts, such a low fuel consumption and emissions due to prolonged searches of parking.

The project met its aims and objectives, showing the feasibility of microcontrollers in solving real-life parking problems. The results indicate gain automation, efficiency and environmental sustainability. This work could be a good base for potential modifications in the future, including us of IoT, AI, and renewable energy, which may enhance scalability, flexibility, and durability to further extend uses in smart parking systems.

5.2 Project Potential

Smart parking system has huge potential to transform how urban car parking is managed. With the use of microcontrollers and real-time data, this can provide enormous benefits concerning managing optimal utilization of available parking space and lessening congestion. Immediate updates about the availability of parking lots add convenience not only to the user side but facilitate fluent traffic, a reduction in fuel consumption, and other toxic emissions. This system can be applied to any commercial complex, residential area, and public facility where demand for parking is high. The prototype can also support advanced features, including mobile app integration, to allow users to book a parking spot remotely, with only minor adjustment. Such expansion may further enhance access to the system and make it more appealing to potential users. Moreover, the data gathered by parking sensors provides insights into the usage of spaces by facility managers for decision-making processes. It considers activities like space allocation, pricing, and future development. This adaptability and scalability go to position that the smart parking system as a transformative solution in smart city initiatives.

5.3 Future Works

Some of the future works to this project are:

Firstly, IoT integrated into the system can monitor and control the parking spaces through a mobile or web application that would reserve the spot and send updates on your smartphone in real time. This would be further enhanced by the integration of high-performance sensors, such as a camera-based system or object detection using AI. These will also pave the way for the other value-added features like number plate recognition and security monitoring. This will also provide a system, especially in extending towards renewable energy resources such as solar panels to become even more sustainable and cost-effective in its operation. Future developments can also include machine learning algorithms in demand forecasting for dynamic adjustments to parking space allocation. This will increase functionality, reliability, and relevance of the system in developing city environments.

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APPENDICES

Appendix A Gantt Chart for BDP1

Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Find an idea for project														
Briefing for BPD1														
Study problem statement														
Identify the objective and scope														
Briefing about Chapter 3,4,5														
Submit logbook W6								MID-						
Literature Review								TERM						
Methodology								BREAK						
Schematic Diagram &Flowchart														
Testing Circuit & Simulation setup														
Experimental Review														
Submit Logbook W12														
Preparation for submit report PSM1														
Presentation PSM1														

Appendix B Gantt Chart for BDP2

Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Planning and Research														
Define Requirement and Features														
Research Components														
Buy Component														
Material Acquisition														
Submit logbook W6								MID-						
Circuit Assembly								TERM						
Wiring and Connection								BREAK						
Develop Sensor														
Testing Circuit														
Experimental Review														
Submit Logbook W10														
Preparation for submit Poster and Presentation														
Submit Report W14														

Appendix C Source Code

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Servo.h>

// Initialize LCDs
LiquidCrystal_I2C lcdGate(0x27, 16, 2);
LiquidCrystal_I2C lcdSlots1(0x25, 16, 2);
LiquidCrystal_I2C lcdSlots2(0x24, 16, 2);


Servo entryServo;
Servo exitServo;


int entryIR = 2;
int exitIR = 3;


int slotSensors[] = {4, 5, 6, 7, 8, 9, 10, 11};
int totalSlots = 8;
int slotsPerLCD = 4;
int Slots = 8;


int freeSlots = 8;


int ledSlots1 = 24;
int ledSlots5To8 = 22;

void setup() {

  Serial.begin(9600);


  lcdGate.init();
  lcdGate.backlight();
  lcdSlots1.init();
  lcdSlots1.backlight();
  lcdSlots2.init();
  lcdSlots2.backlight();


  pinMode(entryIR, INPUT);
  pinMode(exitIR, INPUT);
```

```
  for (int i = 0; i < totalSlots; i++) {
    pinMode(slotSensors[i], INPUT);
  }


  pinMode(ledSlots1, OUTPUT);
  pinMode(ledSlots5To8, OUTPUT);
  digitalWrite(ledSlots1, LOW);
  digitalWrite(ledSlots5To8, LOW);


  entryServo.attach(12);
  exitServo.attach(13);


  entryServo.write(90);
  exitServo.write(90);


