Faculty of Electronic and Computer Technology and Engineering

DESIGN AND DEVELOPING SMART RECYCLE BIN USING ARDUINO FOR WASTE SORTING

FARAH NABIHAH BINTI RAMLAN

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

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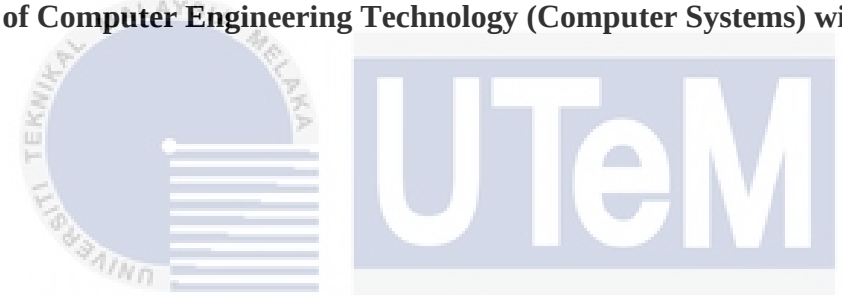
A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours



Faculty of Electronic and Computer Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

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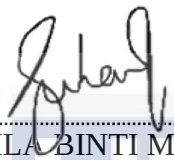
Signature : 

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Date : 14/02/2024

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Co-Supervisor :

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Date :

DEDICATION

First, I would like to sincerely thank several people and institutions for their assistance with my studies. This project is dedicated to my family, who have always been there for me through all my struggles and victories. Your affection and faith in my abilities gave me the drive to accomplish this goal. I am incredibly grateful to my family, whose unwavering support and selfless efforts made it possible for me to pursue my education. Your conviction in my potential has been my guiding light, and I am sincerely grateful for the ideals and perseverance you instilled in me.

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Thank you to my friends for being my pillars of strength during the trying times; your companionship brought me both joy and peace. Your support, understanding, and shared laughs have been a continual source of strength, enabling me to convert obstacles into successes and milestones. Your relationship has helped me through times of self-doubt and late-night study sessions. This journey has been made richer and more meaningful by your conviction in my talents and your willingness to share in both the successes and the setbacks.

Lastly, thank you to the Universiti Teknikal Malaysia Melaka for accepting me into the graduate program. I am grateful for the financial support through the Bachelor Degree Project (BDP) I and II, which enable me to accomplish the project.

ABSTRACT

As we all know, the fast rise of the Earth's population and the advancement of contemporary living have made environmental issues one of the most pressing concerns today. The only way to build a sustainable environment is to recycle everything that would otherwise wind up in the trash and turn it into something entirely new. We will be able to replace the conventional approaches to treating both old and new waste problems to achieve smart waste management with AI and machine learning. Increasing recycling rates was a global challenge since it can be difficult for consumers to determine which things can be recycled and which cannot. Therefore, the purpose of this project is to develop smart recycling bins for waste sorting. The objective of this project is to design and develop smart recycling bins using Arduino UNO for waste sorting. For smart recycling bins, in operation is using a sensor to make a sorting system to identify the trash based on metal, plastic and paper. This project also focuses more on the users using this smart recycle bin in homes. This smart recycle bin used an Arduino Uno as a microcontroller to control input and output system and it use a several sensors to create a sorting system such as inductive proximity sensor to detect metal-based waste, light dependent sensor (LDR) to detect the presence of plastic and paper based that can be integrated into the smart bin. Ultrasonic sensors are used to detect the level of bin usage. According to the study, smart recycle bins with automated isolation are more beneficial for usage by everyone. This intelligent container can be used by the users to inspire them to practice recycling habits. In a word, this approach effectively diverts waste, helps more people recycle and enhances the recycling bin system.

ABSTRAK

Seperti yang kita sedia maklum, peningkatan pesat penduduk Bumi dan kemajuan kehidupan kontemporari telah menjadikan isu alam sekitar sebagai salah satu kebimbangan yang paling mendesak hari ini. Satu-satunya cara untuk membina persekitaran yang mampan ialah mengitar semula segala-galanya yang sebaliknya akan berakhir dalam tong sampah dan mengubahnya menjadi sesuatu yang baharu sepenuhnya. Kami akan dapat menggantikan pendekatan konvensional untuk merawat masalah sisa lama dan baharu untuk mencapai pengurusan sisa pintar dengan AI dan pembelajaran mesin. Meningkatkan kadar kitar semula adalah cabaran global kerana ia boleh menjadi sukar bagi pengguna untuk menentukan perkara yang boleh dikitar semula dan yang tidak boleh. Oleh itu, tujuan projek ini adalah untuk membangunkan tong kitar semula pintar untuk pengurusan sisa. Objektif projek ini adalah untuk mereka bentuk dan membangunkan tong kitar semula pintar menggunakan Arduino UNO untuk pengurusan sisa. Untuk tong kitar semula pintar, sedang beroperasi menggunakan penderia untuk membuat sistem pengisihan bagi mengenal pasti sampah berdasarkan logam, plastik dan kertas. Projek ini juga lebih memfokuskan kepada pelajar yang menggunakan tong kitar semula pintar ini di kolej. Tong kitar semula pintar ini menggunakan Arduino Uno sebagai mikropengawal untuk mengawal sistem input dan output dan ia menggunakan beberapa penderia untuk mencipta sistem pengisihan seperti sensor jarak induktif untuk mengesan sisa berasaskan logam, sensor bergantung cahaya (LDR) untuk mengesan kehadiran. plastik dan bahan berasaskan yang boleh diintegrasikan ke dalam tong pintar. Penderia ultrasonik digunakan untuk mengesan tahap penggunaan tong. Menurut kajian itu, tong kitar semula pintar dengan pengasingan automatik lebih bermanfaat untuk kegunaan semua orang. Bekas pintar ini boleh digunakan oleh pelajar

untuk memberi inspirasi kepada mereka untuk mengamalkan tabiat kitar semula. Pendek kata, pendekatan ini mengalihkan sisa secara berkesan, membantu pelajar kolej mengitar semula lebih banyak dan mempertingkatkan sistem tong kitar semula.

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First and foremost, I would like to express my gratitude to my supervisor,Pn Nurliyana Binti Abd. Mutalib and co-supervisor, Dr. Suhaila Binti Mohd Najib for their precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) for the financial support through the Bachelor Degree Project (BDP) I and II, which enables me to accomplish the project.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In general, the smart bin nowadays is very popular among the world but for the smart recycle bin still did not know from many sides. Here I decided to do something that can help to reduce waste management and increase recycling among many people. This project aims more to student as they can practice recycling and the smart recycle bin suitable to put in the university. For sure, if they already practice it, no wonder they can implement it when they are outside. This project[1] some ideas to design and development this BDP project as I need to choose another way to make it more simplify and easier to get the better result. This project will use a component like sensor to detect waste while Arduino Uno as a microcontroller. To create the model, the project flow must be planned so that it moves in accordance with the algorithm that must be carefully considered. Additionally, a feature that makes the smart recycle bin more intriguing is necessary because it will be explored further in the following stage to do research on a related previous project. Making ensuring that the output of the model can identify the three different forms of waste detect metal, plastic, and paper to their respective bins is essential to the project's success. In essence, it is intended to be automatic segregation of the trash to their bin utilizing sensors that can be used by modifying their trial setup on the detect metal, plastic, and paper to their specific bin.

1.2 Background

The main goal of this project is to design and create a smart recycling bin for waste sorting. Using modern technology, the present recycling bin has been improved based on research and analysis, which will encourage more people to start recycling. A case study is done by referring to the summary analysis of the smart recycle bin in previous project. Besides, the functionality of the bin to separate the waste depending on the metal, plastic, and paper has also been tried in smart recycling bins. Additionally, this project provides an extra item that may be integrated into the recycle bin while minimizing the drawback that existed in the prior project. Additionally, smart recycling bins are created employing a variety of sensors to create a useful recycling bin. Mainly, the inductive proximity sensor and light dependent sensor (LDR) are used to detect metal, plastic, and paper. As the next step after the user feeds the object into the bin, these sensors are proposed to be placed at the top of the prototype. Therefore, the platform will rotate to the appropriate bin after the sensor picks up the object to isolate the waste in the proper bin. Before it is dropped into the bin, ultrasonic sensors are used to detect the level of the bin usage. Additionally, the system was designed to expand with several additional capabilities built in to support the smart recycle bin. For instance, the LCD display will be utilized to show which bins are full and require cleaning before the recycle bin operation is restarted from scratch. Finally, the project's input, processing, and output are handled by the Arduino uno, which serves as a microcontroller.

1.3 Addressing Global Issue for Smart Recycle Bin Project

Nowadays, recycle issue is one of the most common problems that always happen in every country especially in Malaysia. Because recycling practices have not been integrated into daily life, Malaysia loses roughly RM476 million worth of recyclable

resources per year [2]. It may be possible to organize a recycling drive in our neighborhoods or at school to stop this problem from getting worse. For instance, it can encourage more individuals to collect and bring bottles, glass, and plastic to their neighborhood recycling facility. The best way is smart recycling bin project can be a critical intervention as it aids in waste management. To make it easier for metal, plastic, and paper to be separated before being collected and delivered to a recycling facility, this project includes three different types of bins. Automated isolation for the three types of recyclable objects is part of the smart recycling bin project's design. Additionally, the recycling bin project also has the capability to detect levels of bin usage so that it is simple to determine whether the bin needs to be cleaned. Overall, a smart recycle bin project can be a potent weapon in the fight against the society recycling issue as it is providing three types of bins for metal, plastic and paper that can help many people to recycle waste.

1.4 Problem Statement

There are several challenges faced based on finding ways to design the smart recycle bin and produce an efficient solution in facing all the problems. Finding ways to construct the smart recycle bin and come up with effective solutions to the issues is fraught with difficulty. The common problem that always happens is to isolate all the trash to be dropped into the three types of bins based on metal, plastic, and paper. This problem is not easy to solve because it does not have a specific sensor that can be used to detect the following rubbish, especially have a problem in detecting plastic and paper. However, to solve this problem, the previous project used three types of different sensors to detect rubbish for metal, plastic, and paper. In this way, it uses the frequency of the specification of the rubbish of paper and plastic to detect it by using a sensor. In addition, the problem can be resolved by using a variety of sensors, but it is difficult to determine the precise information for each

piece of trash since it has unique features that require further research in earlier projects for smart recycling bins or projects that utilize the same sensor. This smart recycle bin must be designed to function properly based on its functional ability to automatically isolate all the trash into the designated container. Therefore, to overcome this problem in the smart recycle bin project, it can be designed by using one sensor to detect the specific thing that can make a comparison. For example, use a light dependent sensor (LDR) to detect light intensity in detecting plastic and paper rubbish.

1.5 Project Objective

The aim of this project is to design and develop a smart recycle bin using Arduino uno for waste sorting. The goal of this thesis should be fulfilled for it to serve as the basis for constructing this project.

Specifically, the objectives are as follows:

i. To study the current features of the recycling bin to make an improvement.
ii. To develop a smart recycling bin that can isolate rubbish based on metal, plastic, and paper.
iii. To analyze the performance of the smartrecycle bin to detect the level of the bin usage.

1.6 Scope of Project

The scope of this project are as follows:

a) Smart recycle bin that can isolate the three type of the rubbish which are metal, plastic and paper.
b) Arduino Uno as a microcontroller that has ATmega2560 that being a processor in this project.

c) Light Dependent Sensor (LDR) is use to detect the paper and plastic that the light comes based on the brightness from surroundings environment.

d) Inductive Proximity Sensor is use to non-contact detection of metallic objects.

e) Servo Motor that use to rotate to the specific bins to give a way for waste to drop into the bin.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review was conducted as part of the Design and Development of Smart Recycle Bin utilizing Arduino for Waste Management process to verify that the system built appropriately reflects both the benefits and drawbacks of the technology. Numerous studies on the deployment of the Smart Recycle Bin have been conducted to ensure that this project develops smoothly and without many barriers. These studies looked at the advantages and disadvantages of various options when this project was being created. The implementation of this project can use the flaws discovered in the system that was previously implemented as a guide to fix these issues. A literature review provides details on the various applications that can be used to upgrade a system or application, add new features, or both. In addition, literature evaluation can be a source of inspiration for brand-new features that will set this app apart from the competition and make it more intriguing than the competitors. In addition, the way we learn and compare each project to its predecessors will aid us in determining the optimum strategy for project success.

2.2 Understanding Global/Current Issue in the Literature

Through a review of the literature on smart recycle bin project and project that use a sensor. Based on the observation, it works towards solving the global issue of recycling waste. In other words, it might be one of the planned in future of recycling. In addition, only 9% of plastic in the world gets recycled [3] and it is not easy to make a zero-waste vision as humans do not think recycling is important in our daily life. Mostly, the developer that

designs the previous project that I have been researching will mostly talk about the global issue in problem of recycling. The starting point of the most important project will make a global issue in recycling as the intro of the project to give users that read their thesis understand what exactly they do for future in recycle problem. In conclusion, they planned to design and develop solutions to recycle problem by make a smart recycle bin for everyone can use in many places.

2.3 Literature Review

2.3.1 Smart Solid and Wet Waste Management System

The smart solid and wet waste management system is designed to separate garbage into biodegradable and non-biodegradable waste, according to [4].Then, a conveyor belt with a variety of sensors attached to it is used as part of the sorting system to detect different kinds of materials. The main part of this system is driven by a microcontroller which is Arduino UNO. Examples of functionality in this system include automated bin level detection, scent detection, and automated message and notification sending. As we can see, the majority of projects that are comparable to this one typically employ a system like using a mobile application to send an alert to the user when the waste has reached the maximum amount. This technology will lessen the workload associated with garbage separation by hand. In addition, an odour sensor based on an odour system is utilized as an indication alert to dispose of garbage when a bad stench appears and when the trash can is full. The development of technology will also aid in this essential aspect of achieving environmental sustainability.

