Faculty of Electronics & Computer Technology and Engineering

DESIGN AND DEVELOPMENT OF AN AUTOMATED BASED TRASH SORTING BIN BY USING ESP32

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

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DEDICATION

To my beloved family and cherished friends, I humbly dedicate this project report. Special recognition is due to my parents, Rosli Bin Idris and Noor Ainun Binti Sulaiman, for imparting invaluable lessons that have shaped my understanding that daunting tasks can be conquered when approached methodically, one step at a time.

Furthermore, I extend this dedication to my friends and the local community whose unwavering support has been instrumental in bringing this project to fruition. Your assistance and guidance are deeply appreciated, and I am profoundly grateful for the encouragement I have received.

In addition, heartfelt thanks go to my PSM Supervisor, Dr. AKM Zakir Hossain, whose expert guidance and advice have been pivotal in navigating the complexities of completing my final year project effectively. Your mentorship has been invaluable, and I am truly thankful for your support.

ABSTRACT

This project aims to design and develop an automated trash sorting bin that utilizes using Microcontroller technology. The escalating global concern over waste management necessitates innovative solutions. Despite the importance of recycling and waste sorting, traditional methods prove labor-intensive and prone to contamination. This project addresses the challenge by developing a smart trash sorting system using IR, proximity, and water drop sensors. The bin can sort various types of waste materials namely metal, wet and dry, thus making waste management easier and more efficient. By using IR sensor, proximity metal sensor and water drop sensor to detect different type of materials, the rotating trash shorting machine will automatically sorts the materials into separate containers. The ESP32 is used to control and manage the sorting process. The system is designed to be user-friendly and easy to operate, making it ideal for use in various settings such as homes, offices, and public places. This project was develop an IoT system which is to sending a notification to a smartphone to notice if the trash is full by using Blynk application. Using an Ultrasonic sensor makes it achievable to detect how much trash is in the container. Employees will be duly informed and empowered to take appropriate measures in response. The project demonstrates the potential of using automation technology to address waste management challenges and promote sustainability.

ABSTRAK

Projek ini bertujuan untuk mereka bentuk dan membangunkan tong pengasingan sampah automatik yang menggunakan teknologi Pengawal Mikro. Kebimbangan global yang semakin meningkat terhadap pengurusan sisa memerlukan penyelesaian yang inovatif. Walaupun kepentingan kitar semula dan pengasingan sisa, kaedah tradisional membuktikan intensif buruh dan terdedah kepada pencemaran. Projek ini menangani cabaran dengan membangunkan sistem pengisihan sampah pintar menggunakan penderia IR, kedekatan dan titisan air. Tong sampah boleh menyusun pelbagai jenis bahan buangan iaitu logam, basah dan kering, sekali gus menjadikan pengurusan sisa lebih mudah dan cekap. Dengan menggunakan penderia IR, penderia logam kedekatan dan penderia titisan air untuk mengesan jenis bahan yang berbeza, mesin pemendek sampah yang berputar akan secara automatik mengisih bahan ke dalam bekas yang berasingan. ESP32 digunakan untuk mengawal dan mengurus proses pengisihan. Sistem ini direka bentuk untuk mesra pengguna dan mudah dikendalikan, menjadikannya ideal untuk digunakan dalam pelbagai tetapan seperti rumah, pejabat dan tempat awam. Projek ini telah membangunkan sistem IoT iaitu menghantar pemberitahuan kepada telefon pintar untuk melihat jika sampah telah penuh dengan menggunakan aplikasi Blynk. Menggunakan penderia Ultrasonik menjadikannya boleh dicapai untuk mengesan jumlah sampah di dalam bekas. Pekerja akan dimaklumkan dan diberi kuasa untuk mengambil langkah yang sewajarnya sebagai tindak balas. Projek ini menunjukkan potensi menggunakan teknologi automasi untuk menangani cabaran pengurusan sisa dan menggalakkan kemampanan.

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.

I extend my deepest appreciation to my supervisors, Dr. AKM Zakir Hossain from the Department of Electric & Electronic Engineering Technology at University Teknikal Malaysia Melaka, for their exceptional guidance, insightful suggestions, and constructive criticism. Their thoughtfulness, kindness, and unwavering support have played a pivotal role in the successful completion of this project. I am truly grateful for their contributions and the valuable lessons I have gained under their mentorship.