  lcdGate.setCursor(0, 0);
  lcdGate.print("  SMART ");
  lcdGate.setCursor(0, 1);
  lcdGate.print("  PARKING SYS ");
  delay(2000);
  lcdGate.clear();

  lcdSlots1.setCursor(0, 0);
  lcdSlots1.print("  PARKING 1-4 ");
  lcdSlots1.setCursor(0, 1);
  lcdSlots1.print("  SYSTEM READY ");
  delay(2000);
  lcdSlots1.clear();

  lcdSlots2.setCursor(0, 0);
  lcdSlots2.print("  PARKING 5-8 ");
  lcdSlots2.setCursor(0, 1);
  lcdSlots2.print("  SYSTEM READY ");
  delay(2000);
  lcdSlots2.clear();
}

void loop() {

  updateFreeSlots();


  if (carDetected(entryIR)) {
    if (Slots > 0) {

      entryServo.write(0);
```

```
    delay(1500);
    entryServo.write(90);
    Slots--;

    lcdGate.clear();
    lcdGate.setCursor(0, 0);
    lcdGate.print("   WELCOME!    ");
    lcdGate.setCursor(0, 1);
    lcdGate.print("Slots Left: ");
    lcdGate.print(Slots);
    delay(2000);
  } else {

    lcdGate.clear();
    lcdGate.setCursor(0, 0);
    lcdGate.print("    SORRY :(    ");
    lcdGate.setCursor(0, 1);
    lcdGate.print("  Parking Full  ");
    delay(2000);
  }
}


if (carDetected(exitIR)) {

  exitServo.write(0);
  delay(1500);
  exitServo.write(90);
  Slots++;


  lcdGate.clear();
  lcdGate.setCursor(0, 0);
  lcdGate.print("   THANK YOU!   ");
  lcdGate.setCursor(0, 1);
  lcdGate.print("Slots Left: ");
  lcdGate.print(Slots);
  delay(2000);
}


lcdGate.setCursor(0, 0);
lcdGate.print("  ENTRY/EXIT  ");
lcdGate.setCursor(0, 1);
lcdGate.print("Slots Left: ");
lcdGate.print(Slots);


bool slots1To4Full = true;
for (int i = 0; i < slotsPerLCD; i++) {
```

```
  if (digitalRead(slotSensors[i]) == HIGH) {
    slots1To4Full = false;
    break;
  }
}


if (slots1To4Full) {
  digitalWrite(ledSlots1, HIGH);
} else {
  digitalWrite(ledSlots1, LOW);
}


bool slots5To8Full = true;
for (int i = 4; i < slotsPerLCD ; i++) {
  if (digitalRead(slotSensors[i]) == HIGH) {
    slots5To8Full = false;
    break;
  }
}


if (slots5To8Full) {
  digitalWrite(ledSlots5To8, HIGH);
} else {
  digitalWrite(ledSlots5To8, LOW);
}


lcdSlots1.clear();
lcdSlots1.setCursor(0, 0);
lcdSlots1.print("Slots 1-4->->");
lcdSlots1.setCursor(0, 1);
for (int i = 0; i < slotsPerLCD; i++) {
  if (digitalRead(slotSensors[i]) == LOW) {
    lcdSlots1.print("F");
  } else {
    lcdSlots1.print("E");
  }
  lcdSlots1.print(" ");
}

// Display slot status on the second LCD (Slots 5-8)
lcdSlots2.clear();
lcdSlots2.setCursor(0, 0);
lcdSlots2.print("Slots 5-8->->");
lcdSlots2.setCursor(0, 1);
for (int i = slotsPerLCD; i < totalSlots; i++) {
  if (digitalRead(slotSensors[i]) == LOW) {
```

```
    lcdSlots2.print("F"); // F for Full
  } else {
    lcdSlots2.print("E"); // E for Empty
  }
  lcdSlots2.print(" ");
 }

 delay(500);
}



bool carDetected(int sensorPin) {
 if (digitalRead(sensorPin) == LOW) {
  delay(500);
  if (digitalRead(sensorPin) == LOW) {
    return true;
  }
 }
 return false;
}


void updateFreeSlots() {
 int occupiedSlots = 0;
 for (int i = 0; i < totalSlots; i++) {
  if (digitalRead(slotSensors[i]) == LOW) {
    occupiedSlots++;
  }
 }
 freeSlots = totalSlots - occupiedSlots;
}
```