2.3.2 Portable Waste Capacity Detection System Using Android Based Arduino

Based on the [5], the portable waste-based capacity detection system using android based Arduino can help the trash owner monitor the trash capacity that will be easier to user for not having to check all the bin one by one. Figure 2.1 shows a diagram system that explains the block diagram of the system. The system has been put through its paces by filling trash cans to various levels, including empty, small, medium, almost full, and full. The goal of this project is to enhance the benefits of connected internet connectivity through the Internet of Things (IoT) concept. The creator of this system gathered all the information through literature research in order to determine which component would be best for this project. It also has a number of stages, including the stages for system design, tool production, application creation, and system testing. This system's procedure differs from other procedures in that it goes through each stage one at a time to prevent issues.. In addition, this project also employs a use case design to make it simpler to comprehend how it functions.

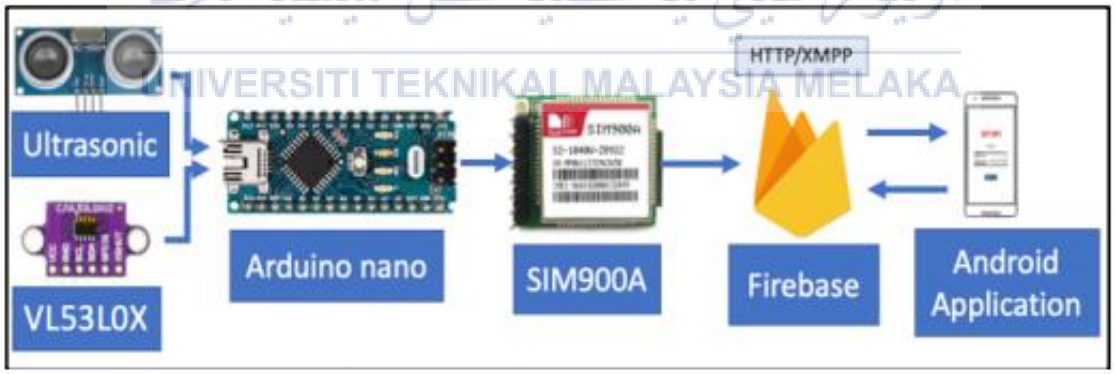

Figure 2.1 Diagram system[5]

2.3.3 Smart Bin for a Smarter City

The perfect smarter bin for a smarter city, according to [6] was from the national smart city by the government of INDIA honors smart city. For proper operation, the Arduino board has coded each sensor. Based on this approach, we can see that the sensor's ability to

identify objects is dependent on its coding and functioning. Figure 2.2 is the flowchart of the proposed smart bin operation that will explain in this summary. For instance, it uses an ambient light sensor to measure the amount of light present. Then, to determine whether the trash can is full or not, this system also uses an ultrasonic sensor to measure the distance of the trash in the can by delivering a wave that reflects. Move on to the gas sensor's operation, which is based on the density of gases. If the maximum amount of gases released from the bin exceeds a specific level of density, the gas sensor is triggered. This method is intended to assist prevent sanitation personnel from inhaling the dangerous gas released by wet solid household waste that has been placed.

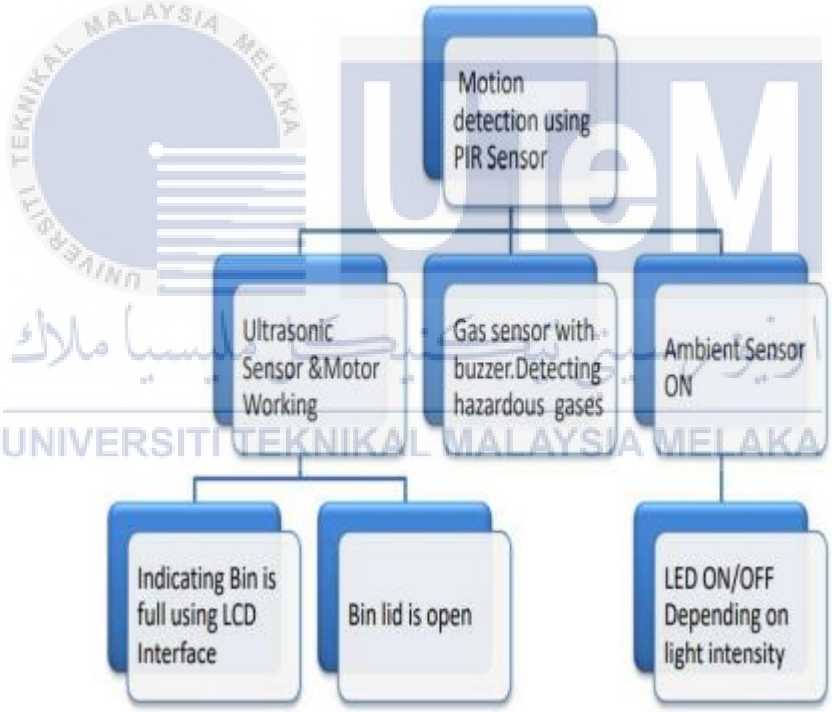

Figure 2.2 Flowchart of the proposed smart bin operation[6]

2.3.4 Sorting System for e-waste recycling Using Contour Vision Sensor

The rapid sorting approach created for waste management is the main emphasis of the [7] sorting system for recycling e-waste employing contour vision sensors. One component at a time was transported via a conveyor belt for sorting. The articles from the

conveyor belt are positioned into distinct bins using this system's four electro valves with directional air flow control. A component is detected by the vision sensor during the sorting process while it moves along the conveyor belt. When the output is connected to a Mitsubishi Electronic PLC's digital inputs, it will then represent at a low or high level depending on the binary code. This project system has the ability to separate some parts from a broken-down PC motherboard. According to the literature studies, more waste might be separated based on material categories with a more complicated conveyor belt, sensor and camera system. Figure 2.3 show a how the model of the complex sorting system will be design

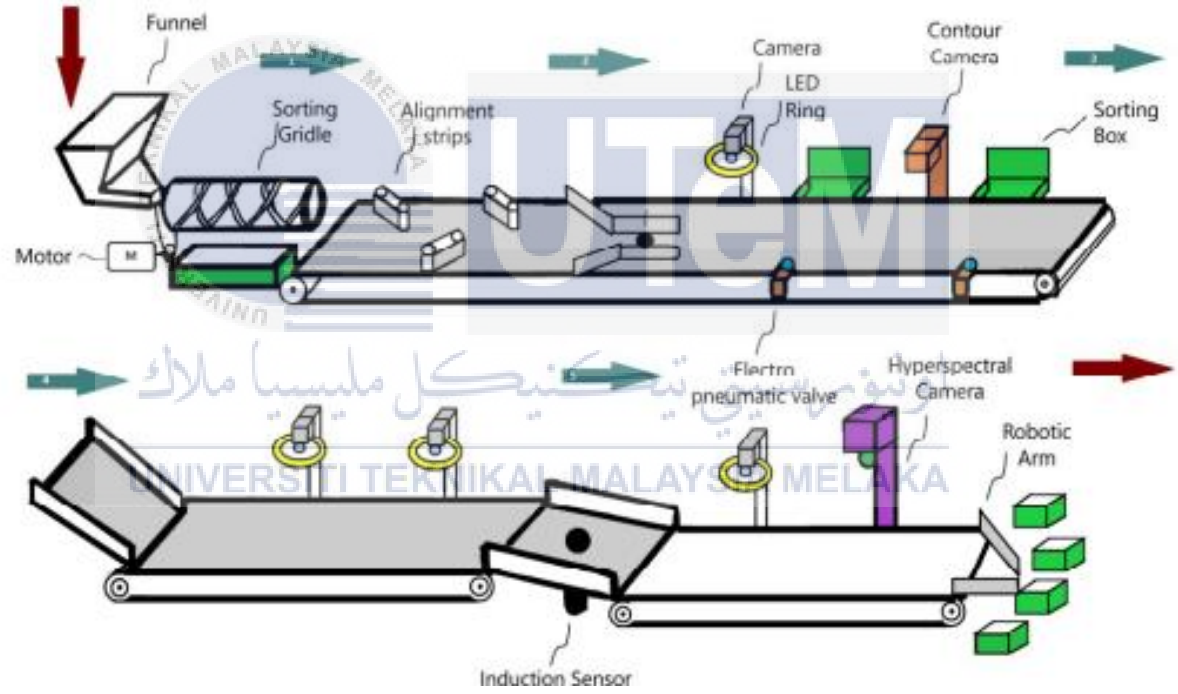

Figure 2.3 Complex sorting system for dismembered e-waste components[7]

2.3.5 Reverse Vending Machine using TCRT5000 and Inductive Proximity Sensor for Bottles and Cans Sorting

The reverse vending machine using TCRT5000 and inductive proximity sensors for sorting bottles and cans has been built as a trash bin as a Reverse Vending Machine (RVM), according to [8] .This project differs from others in that it offers incentives to users who

recycle their bottles and cans. The incentives were determined depending on the total number of bottles and cans that were placed inside. In this project, the ultrasonic sensor checks the RVM's trash bin while the LED alerts the user when the bin is full or not. In addition, designing and deploying an RVM that can compensate individuals for throwing trash into it is another important step.

2.3.6 Research on the Design of Household Intelligent Sorting Garbage Bins Based on Raspberry Pi

The research on the design of home intelligent sorting garbage bins based on raspberry pi was a smart garbage bins to automatically recognize the recyclable waste, according to [9]. With a revolutionary system that operates steadily and properly, this initiative lessens the resource waste of conventional trash cans. Based on this concept, a Raspberry Pi is used as the primary controller, interpreting the picture data supplied by the USB camera and controlling the servo to carry out the necessary sorting activities, which leads to the realization of intelligent garbage sorting. In a nutshell, this smart waste bin simulation solution uses an Arduino development board, Raspberry Pi, and image recognition. Based on the observation, it can be concluded that the design of the trash can is sensible, successfully alleviates people's anxiety over rubbish sorting, and enhances their quality of life. Figure 2.4 show the overall of the system structure in block diagram.

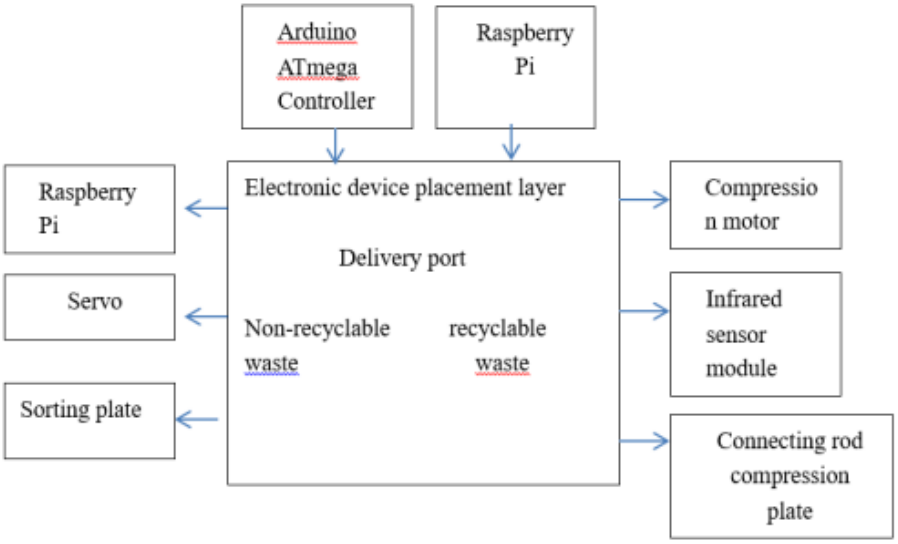

Figure 2.4 Overall system structure[9]

2.3.7 Environmental Monitoring and Smart Garbage Sorting System Based on LORA Wireless Transmission Technology

For the [10] claim that the development of an environmental monitoring and smart garbage sorting system based on LoRa wireless transmission technology helped to reduce littering in the city. This system is deployed in various areas to sort recyclable waste. From this system, we may learn how Lora WAN communication networks are integrated. Additionally, it uses proximity sensors of the electrostatic capacitance variety to identify the types of trash dumped in trash cans. Additionally, this project makes use of a C# graphical monitoring interface to remind users to remove the trash. In more detail, this project involves using a Lora WAN wireless communication network to enable two-way communication between terminal nodes and gateways, opening and closing its garbage insertion point, performing environmental sensing to obtain regional parameters, and more. Additionally, this study actively developed a waste system rather than passively establishing one based on people's habits by introducing it.

2.3.8 Waste Sorting System using Binarized Neural Network

For the [11] claim that the binarized neural network-based garbage sorting system was developed as a tiny, low-complexity network structure that could be installed on embedded devices with limited resources. For accurate garbage classification in this research, a binarized neural network (BBN) is utilized. According to fig. 8, this model has two FC layers and two convolutional layers, and each convolutional layer's output size is equal to the output fmap size multiplied by the output dimension. The gathered trash photographs were sent to the cloud for recurring training, and network settings for the embedded device were updated to give the entire system access to online learning. Figure 2.5 show the model how the sorting garbage will be designing.