I am also indebted to my friends and classmates for their constant encouragement and support throughout the research process for my bachelor's degree thesis. Their positive influence has been a source of inspiration, and I am thankful for the camaraderie that made this journey more enriching.

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V	-	Voltage
VCC	-	Input for microcontroller
GND	-	Ground
A	-	Ampere

LIST OF ABBREVIATIONS

SWG	-	Solid waste generated
SWM	-	Solid waste management
RGB	-	Ground
IWS	-	Ampere
MMP	-	Multi-Mini-Processor.
TX/RX	-	Transmitter/Receiver
LCD	-	Liquid crystal display.
LDR	-	Light-dependent resistor
LED	-	Light emitting diode
IR	-	Infrared radiation
WI-FI	-	Wireless Fidelity
IDE	-	Integrated development environment
IOT	-	Internet of things
RFID	-	Radio frequency identification

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CHAPTER 1

INTRODUCTION

1.1 Background

Waste management is a growing concern globally, as the amount of waste generated by human activities continues to increase. Proper waste management is essential for public health, environmental sustainability, and economic growth. Recycling and waste sorting are some of the key strategies used to manage waste effectively. However, traditional waste sorting methods can be time-consuming and labor-intensive[1]. With the advancement of technology, there is a growing interest in developing automated waste sorting systems that can improve waste management efficiency. Waste management has played a crucial role in shaping history. Epidemics such as the Bubonic Plague, cholera, and typhoid fever had a profound impact on European populations and governments. These diseases were perpetuated by unsanitary conditions that provided a breeding ground for rats and contaminated water sources. When wastes are not adequately managed, they can pose a major risk, as witnessed in 1350. "Black plague" emerged, killing nearly 25 million people across Europe in just five years. But nowadays, most of people lack of awareness or education by not throwing the recycle trash in the correct bin based on their type, it can have several negative consequences[2]. When recycling facilities receive contaminated materials, the workers must spend extra time to separate again and resources sorting out the non-recyclable items. This can increase the cost of recycling and ultimately make it less economically feasible. In order to rectify this concern, the project aims to sort waste into three distinct categories which is non-metal (dry and wet) and metal.

The objective of this project is to design and improve the complexity of separating three different types of materials automatically using only one trash bin. It also can reduce the waste of time to separating the garbage. By using IR sensor, proximity sensor and water drop sensor to detect different type of materials, the rotating trash shorting machine will automatically sorts the materials into separate containers, such as dry, metal and wet object can be track accordingly. Once the material is detected by the sensor, these signals are received by the ESP32 and passed on to the motor that located at the bottom of the device to rotate the bin and automatically open the trash lid. By using arduino, it can increased efficiency and accuracy which can be time consuming. In addition, this design develop an IoT system concept, which is to sending a notification to a smartphone to notice if the trash is full by using Blynk application. Employees will be duly informed and empowered to take appropriate measures in response. ESP32 is an open-source hardware and software platform widely used in IoT applications. It offers a flexible and cost-effective solution for developing smart systems that can monitor and control various processes.

The system was made more efficient and convenient by incorporating an automated process through the use of an Microcontroller ESP32 board. This project highlights how the usage of IoT technology in conjunction with ESP32 platform can lead to innovative waste management solutions which aid in environmental sustainability advancement by optimizing resource utilization. The development of an automated waste sorting system using IoT technology and the ESP32 platform is a part of our innovative approach towards managing wastes, encouraging such practices helps spread advanced technology and improve smart waste management. Working towards a more sustainable future involves taking steps to reduce waste from ending up in landfills and promoting recycling.

1.2 Addressing Global Issues Through Automated Trash Sorting Bin

Addressing global and community issues related to recycling, such as waste sorting bins, is an important matter that requires attention and action. The improper sorting and disposal of garbage on a global scale contributes to environmental contamination and ecosystem degradation. Adopting efficient and standardised waste sorting bins is critical for addressing these concerns. Waste management systems that involve segregation, recycling, and appropriate disposal can lessen waste's environmental effects[3].

Encouraging garbage sorting in communities is crucial. A lack of interest and carelessness might result from ignorance about proper trash disposal. Education, outreach, and public awareness may promote proper garbage sorting. Effective waste management has environmental, health, and economic benefits, which should be promoted to encourage garbage sorting.