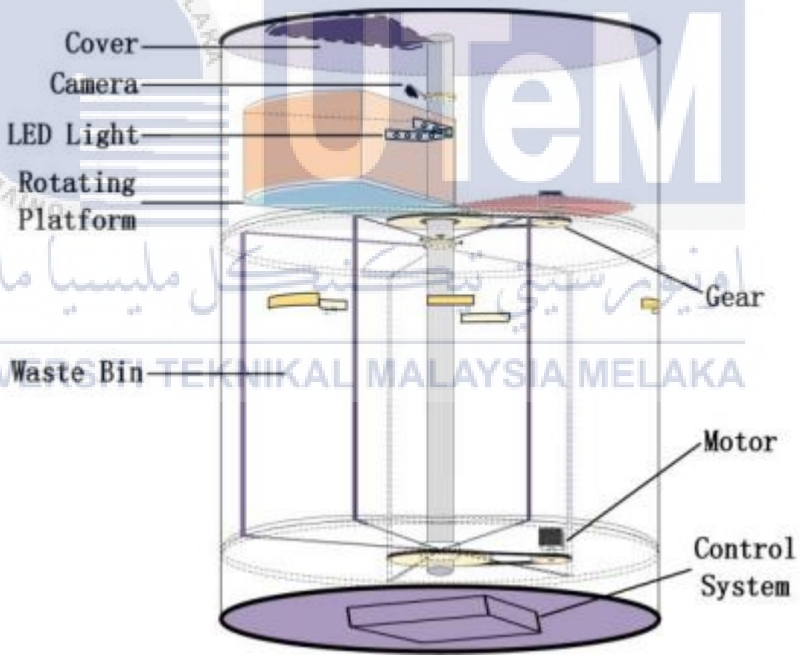

Figure 2.5 The sketch of the garbage classification system[11]

2.3.9 Design and Assembly of a Smart Recycle Bin

For the [1] describe the design and assembly of a smart recycling bin that Enviro-Bin implemented in accordance with the following material types: metal, glass, and paper. It's because we want to promote recycling and lessen the quantity of hazardous emissions

produced when rubbish is burned. This project uses a variety of sensors to sort rubbish and gauge the amount of waste in the container. It has four bins, three of which correspond to the aforementioned sorts of material and the fourth is for undetermined materials. When the sensor is unable to identify the type of material, it aids in sorting. The other characteristic is that when a compartment is full, sensors connected to LEDs in each compartment turn them on. Additionally, it has an Enviro-Bin mobile application that is utilized to alert users when a compartment's maximum level has been reached. According to the project, they created a testing procedure to evaluate the sensor's functionality. They found that using a capacitive sensor to detect plastic was less effective, thus it was changed to a color sensor as a result. Its replacement led to a 70% boost in sorting efficiency for plastic objects. In addition, users were drawn to this Enviro-Bin's design because it works with various kinds of houses. The mobile application served as a supporting system to make it more user-friendly because it will be simple for users to keep an eye on a compartment when it becomes fully because the system will alert them.

2.3.10 Prototype Smart Door Lock by using Wireless Network Based on Arduino UNO

The prototype smart door employing a wireless network based on an Arduino Uno was created to defend the home from intruders, according to [12] .The Arduino IDE software now includes a Telegram app that can be used to connect and serves as a notification system for when a door to a house or room is opened. In this project, we discover that the Arduino board will automatically pull power from the AC adapter if electricity is supplied through the USB port and AC adapter at the same time. The Arduino Uno microcontroller may communicate and direct the tool to operate in accordance with the algorithm specified in the programmed. Figure 2.6 show that the block diagram of the project that it is a summarize of it as it have the flow of the process.

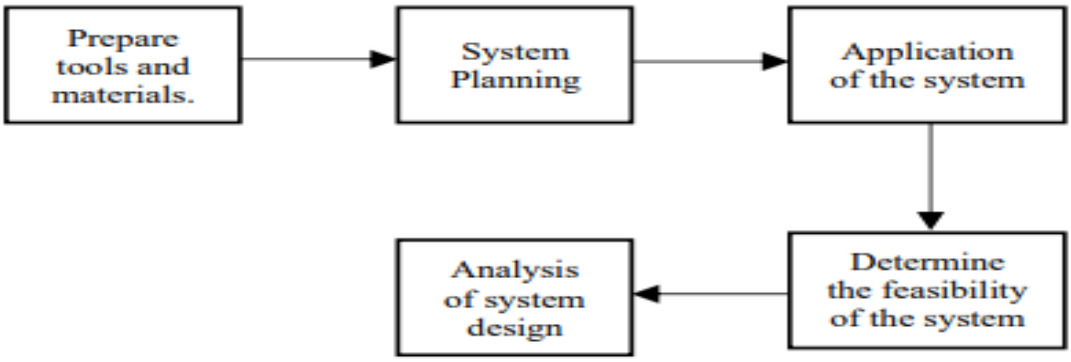

Figure 2.6 Research block diagram[12]

2.3.11 Iot System Implementation for ATmega328 Microcontroller based Home Door Control

The IoT system implementation for ATmega328 microcontroller-based home door control was created to be utilized automatically and is based on the [13] .The ATmega328 microcontroller in this project will switch on when the system automatically supplies electricity. It is not an issue that this project employs the ATmega328 to build the system because, as can be seen, the Arduino Uno is a circuit board based on the ATmega328 microprocessor. The outcome showed that the proposed ATmega328 microcontroller-based home door could operate effectively by receiving some commands supplied by cellphones to open the entrance.

2.3.12 Infrared Line Following and Ultrasonic Navigating Robot with ATmega328

The infrared line-following and ultrasonic navigating robot with ATmega328 pro was created to create an Arduino robotic car with a variety of features, including line-following, ultrasonic navigation, and automatic parking, according to [14]. In contrast to other projects, this one uses battery boxes to power all of the peripheral devices and an energy power source to switch on the ATmega328.

2.3.13 Sensor Design for Inductive Proximity and Moving Direction Sensing of Metal Targets

The sensor design for inductive proximity and moving direction detection of metal objects was created based on the [15] in order to detect metal and their direction of movement. For the purpose of detecting various metal targets, including copper, brass, aluminum, and stainless steel, a full hardware prototype has been created. The near-field magnetic field produced by the sensor board was simulated, and hardware measurements were found to agree with those calculations. Figure 2.7 shows how the flow of the project to make it more easier to understand.

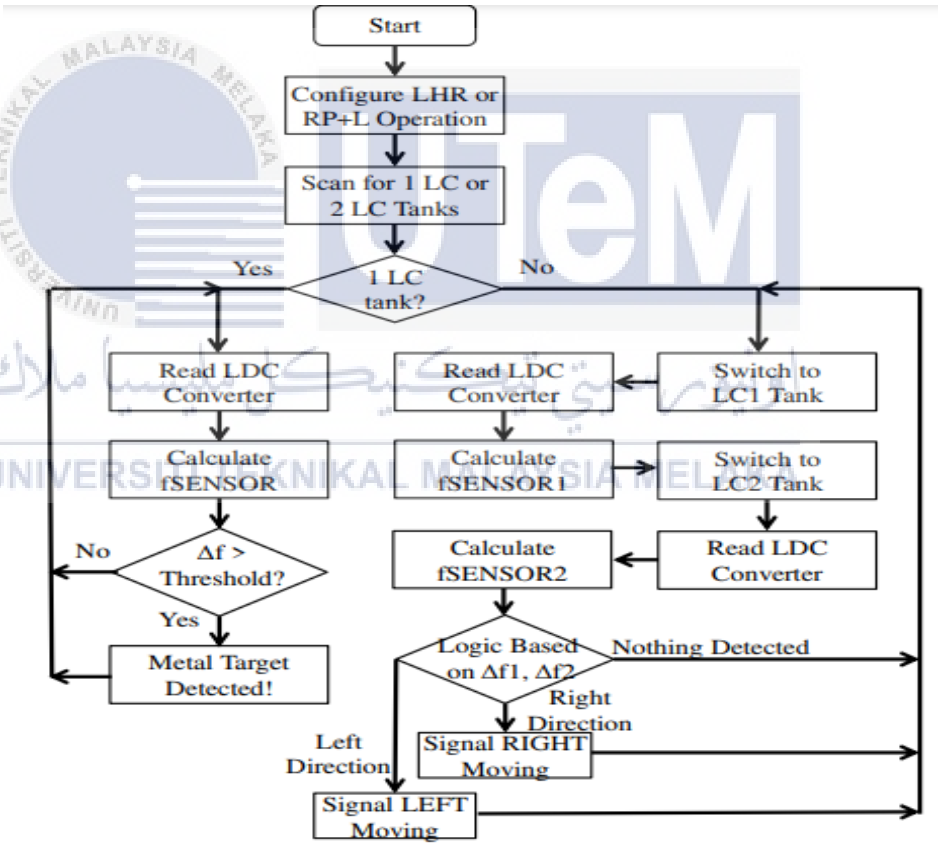

Figure 2.7 Flowchart of the intelligent firmware executed on the microcontroller[15]

2.3.14 Development of Low-Cost Soil Moisture Soil

For the [16] state that the capacitive measurement technique was used in the creation of a low-cost soil moisture sensor due to its advantages in terms of low cost and high

sensitivity. In order to employ the capacitive type soil moisture sensor in future projects, we learned how it works from this. The amount of charge retained for a specific electric potential is measured by this capacitive type soil moisture sensor. Using probes related to the dielectric constant, the soil moisture was measured as the capacitance between the two electrodes. This capacitive type soil moisture sensor is very accurate, affordable, and simple to use. According to the finding, the capacitance was relatively low at high frequencies and changed significantly at low frequencies. Figure 2.8 shows that the model of the project to be as a expected output.

Figure 2.8 Experimental Setup using Capacitive type soil moisture sensor and[16]

2.3.15 Wireless Power Transfer Through for Energizing an Underground Soil Moisture Sensor

According to the [17] , the wireless power transfer through soil for energizing an underground soil moisture sensor was designed to measure result of an inductively coupled power transfer system using a soil moisture sensor. For this project, we learnt how the soil moisture sensor functioning so from that we can implement in our project to avoid from

happen any issue. The received RF power was sufficient to energize a soil moisture sensor, thus enabling an underground batter-less sensing operation.

2.3.16 Smart Trash Can System with Ultrasonic Sensor and Flame Detector using Arduino

According to the [18] ,the smart trash can system with ultrasonic sensor and flame detector using Arduino was designed to offer an intelligent garbage bin monitoring gadget that includes many sensors to monitor garbage status. The example sensor that use in this project are level sensor, temperature and humidity sensor, flame sensor, moisture sensor and opening sensor. This Smart Waste Bin that offers smart trash system technology that reduces human time and effort and leads to a healthy, and waste-free environment. This method informs municipalities better about the state of waste at the waste bin site when the rubbish status is complete.

2.3.17 Automatic Garbage Classification System using Arduino Based Controller and Binary Tree Concept

Based on the [19] a system with an automatic door, a garbage sorter, a user interface, and a capacity observer made up the automatic garbage classification system using Arduino and the binary tree concept. Three different types of sensors are used in the testing procedure to evaluate how well the automatic garbage classification system performs when sorting rubbish using the binary tree idea. This project claims that it is made up of metal, glass, and plastic bottles. Reduced waste disposal and garbage pollution of groundwater are the effective garbage classifications. Additionally, it can enhance the standard of living. This project's design was only intended to classify metallic and non-metallic waste, hence it cannot classify other sorts of garbage. By putting in place a control system that regulates input variable values and generates the desired output variable Value, the automatic process

of garbage classification system was successfully implemented. To implement a smart waste management system, a decision tree based on artificial intelligence was developed, but it was not as simple as ABC since it had nodes that indicate the attribute, branches that express the attribute's value, and leaves that are present to the class. When this tool makes a decision, there will only be a maximum of two possible outcomes. According to the project, it provides instructions on how to construct a smart recycle bin system and add additional features, such as an alarm system with a buzzer that will ring and an LED that will light on when the garbage level reaches a certain level. Figure 2.9 shows the block diagram of the Arduino Based Controller for all the process in the project.

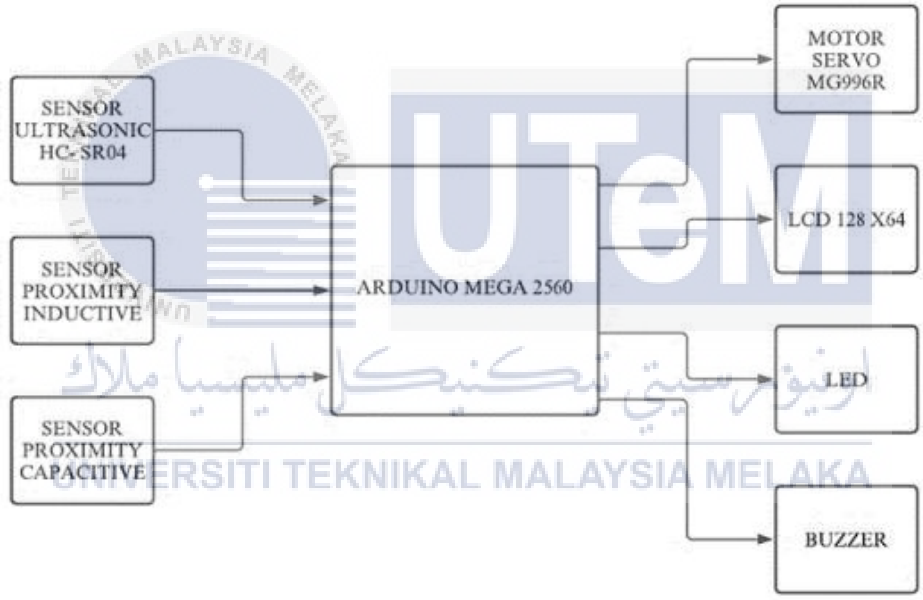

Figure 2.9 Block Diagram of the Arduino Based Controller[19]

2.3.18 Design of an Intelligent Waste Separator with the Combination of Different Sensors

The design of an intelligent waste separator with the combination of various sensors was created to separate solid wastes into four categories, according to the [20].This project creates process testing that demonstrates the distinct behavior of each component and the overall effectiveness of the device that achieves at least 75% overall effectiveness. This

technique separates the metals, plastics, and papers that are put in the trash can, making it simple to clean and preserve the environment in a private setting, such as at home. Figure 2.10 show the final assembly of the system for the project model.

Rajah 2.10 Final Assembly of the system[20]

2.3.19 Automated Waste Segeration Bin IoT based Mobile Monitoring Application

According to the [21] was design to separate waste into three categories wet, dry, and metal an autonomous waste segregation bin with an IoT-based mobile monitoring application was developed. Information about the operation of the bin was transmitted using a mobile application. Based on this research, a prototype was created to demonstrate the functionality of the system's overall accuracy and precision. We can see that this project was put into place for trash management, using a technology that automatically separates garbage inside waste bins, making it suitable for smart private units like homes, offices, and schools. This study's restriction is to offer a system in tiny area units. The project puts out the concept of an Internet of Things (IoT) using wireless sensor networks and mobile apps. We may learn from this project how testing is conducted when garbage is sorted into dry and wet metal categories. Last but not least, the use of sensors and a cloud connection were

effectively integrated to separate garbage and check on bin status. This project has an extra sensor that checks the container weight when it is already full. Additionally, it has the ability to change the way the trash can opens, reducing human error when disposing of trash.

2.3.20 IoT Based Automatic Waste Segregator

The IoT-based automatic trash segregator was created, according to [22] to minimise human participation in the process of garbage segregation while yet ensuring effective segregation of waste. The home waste is detected by this system, which separates it into dry, wet, and metallic waste. Monitoring the amount of trash in the trash cans in real time is also important. It employs an ultrasonic sensor to identify approaching garbage and a metallic sensor to identify the presence of metal. Additionally, this invention uses a capacitive sensor to distinguish between trash that has dry and moist residue. If the trash can is full, an LCD screen will display an instruction to clean using GSM and Arduino. The experiment's findings show that waste is separated into metallic and non-metallic waste. Figure 2.11 is the block diagram of the project that have list all the component and microcontroller that have been used.

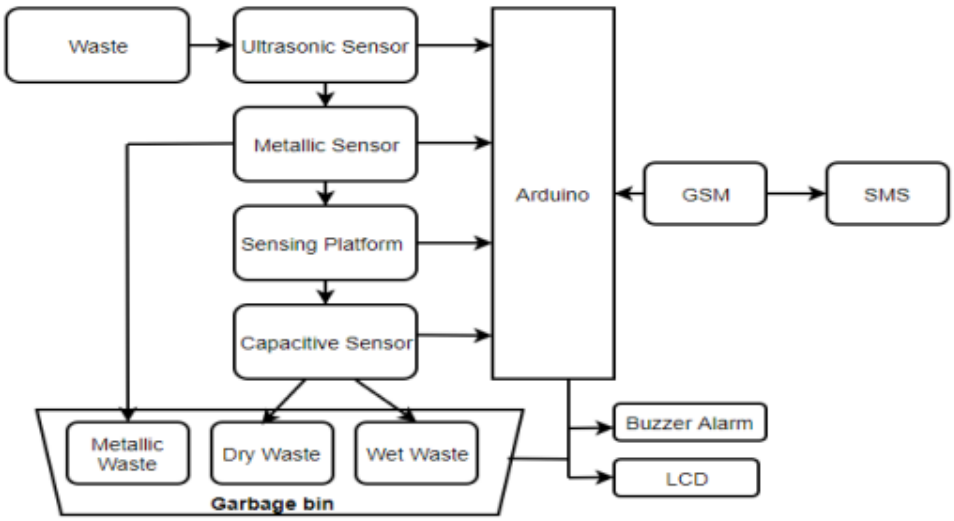

Figure 2.11 Block diagram of IoT based automatic waste segregator[22]

2.4 Discussion

With all the data obtained, it is clear how crucial this system is to help waste management to improve quality hygiene in this country. Furthermore, data collecting and two-way communication are this system's most crucial features. All information obtained, including data collecting and the types of the variety sensor used in the previous project will be examined to guarantee the system's performance.

2.5 Comparison Table

Table 2.1 Comparison Table

Author/Years	Project title	Platform	Sensor/Component	Advantage	Disadvantage
Rajapandian B, Akshaya D, Tamilselvi T, Dilli Rani D, and Divya N (2022)	Smart Solid And Wet Waste Management System	Arduino UNO	Ultrasonic Sensor	To make a simple to dispose the collected waste	Dustbin are custom in separately that will cost the project
Gusti Made Ngurah Desnanjaya, Made Aditya Nugraha, Ida Bagus Gede Sarasvananda, and Ida Bagus Ary Indra Iswara(2021)	Portable Waste Based Capacity Detection System Using Android Based Arduino	Arduino Nano	Ultrasonic Sensor, VL53LOX	Help trash owner monitor trash bin capacity	Focus on one main place area only
Kolachalama Venkata Naga Sreya, Rengarajan Amirtharajan, and Padmapriya Praveenkumar (2022)	Smart Bin For A Smarter City	Arduino	Ultrasonic Sensor, Gas Sensor	Automatic open and close the bin at appropriate timings and monitor the bin's level	Do not have sorting machine for the trash

Author/Years	Project title	Platform	Sensor/Component	Advantage	Disadvantage
Rapolti Laszlo, Rodica Holonec, Romul Copindean and Florin Dragan (2019)	Sorting System for e-Waste Recycling using Contour Vision Sensors	Mitsubishi FX3G	Contour Camera	Conveyor belt used to transport the component one by one to sorting when through the contour camera	Difficult to use a conveyor when the project are display at the public place.
Joni Welman Simatupang, Vincent and Shulhan(2022)	Reverse Vending Machine Using TCRT5000 and Inductive Proximity Sensors for Bottles and Cans Sorting	Arduino Uno R3	Inductive Sensor, TCRT5000 Sensor, Ultrasonic	The ability to detect bottles and cans and rewards for the person	Just only focus to the bottles and cans
Aiqin Lin (2021)	Research on the Design of Household Intelligent Sorting Garbage Bins Based on Raspberry Pi	Raspberry pi	USB Camera	Software and hardware design ideas of garbage bins in the implementation process	Need a smoothly algorithms in implemented on Raspberry Pi.
Chun-Yen Chung, I-Ting Peng and Jong-Chao Yeh (2020)	Environmental Monitoring and Smart Garbage Sorting System Based on LoRa Wireless Transmission Technology	LoRa wireless transmitter	Capacitance-type proximity sensors	Can be used in various locations to help waste management	Need to create a LoRaWan environmental monitoring

Author/Years	Project title	Platform	Sensor/Component	Advantage	Disadvantage
Mingmei Wu, Wei He, Yingcheng Lin, Li Li, Songhong liang and Xichuan Zhou (2020)	Waste Sorting System Using Binarized Neural network	Binarized Neural Network (BNN)	Camera	Small and low complexity network structure deployed to resource-limited embedded devices	This country do not familiar with the Binarized Neural Network (BNN)
Kholidiyah masykuroh, Afifah Dwi Ramadhani, Fikra Titan Syifa, Danny Kurnianto, Gatot Rizky Setiyanto and Nanda Iryani(2021)	Prototype Smart Door Lock By Using Wireless Network Based On Arduino Uno	Arduino Uno	PIR Sensor	Telegram application was added , connected through the Arduino IDE to notify when door is open	Do not have database system when using a biometric function like fingerprints as it easy to remember the owner.
Yamato Tan, Mochamad Yunus, Anton Setiaji, Mufid Ridlo Effendi, Evyta Wismiana and Achmad Munir(2019)	IoT System Implementation for ATmega328 Microcontroller Based Home Door Control	ATmega328	Wi-Fi NodeMCU ESP8266 module	Use a electricity supply to turn on the ATmega328 microcontroller	Control system can accept orders to open/close gate depends on speed of internet connection
Yuhang Tian and Gengwu Du (2019)	Infrared Line Following and Ultrasonic Navigating Robot with ATmega328 Pro	ATmega328	IR reflective sensors and Ultrasonic Sensor	The both sensor used for detecting the distance and parking line that detect final parking area	Do not add features to control robot using a remote control

Author/Years	Project title	Platform	Sensor/Component	Advantage	Disadvantage
Cristinel Ababei and James E. Richie (2021)	Sensor Design For Inductive Proximity and Moving Direction Sensing of Metal Targets	ATmega32p	Inductive Proximity Sensor	Detect metal targets and their direction of movement	Not integrate the capability of detecting both metal and non-metal target into proposed sensor design
Sheng Ding, John Sanches, Aidan Jackson, Shad Roundy, Ramesh Goel, Cody Zesiger and Darrin J. Young (2022)	Wireless Power Transfer Through Soil for Energizing an Underground Soil Moisture Sensor	Soil Moisture Sensor	Soil Moisture Sensor	Transfer the wireless power through soil	Implemented the sensor function based on the circuit
Preeti Verma and Anil Kumar Shukla (2021)	Smart Trash Can System with Ultrasonic Sensor and Flame Detector Using Arduino	Arduino	Ultrasonic Sensor	Automated waste monitoring system based on Arduino sensor	Do not explain detail about the function of the Ultrasonic Sensor
Ginas Alvianingsih, Tri Wahyu Oktavianna Putri and Danu Azhar Hidayat (2022)	Automatic Garbage Classification System Using Arduino-Based Controller and Binary Tree Concept	Arduino Mega 2560	Ultrasonic Sensor, Inductive Proximity Sensor and Capacitive Proximity Sensor	Use a sensor to sorting the trash	Only one trash can be throw into bin at a time
Raul Alberto Davila Vega, Mauricio del Hoyo de la Serna, David Meza Herz, David Jurado Martinon,mariade LourdesMenendez Gomory, Alan Gerardo Perez Martinez, Hiram Ponce and Jorge Brieva (2021)	Design of An Intelligent Waste Separator With The Combination of Different Sensors	Arduino	Ultrasonic Sensor, Inductive Proximity Sensor, Capacitive Proximity Sensor and Infrared Sensor	Determine the category to which the inorganic waste belongs	Cannot separate the paper waste

Author/Years	Project title	Platform	Sensor/Component	Advantage	Disadvantage
Jessie R. Balbin. Irish Joy N. Maliban and Joshua Mark A. Marquez (2021)	Automated waste Segregation Bin With IoT-Based Mobile Monitoring Application	Arduino Mega	Inductive Proximity Sensor and Capacitive Proximity Sensor	Segregates waste into three division like wet, dry and metal	Difficult to classification the wet and dry trash
Snehal Lopes and Sweedle Machado (2019)	IoT Based Automatic Waste Segregator	Arduino	Ultrasonic Sensor, Capacitive Sensor and Metallic Sensor	Isolation of waste into metallic and non-metalic	Do not specific example of the trash that use in this project as a experiment thing

2.6 Summary

The smart recycles bin system's outcome for the project must be correct because it reflects lowering the recycling problem. The literature review aids in expanding one's knowledge of the elements employed in other projects, even those that are not exactly like my BDP project. The issue is that without further investigation into other past projects to gain more insight into what sensor can be utilized soon, it may be challenging to detect paper and plastic. According to the research, an Arduino Uno is mostly used to create and construct smart recycle bin, and the metal detection sensor is simple to recognize because it already has a sensor that can detect it. In conclusion, conducting research has given me more ideas for structuring my project.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This approach describes the methods used to choose, categorize, organize, and analyze the material and data that were relevant to the research in the preceding project. The project's goal is being accomplished using a strategy that will produce an ideal outcome. The flow chart plays a crucial role in outlining the workflow required to complete the task as it will direct in completing the assignment. Additionally, this method will describe more about concept generation in this chapter. I made the decision to utilize a block diagram to quickly explain the idea behind this project because it allows us to view the IPO concept which are input, process, and output. After that, the choice of materials must be made before fabrication process. This is done in order to choose the best material to employ. Figure 3.1 show the flow in completing all chapter of Bachelor Degree Project 1 (BDP1).

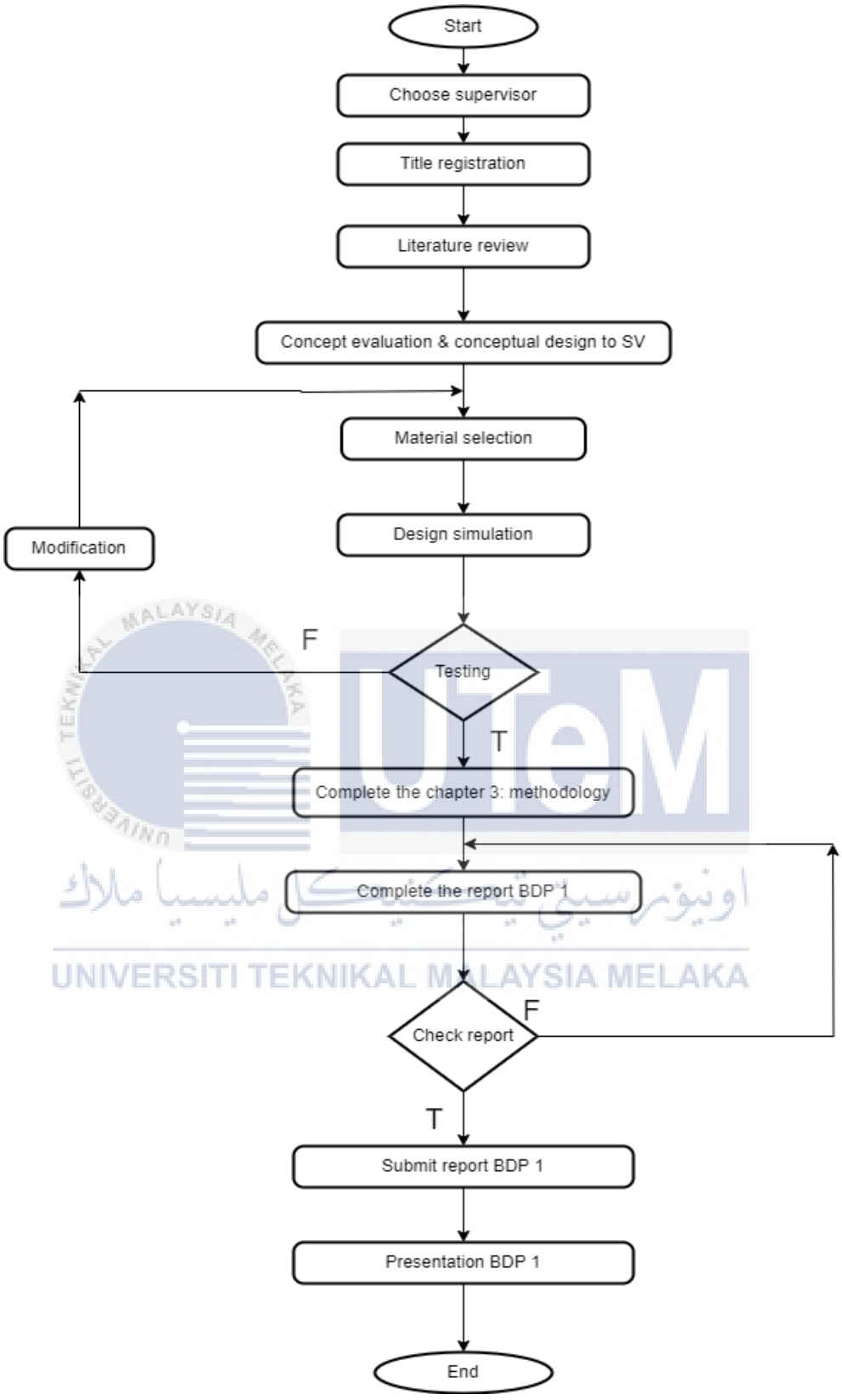

Figure 3.1 Flow chart BDP1

3.2 Selecting and Evaluating Tools for a Smart Recycle Bin

In designing and implementing a smart recycle bin, it is important to carefully select and evaluate the tools and technologies that will be used to collect and analyze data. This includes the specific tools that can be used in this project as it will not have a bad effect when implementing it in the project integrated process. This is because it is necessary to look at the accuracy of the sensors used in identifying the three types of rubbish. Additionally, it is important to consider that the data input and the displaying output are easy to understand and identify whether the output is true or false. From that, it can make some differences summary on this project as it will be as an additional feature in part of improvement the project and considering the costs and benefits of different tool selections. To support these methodological considerations, there are a range of approaches that can be used, such as making a simulation circuit for all the sensors use that need to be connect soon with the Arduino uno as it can be as an expected output for this project. From that it can help to choose whether the equipment chosen is suitable or not. By carefully selecting and evaluating tools for a smart recycling bin project, research and analyze all the similar previous projects can help to design a functional recycle bin. Figure 3.2 shows to better grasp the project's details, a block diagram was created using the input, process, and output method.

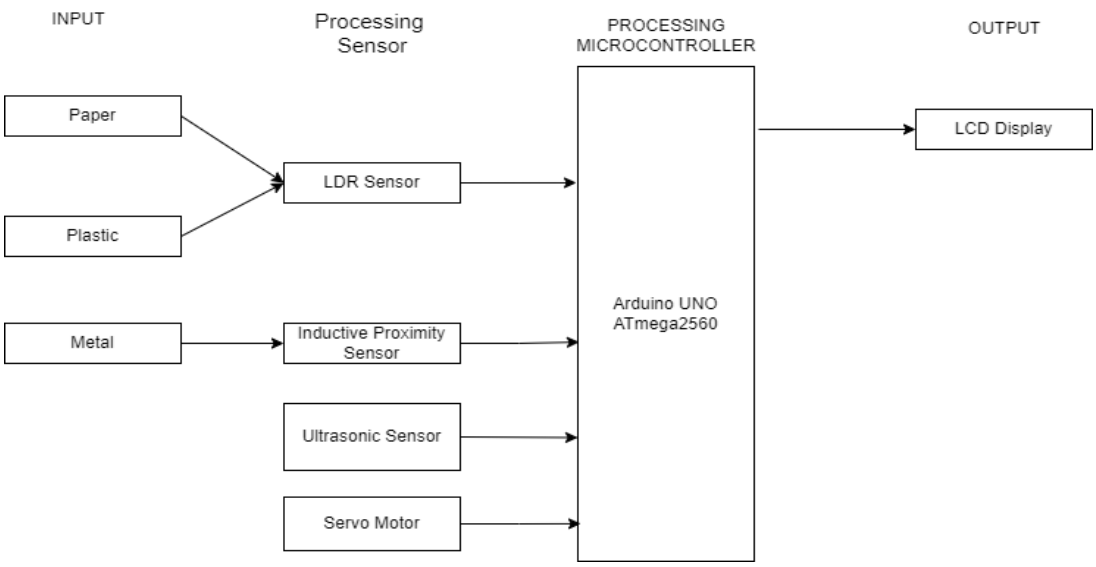

Figure 3.2 Block diagram project

3.3 Methodology

This thesis presents a new and integrated analytical approach to design a smart recycle bin for waste management. The essence of the approach used in this project is how to isolate the rubbish based on the metal, plastic and paper. For detect metal we use a inductive proximity sensor as it use electromagnetic fields to identify metal objects while for plastic and paper we use Light Dependent Sensor (LDR) as we can see in the Figure 3.2 on the part of processing sensor to make sure the input can be detected. This selected LDR sensor measures how much light is reflected back or passed through the trash. Subsequently, the experimental design flow for the smart recycle bin project, which makes use of empirical modelling, is shown in Figure 3.3.

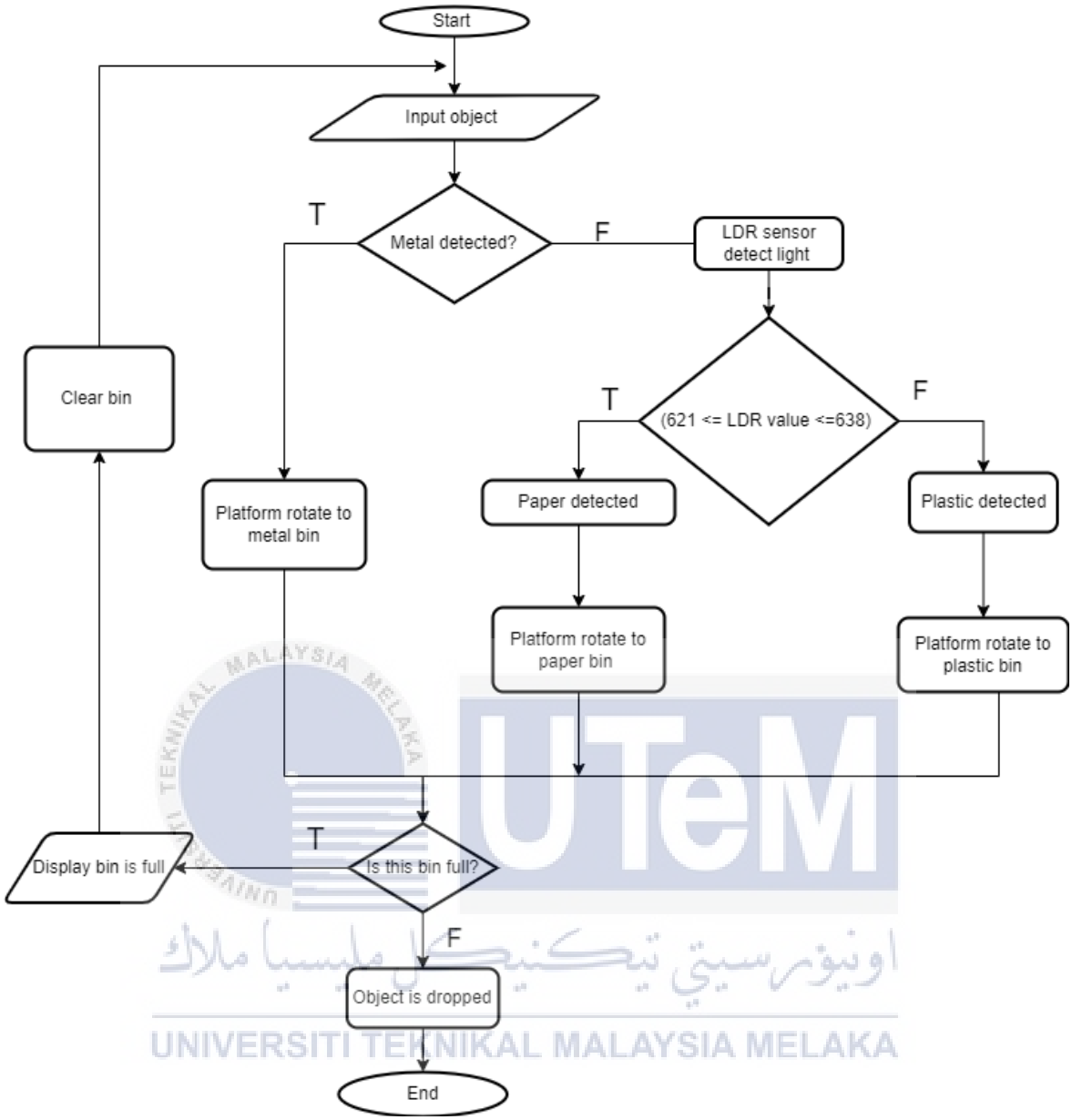

Figure 3.3 Flowchart project

Three different types of sensors which are an inductive proximity sensor, a light-dependent sensor (LDR), and an ultrasonic sensor are used in this project, which are powered by an Arduino Uno. All of these types of sensors have unique functions that I have been modified to fit the project's experimental setting. First, it is determined whether or not there are any metal objects present. If the result is accurate, it moves on to determining whether or not the trash bin is full. If the result is correct, the metal trash is then dropped into its designated bin. When a non-metal object is detected, the same procedure will be followed,

except that instead of using an LDR to detect the presence of light, it will instead be used to measure how much light is being transmitted through the trash to the sensor. Additionally, it will first check to see if their bin is full before dropping the specified trash into their bin if it is detected correctly. The level of the bin is shown on an LCD display; if it is full, the user must empty the bin first before inputting another object to restart the procedure from scratch. In addition, trash will be dropped into the bin if it is not yet full. Subsequently, Figure 3.2 shows the flow design of experimental setup.

3.4 Parameters

In this part, it might also a have some factor that can be cause to get inaccurate results for detection paper and plastic . It is because in this part, it use a light dependent sensor (LDR) that migh be not meet the characteristics of plastic and paper. In general, the LDR not specifically designed to differentiate plastic and paper but it can be modify in certain setup to detect the presence of these two type of trash. It is based on the research that anyone can explore more on the LDR that how it use to detect palstic and paper as the most important equipment, it need a light from surroundings that based on the environment. For example, it can be adjust by the light intensity detection which is detect the amount of light relected back or transmitted through the trash. Additionally, it need to remember that the colour, transparency, and surface properties of the materials can all affect how well light-dependent sensors can identify paper and plastic trash. In contrast to paper, which can absorb or scatter more light, some plastics may be more transparent and allow more light to pass through. To obtain the desired detection outcomes, the sensitivity and sensor parameters must be appropriately adjusted.

3.5 Equipment

3.5.1 Arduino Uno ATmega 2560

The Atmega 2560 is a based Arduino UNO microcontroller board includes 54 digital input/outputs, 15 of which can be used as PWM outputs and the remaining 16 as analog inputs and 4 hardware serial ports. This component features a USB connector, making it simpler to use a USB cable to connect it to a device .Besides, it also includes everything needed to support the microcontroller as it works to do all processing. For instance, in this project all additional components, such as the inductive proximity sensor, light dependent sensor (LDR), ultrasonic sensor, and servo motor, will be connected to the Arduino Uno Atmega2560 so that all necessary processing can be carried out in each experimental setup. Figure 3.4 show that the 14 digital input/outputs.

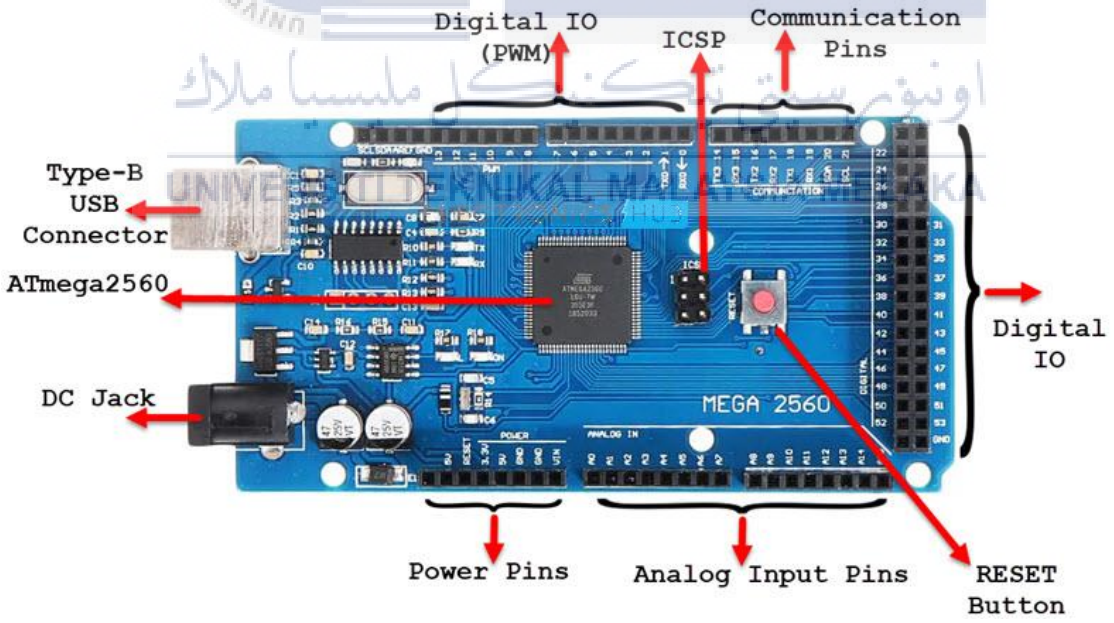

Figure 3.4 Arduino UNO ATmega 2560

3.5.2 Ultrasonic Sensor HC-SR04

Ultrasonic sensor HC-SR04 is a device that uses ultrasonic sound waves to gauge a distance to an item. As part of my BDP project, I decided to build this device that can be used to detect bin levels. If trash is almost at the top of the bin, an ultrasonic sensor will detect it and determine that the bin is full, requiring immediate cleaning. It provides outstanding non-contact range detection from 2 cm to 400 cm or 1 inch to 13 feet in a user-friendly design with high accuracy and reliable readings. Its has 4 Pinout which are VCC, GND, TRIG and ECHO. Every of this Pinout has their function and characteristic like VCC and GND as general they are supply power to sensor and ground pin. For the TRIG is used to trigger ultrasonic sound pulses while ECHO as when an ultrasonic burst is broadcast, the pin goes high. It stays high until the sensor gets an echo, at which point it becomes low. Figure 3.5 shows all of the pinout.

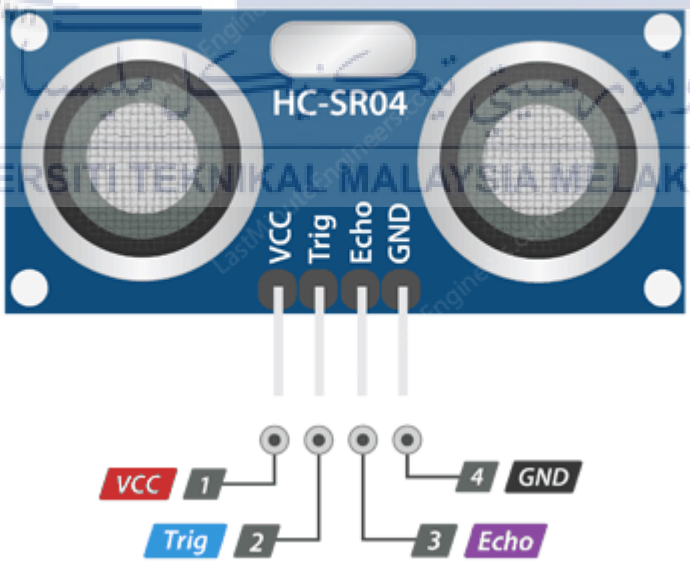

Figure 3.5 Ultrasonic Sensor HC-SR04

3.5.3 Inductive Proximity Sensor

Inductive Proximity Sensor is use to detect metal using electromagnetic energy and without contact. In this project, it has been used to detect metal trash and can be isolate correctly. It cannot be used to detect non-metal targets such as plastic, paper and wood. For the connection it need 9V to be works so it need to resistor in series with the output of sensor that will connect to the battery. It have three wire out which are Vin, GND and Out like based on the Figure 3.6

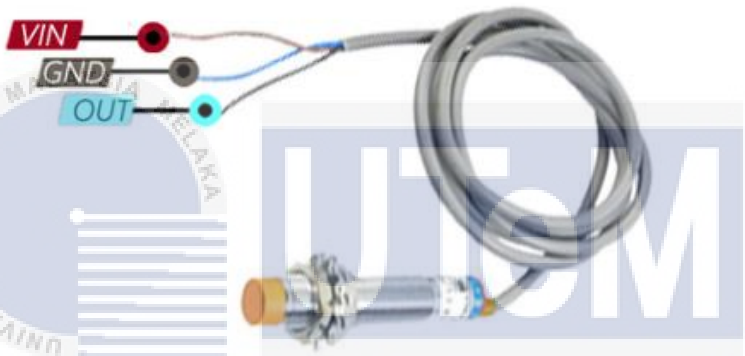

Figure 3.6 Inductive Proximity Sensor

3.5.4 Photo-resistor LDR Light Sensor Module (Light Dependent Resistor)

Light Independent Resistor (LDR) is used to light intensity detection which is detect the amount of light that trasmitted through the trash as it will used to detect paper and plastic trash. It has analog output pin (AO) and digital output pin (DO) on the board. In adjusting this, it wll be implement in the code to make it detect paper and plastic if it detect amount of light that based on the brightness from surrounding as it affecting the enviroment. So the trash is put infront of the LDR sensor module. Figure 3.7 show the LDR component that already label it's Pinout.

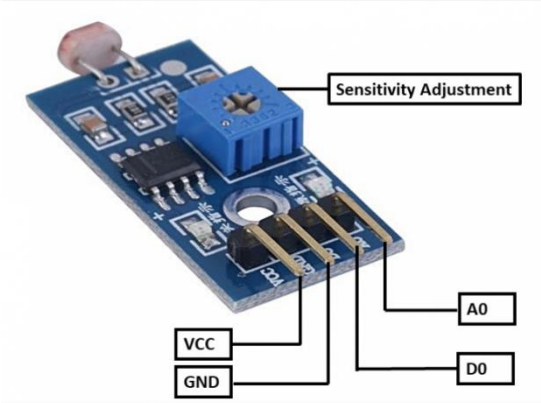

Figure 3.7 Photo-resistor LDR Light Sensor Module (Light Dependent Resistor)

3.5.5 LCD Display 1602 12C

LCD Display 1602 12C is used to display output which is bin status like which bin is full and trash can't be dropped into the bin. This LCD has four Pinout which VCC, GND, SDL, and SCL that will connect to the Arduino UNO. I decided to use this LCD because it is simple to handle it as it only has two bidirectional data lines which are serial data line and serial clock one. Figure 3.8 show the LCD and the 4 Pinout that will be more understand about this component.

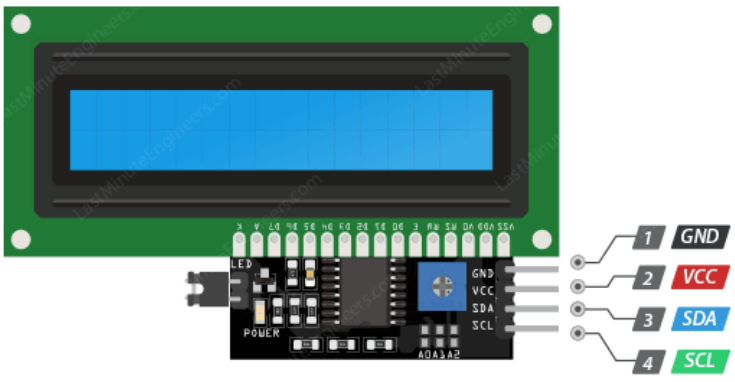

Figure 3.8 LCD Display 1602 12C

3.5.6 Servo Motor

Servo motor is a electronic devices that can rotate and push parts of machine. In general, it is used on linear position and angular .In this project, servo motor is used to make rotation for the bin part which is will rotate to the metal bin, paper bin and also plastic bin. For example, if the metal bin required so the platform of the rotation will rotate to the metal bin. In addition, the servo motor also use to turn the sensing platrform to gave a way to waste drop into the bin. Figure 3.9 show the Servo motor that consists of three parts which are GND, VCC and control signal that will connect to the microcontroller

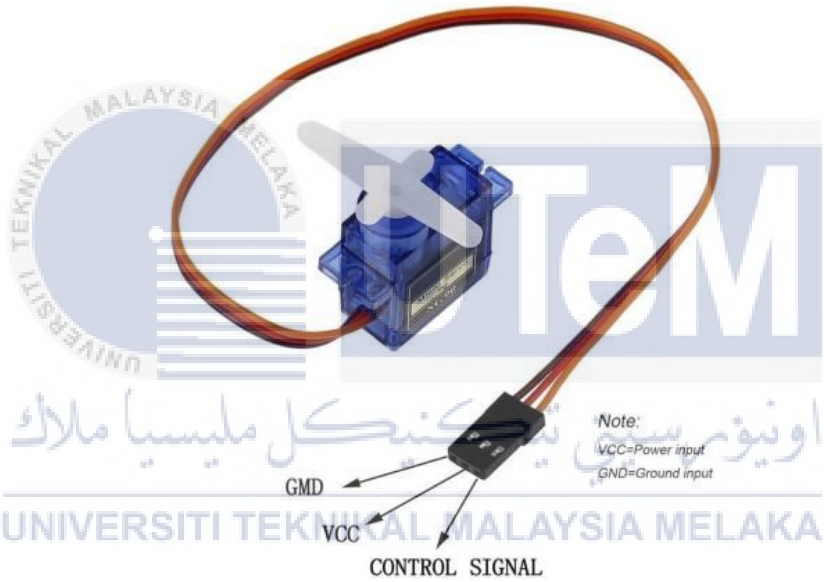

Figure 3.9 Servo Motor

3.5.7 Breadboard

Breadboard is a base of the build semi permanent of electronic circuit permanenet. It has different types of size depends on the how much we needed to use the hole on the board. The common size are mini breadboard, half mini breadboard and full size breadboard. In this project, it used a full breadboard that can make it easily to connect among the device that need to be used in project. Figure 3.10 show the full size of breadboard that has 830 holes.

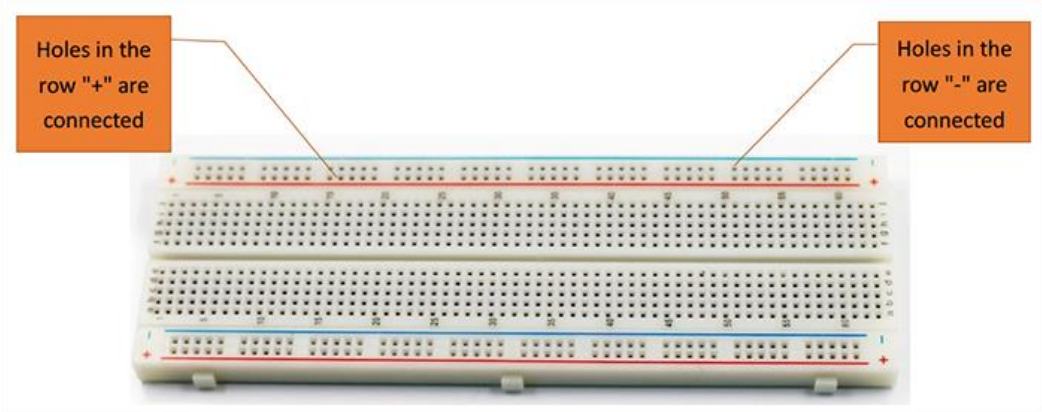

Figure 3.10 Full Size Breadboard

3.5.8 Jumper Wire

In general, jumper is used to close or open the part of electrical circuit. Jumper has variety type that make the connection circuit more easier. In this project, I choose to used a male-to-male and male-to-female as the sensor component need a male-to-male jumper wire to connect it to the others component or breadboard. Figure 3.11 show the three kinds of wire jumper.

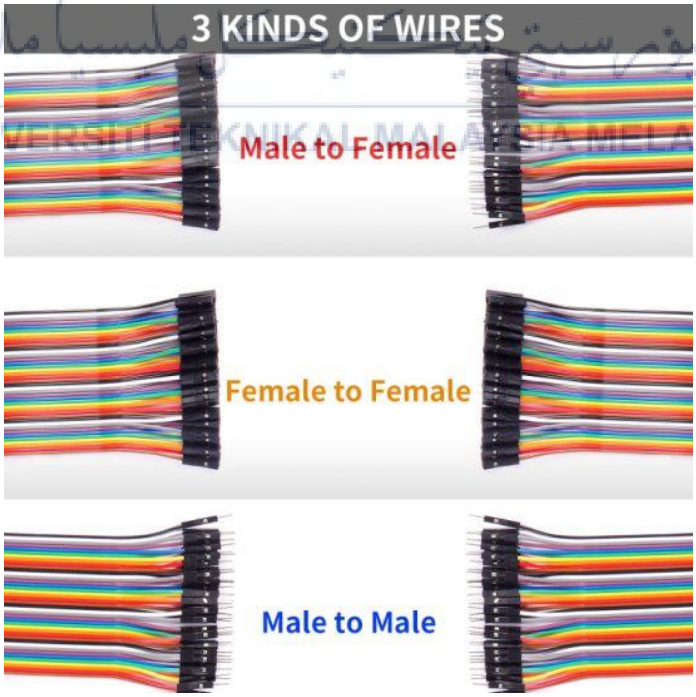

Figure 3.11 Jumper Wire

3. 6 Project Plan

Project plan is the flow how the BDP 1 and BDP 2 works in this semester, as can see that in Figure 3.12 and Figure 3.13. In addition, the flow was implemented by using Gantt chart as it easy to refer and follow the step.

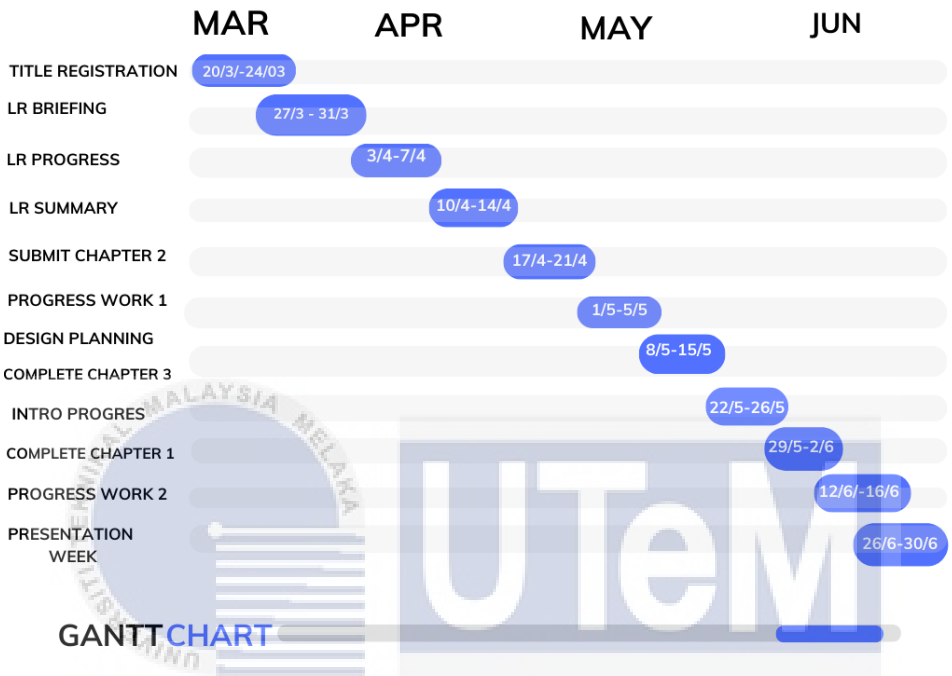

Figure 3.12 Gantt Chart BDP 1

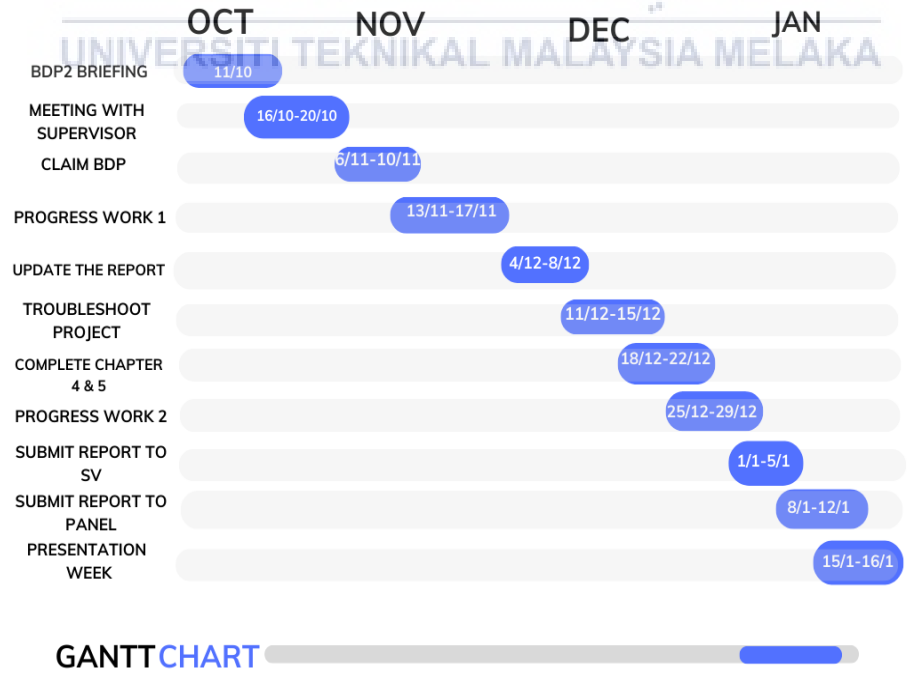

Figure 3.13 Gantt Chart BDP 2

3.7 Limitation of proposed methodology

This proposed methodology may have some potential shortcomings as it need to make a prototype example to show the project output. As it might be different used for the component based on the suitable neeeded in troubleshoot the model. Other than that, it maybe can effect the cost of the required if it have the problems in the model component. In addition, it might be add on features when develop the model soon as it to make the smart recycle bin for waste sorting more user friendly. In addition, the equipment use for detect paper and plastic is not suitable as it affect by the environment which is brightness in surrounding. As the LDR value keep changing in based on the surrounding environment that cannot be controlled, so the LDR value in detect the paper an plastic is not accurate. From that, it effect the rotation of the servo motor to rotate to the paper and plastic bins. Besides, the LCD display also has a limitation in display the output so it just can display what type of material detected and the level bin usage. Other than that, it might be limitation for servo motor as it cannot to rotate in 360 degree as it need to set the rotation properly to be as the declaration of the position bin.

3.8 Summary

This chapter presents the proposed methodology in order to design and develop a smart recycle bin for waste sorting. This methodology can be clearly understand when make a flow of the design project and hot the model will works soon. The primary focus of the proposed methodology is in accomplishing a simple flow and component required to build the model project to see the result of this BDP project. The methods also intended to make it summarize the project function actually as if the project can reduce cost or planned to get the best result.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and analysis on the design and develop smart recycle bin using Arduino Uno for waste sorting. Figure 4.1 shows the prototype of the recycle bin while Figure 4.2 shows the sketch diagram of the recycle bin. Based on both figures, the recycle bin is divided into two parts, which are the sensing part and the mechanical part. For the sensing part, it includes all the sensor that are needed to detect and differentiate three different types of material. For the mechanical part, a servo is attached with a board that has three sorting openings to store different type of materials which are metal, paper and plastic. In the model design, to detect metal waste still use a inductive proximity sensor.

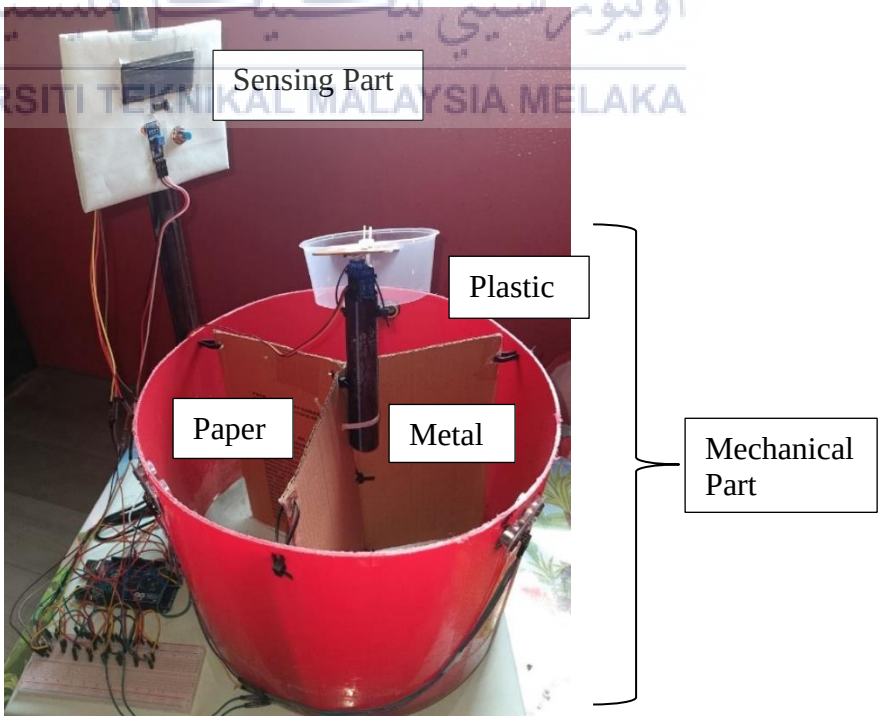

Figure 4.1 Overall prototype

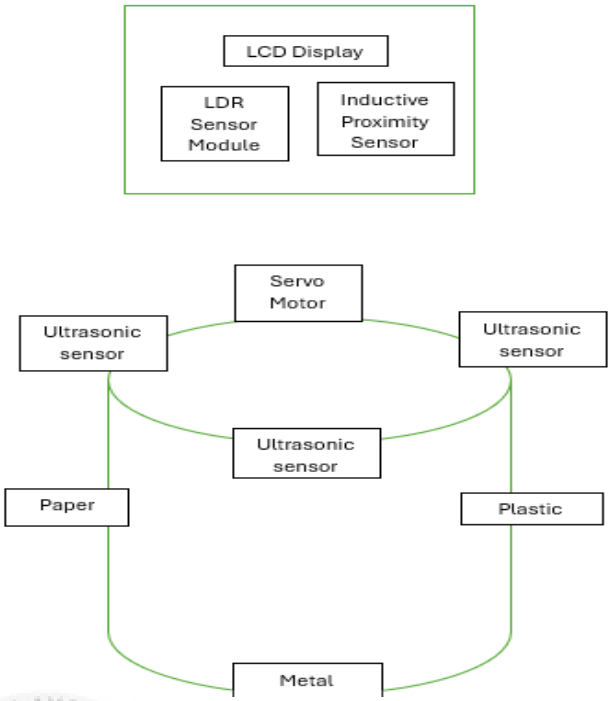

Figure 4.2 Sketch Diagram of recycle bin

There are two different sensors used in the sensing part, which are inductive proximity sensor and LDR sensor module. Based on the Figure 4.3 ,the inductive proximity sensor will detect any metal object ,if the result is metal detected then it will sorts the metal into the metal bin or metal part. In the same time the ultrasonic in the metal bin will detect the presence of any recycle waste. After the object is detected, it send the signal to the microcontroller to display the result if the bin is full or not. The detection distance of the object for all ultrasonic in the bin is less than 10cm.

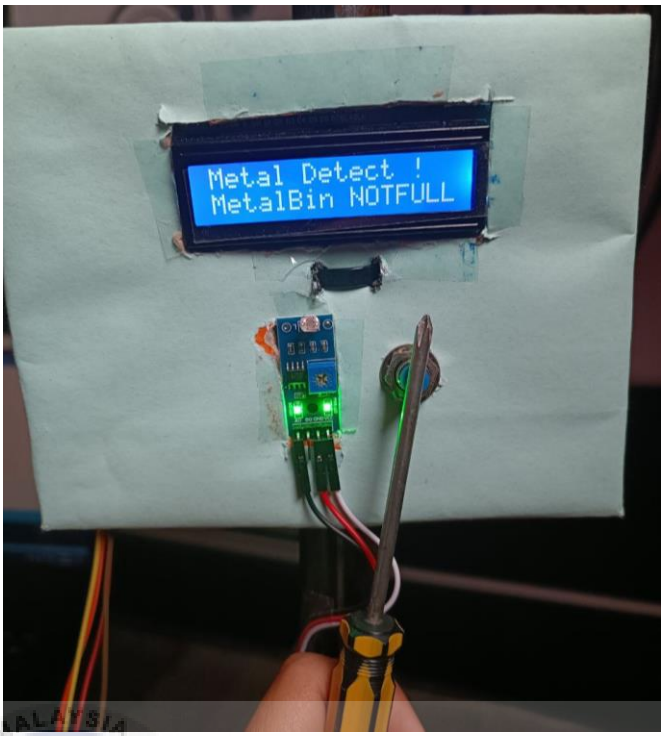

Figure 4.3 Metal detection

Based on Figure 4.4, the next sensor is LDR sensor module that used to detect paper and plastic by capture the light intensity emitted in the surrounding which is the result cannot be accurate as it affected by the surrounding enviroment. For instance, when the environment is bright during the day, the output of the LDR value will differ from when the environment is not light during the night. It will be difficult to fixed the setting value in detect the paper and plastic as the value ldr always changing everytime on the prototype. From that, it will affect the servo motor to sorts the material into the specific bins.

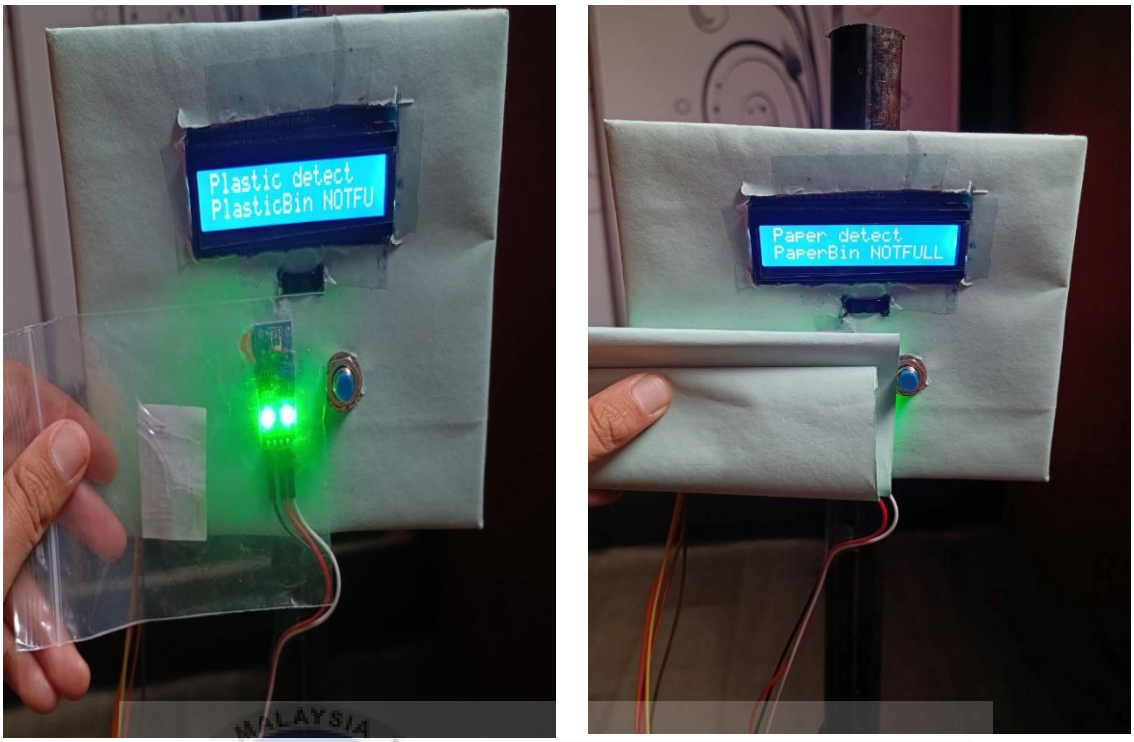

Figure 4.4 Paper and plastic detection

4.2 Results and Analysis

4.2.1 Metal Detection

This subsesction presents the metal detection result as it detected by using the inductive proximity sensor. The result detection metal and non-metal can be observed in Table 4.1 where all the sample of metal objects can be detected. Examples of objects that are used to detect metal is screwdriver, aluminium can, scissors, spoon, fork, paper and plastic. Figure 4.5 shows five count of material have been detected as a metal and two materials from all samples are non-metal. From that can be conclude that there is no issue in detect the metal object using the inductive proximity sensor as can detect metal objects quickly and with high accuracy. It is not too difficult to install and incorporate inductive proximity sensors into current systems. They frequently only need little calibration, which cuts down on setup time and qualifies them for a wide range of uses.

Table 4.1 Result detection metal and non-metal

Material	Metal	Non-Metal	Information
Screwdriver	Yes	No	Succeed
Scissors	Yes	No	Succeed
Aluminium can	Yes	No	Succeed
Spoon	Yes	No	Succeed
Fork	Yes	No	Succeed
Paper	No	Yes	Succeed
Plastic	No	Yes	Succeed

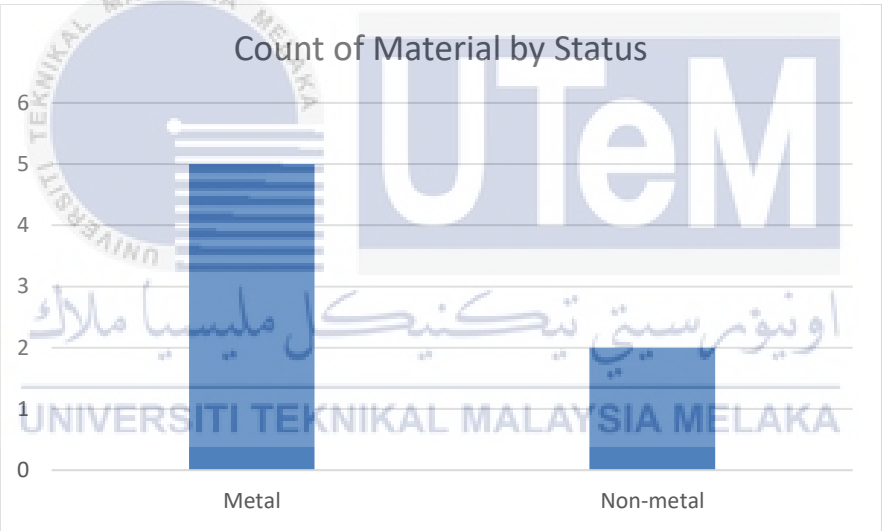

Figure 4.5 Count of material by status metal or non-metal

The success rate of th sensors on detecting metal object can be seen in Equation (1).

$$\%Success\ Rate = \frac{\text{Success Result}}{\text{Number of Test}} \times 100\% \qquad (1)$$

$$\%Success\ Rate = \frac{7}{7} \times 100\%$$

$$= 100\%$$

4.2.2 Paper and Plastic detection

For the this part is represented the result and analysis for paper and plastic detection by using the LDR sensor module. From the experiment that was done found by using the LDR sensor module is not suitable for this project as the output observed is not accurate as it is under control enviroment. The output might be different every time the system is operated as the surrounding environment continously changing and the LDR sensor module is suitable for indoor area. In detecting paper and plastic, the materials need to be closed to the sensor gets the reading output accurately. For paper and plastic are done in two condition which are in a day time and night time as there is a big difference in brightness of surroundings. The experiment also have been done test for in all day by getting the result for each two hours and result observed also not accurate and continously changing. From that its make difficult to fixed the LDR value in detect the paper and plastic. The results for LDR values in paper and plastic detection are shown in Tables 4.2 and 4.3, however they are not reliable results because they are constantly fluctuating within that range.

Table 4.2 Range value of LDR sensor module in a daytime

DayTime				
Range Value LDR	Paper		Plastic	
	Thick	Thin	Transparent	Opaque
First Attempt	703-706	621-623	642-644	682-688
Second Attempt	817-824	635-638	627-629	670-690
Information	Detected	Detected	Detected	Detected

Table 4.3 Range value of LDR sensor module in a nighttime

NightTime				
Range Value LDR	Paper		Plastic	
	Thick	Thin	Transparent	Opaque
First Attempt	779-783	755-760	784-788	807-814
Second Attempt	780-782	683-685	791-796	806-809
Information	Detected	Detected	Detected	Detected

4.2.3 Bin level detection

This section describes the ability of HCSR04 ultrasonic sensor is in monitoring bin level. There are three ultrasonic sensors in each bin to detect the level bin like to inform the user whether the bin is full or not. The sent soundwave is used to calculate the distance till it returns to the sensor receiver. The formula to calculate the error of the sensor measurement can be calculated by using Equation (2)

$$\%\text{Error} = \frac{[sensor(cm) - Ruler(cm)]}{Ruler(cm)} \times 100\% \qquad (2)$$

The following is the result of error percentage of the sensor measurement which is in Table 4.4.

Table 4.4 Error percentage of the sensor measurement

No	Measured by Ruler (cm)	Measure by Sensor (cm)	Error (%)	Information
1	5	5	0	Detected
2	10	10	0	Detected
3	15	15	0	Detected
4	20	20	0	Detected

4.2.4 Servo Motor Test

This section describes how the servo motor determines the right angles based on the setting in the code to make a rotation to the specific bins which are metal bin, plastic bin, and paper bin. In that case the servo can turn to the specific bin correctly if the LDR value detect is based on the range value settings in the code. However, there are instances when it cannot be turned to the appropriate bin because the value set in the code does not match the output LDR value that the sensor detects. This is since the surrounding environment has an impact on the LDR value that the sensor in the paper and plastic detector will detect. The following is the Table 4.5 servo motor position test based on the syntax set and correctly match with the range LDR value in detect paper and plastic.

Table 4.5 Servo motor position test

No	Syntax	Turn Angle	Position	Information
1	tap_servo.write(0);	0°	Paper bin	
2	tap_servo.write(100);	100°	Metal bin	
3	tap_servo.write(300);	300°	Plastic bin	

4.3 Summary

The overall system test aims to determine the functionality of the smart recycle bin for waste sorting when it is fully assembled using the arduino. Based on the result and analysis that has done ,can be observed that the metal detected is sucessfully by using the inductive proximity sensor. For the paper and plastic detection by using the LDR sensor module cannot be as accurate functionality because the Light Dependent Sensor (LDR) module might not be the most accurate methos in a controlled environment due to the nature of LDR sensors and the characteristics of paper and plastic materials. It is because brightness can also affect the performance of LDR sensors over time. Although these effects may be reduced in a controlled environment, they cannot completely prevent the accuracy from gradually declining, which is why the LDR value generated varies. In addition, LDR sensor

module is sensitive to ambient light conditions. Sometimes, though, the value set in the code does not match the output LDR value that the sensor detects, making it impossible to turn it to the correct bin. This is because the LDR value that the sensor in the paper and plastic detector will detect is affected by the environment around it. To make the data stable, the sensing part of the LDR sensor modules need to put the cover as it can reduce the unstable data value. Due to the LDR value not meeting the requirements, this will affect how the servo motor sorts the bins, specifically the paper and plastic bins. In conclusion, the detection level bin exhibits good functionality, with all ultrasonic sensors capable of measuring distance in accordance with the code's setting requirements.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This thesis presents a system isolation for the three types of trash which are metal, paper, and plastic trash into the the specific bin. Based on the result and analysis, the smart recycle bin show how the system will be works. The proposed smart recycle bin for waste sorting prototype has three compartments for metal, paper and plastic. This bin simple design attracts users and suits all types of homes. The proposed prototype is equipped with a servo motor that rotate to the specific angle which are metal bin, plastic bin and paper bin. In addition, ultrasonic sensors are used to measure distance or in others word to detect level bin. LDR sensor module and inductive proximity sensor are use to detect paper ,plastic and metal. The components of the Display is Liquid Crystal Display (LCD), besides when the smart recycle bin for waste sorting can work well, and the LCD works as it should.

5.2 Potential for Commercialization

For this part will describe if this project can be commercialization or not like it is this project can be many benefits to users. Firstly, projects that support sustainability are more desirable to community as a result of growing global awareness of environmental challenges, particularly the significance of recycling and waste sorting ,so this poject can be one of them if make an improvement to the project. For example, use a high quality sensor in detect the paper an plastic material to sort into a specific bin as it might be get the accurate output. By automating the sorting process, smart recycle bins can improve user friendliness in the recycling process. Because of its simplicity, more individuals might start recycling,

especially in their homes. Features that teach consumers how to properly sort rubbish can be added to smart recycling containers. This educational component supports campaigns to raise public knowledge of environmental issues and appropriate trash disposal practices. In a nut shell, commercialization is a possibility, but it's important to take into account obstacles like affordability, scalability, durability, and user acceptability. In addition, this project using all the sensors that have been integrated into the system bin are affordable with the functionality even the data for the plastic and paper detected not accurately.

5.3 Future Works

For this part is to represent how or what can be done for future works by giving some recommendations to improve this project. Firstly, to get the accurate readings need to use sensor calibration and fusion as in this project has a problem in paper and plastic detection that by using the LDR sensor modules so, it can be changing by using computer vision Camera-Based) System that can provide detailed information about the appearance and characteristics of materials. Vision systems are capable of accurately identifying many materials, including paper and plastic, thanks to their great precision in analyzing visual features of things. This can increase the accuracy of sorting when compared to other sensors such as LDR sensors. It is possible to build vision systems that can identify various visual characteristics of materials in addition to their color. This makes it possible to identify materials more thoroughly by considering characteristics like shape, texture, and pattern. However, it also can be used as a machine vision system using cameras and image processing. The system is to recognize and classify paper and plastic based on their visual features. In addition, a machine vision system can identify materials by analyzing images of the items and making decisions based on predefined criteria. Then, the others future works can be done soon is make a user interface (UI) and feedback which is develop a user-friendly

interface to provide feedback on the level bin detection. For example, this feature can allow users or administrators to check the status of the bins and receive notifications for maintenance or issues like the message about the bin is full and needed to clean. Lastly, this project can change the type of servo motor that is used in this project by changing it with the high-quality servo motor that can bear weight of materials to sort into specific bins. For example, can use TowerPro MG996R Servo Motor because of its strong torque, it can be used in applications where moderate to high rotating force is needed. The MG996R is compatible with Arduino and other microcontrollers, offering ease of integration into the project. These tips can help in designing a smart recycle bin system that is more precise, easy to use, and flexible, while also keeping up with the latest technological developments and future waste sorting innovations.

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APPENDICES

Appendix A Code in Arduino

Coding for detect metal, plastic and paper

```
#include <LiquidCrystal_I2C.h>

#include <Servo.h>

LiquidCrystal_I2C lcd (0x27, 16, 2);

/*const int ldrThresholdPaper = 609;

const int ldrThresholdPlastic =0;*/

const int ldrPin = A0;

const int metalTrigPin = 33;

const int metalEchoPin = 32;

const int paperTrigPin = 31;

const int paperEchoPin = 30;

const int plasticTrigPin = 35;

const int plasticEchoPin = 34;
```



```
Servo tap_servo;

int ledPin;

int distanceMetal;

int distancePaper;

int distancePlastic;

int sensor_pin = A1;

int tap_servo_pin =7;

int val;
```

```
void setup() {
  pinMode(sensor_pin,INPUT);
  pinMode(ledPin, OUTPUT);
  tap_servo.attach(tap_servo_pin);
  lcd.begin();
  pinMode(metalTrigPin, OUTPUT);
  pinMode(metalEchoPin, INPUT);
  pinMode(paperTrigPin, OUTPUT);
  pinMode(paperEchoPin, INPUT);
  pinMode(plasticTrigPin, OUTPUT);
  pinMode(plasticEchoPin, INPUT);
}
void loop() {
 val = digitalRead(sensor_pin);
 int ldrValue = analogRead(ldrPin);
 distanceMetal = measureDistance(metalTrigPin, metalEchoPin);
 distancePaper = measureDistance(paperTrigPin, paperEchoPin);
 distancePlastic = measureDistance(plasticTrigPin, plasticEchoPin);
if (val==1) {
   lcd.setCursor(0, 0);
   lcd.print("Metal Detect !   ");
   delay(2000);
   tap_servo.write(100);
   delay(2000);
   if (distanceMetal<10){
```

```
      lcd.setCursor(0, 1);
      lcd.print("MetalBin FULL!   ");
      delay(2000);
    } else {
      lcd.setCursor(0, 1);
      lcd.print ("MetalBin NOTFULL");;
      delay(2000);
    }
}
if (val==0) {
    tap_servo.write(0);
    delay(2000);
}
//Paper Detected
else if (ldrValue >= 0 && ldrValue <= 630) {
    digitalWrite(ledPin, HIGH);
    lcd.setCursor(0, 0);
    lcd.print(ldrValue);
    /*lcd.setCursor(0,0);
    lcd.print("Paper detect    ");*/
    tap_servo.write(0);
    delay(2000);
    if (distancePaper<10){
      lcd.setCursor(0, 1);
      lcd.print("PaperBin FULL!   ");
```

```
    delay(2000);
   } else {
    lcd.setCursor(0, 1);
    lcd.print ("PaperBin NOTFULL");;
    delay(2000);
   }
}
// Plastic detected
else if (ldrValue >= 631 && ldrValue <= 1000) {
   digitalWrite(ledPin, HIGH);
   lcd.setCursor(0, 0);
   lcd.print(ldrValue);
   /* lcd.setCursor(0,0);
   lcd.print("Plastic detect    ");*/
   tap_servo.write(300);
   delay(2000);
    if (distancePlastic<10){
    lcd.setCursor(0, 1);
    lcd.print("PlasticBin FULL!   ");
    delay(2000);
   } else {
    lcd.setCursor(0, 1);
    lcd.print ("PlasticBin NOTFULL");;
    delay(2000);
   }
```

```
}
else {
  lcd.setCursor(0,0);
  lcd.print("Error");
}
}
int measureDistance(int trigPin, int echoPin){
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  long duration = pulseIn(echoPin, HIGH);
  int distance = duration * 0.034/2;
  return distance;
}
```