Effective governance and policy frameworks also help address waste sorting bin challenges globally and socially. Governments and regulatory organisations should mandate and enforce proper waste management, recycling, and disposal. Governments, corporations, communities, and non-profits may work together to create successful waste management programmes. In conclusion, waste sorting bin concerns must be addressed systemically. It requires effective trash management, public knowledge, accessibility, and supporting the government. Solving these concerns can contribute to the enhancement of society and the environment [3].

1.3 Problem Statement

The inefficient process of sorting waste in a recycling bin can make it difficult to maintain proper disposal practices [1]. This is because the methodology of sorting garbage with traditional means demands significant physical exertion from humans which often generates incorrect sorting leading to more litter going into dumps instead of being recycled.[2]. Litter that is left unsorted without any recycling steps may end up polluting the environment by filling up dumpsites. In addition, the emission of methane gas from landfills can contribute significantly to global warming because it's a very strong greenhouse gas. Another thing to consider is that hazardous waste and chemicals in non-recycled garbage can lead to soil and groundwater contamination causing environmental degradation [4].

Also numerous households as well as businesses face the challenge of improper recycling infrastructure thereby contributing significantly to landfill waste [5]. Intensifying the problem of waste management and worsening environmental degradation. Accordingly, the problem statement concerning a refuse classification container is to generate an accurate and efficient waste segregation scheme that endorses ecological sustainability by promoting recycling of valuable resources. Appealing to a wide range of users involves the solution must meet their needs by being low cost and user-friendly [6].

Design and development of an IoT-based trash sorting bin using ESP32 is to develop an efficient and accurate waste sorting solution that promotes environmental sustainability and encourages the recycling of valuable materials [7]. The solution should utilize IoT technology and Microcontroller ESP32 platform to automate waste sorting and improve the accuracy of waste sorting. The system should be user-friendly, cost-effective, and accessible to a wide range of users. It provides a promising solution to the problem of inefficient waste sorting and contributes to the development of sustainable waste management practices.

1.4 Project Objective

The major objectives of the PSM lead after considering the above problem statement are:

i. To design an automated rotating trash sorting system.

ii. To fabricate the automated based trash sorting bin by using ESP32.

iii. To analyze sort of three different types of waste materials automatically using only one trash bin.

1.5 Scope of Project

The goal of this project is to provide automated trash sorting bin that will improve the complexity of separating three different types of materials automatically using only one trash bin. It also can reduce the waste of time to separating the garbage. The power supply of an automated based trash sorting bin is driven by 12V/2A Adapter. Using IR sensor, Proximity sensor and water drop sensor to detect the material of metal and non-metal. Once the material is detected by the sensor, these signals are received by the microcontroller ESP32 and passed on to the servo motor MG996R to open the trash lid container and servo motor TD8120MG to rotate the container. An increase in efficiency and accuracy is achieved with the use of an Microcontroller ESP32 that helps in saving valuable time. Additionally, this design also makes use of an IoT technique by leveraging Blynk app for notifying designated smartphones when garbage reaches certain fill point. Using an Ultrasonic sensor makes it achievable to detect how much trash is in the container.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Automated trash sorting bins can have a significant impact on global issues related to waste management. Trash sorting bins reduce landfill pressure, save natural resources, and lessen garbage disposal's environmental effect by encouraging waste separation and recycling. This technique of sorting bins can enhance health Issues. Effective garbage sorting and containment within trash sorting bins assist in preserving cleanliness, reducing disease transmission, and promoting a healthier community. Trash sorting bins increase safety. Ergonomic design, lockable lids, and visible signs ensure user safety in garbage sorting bins. Accessible trash sorting bins encourage inclusive waste management practices. Compliance with municipal waste management rules, such as trash separation, recycling, and disposal, also improves legal issues. Trash sorting bins must be sensitive to varied cultural practices, beliefs, and attitudes towards garbage management [8].

Utilizing the processing power and flexibility offered by ESP32 microcontrollers has resulted in the creation of an automated trash sorting mechanism which comprises a multi-compartment bin where each compartment is meant only for certain types of garbage. Automated control over a servo motor connected to specific compartments based on detecting different types of waste is achieved using ESP32 microcontroller. Also included in the system are sensors and detectors that classify waste based on factors such as weight, size, and shape. The key objective of this section is to provide a comprehensive overview of previous studies and contextualize them by highlighting important background information. Automated waste sorting system is a topic explored by literature for its potential to reduce landfill waste while improving recycling efficiency rates which can lead to decreased environmental pollution.

This project is being developed by utilizing multiple electronic components which include sensors, detectors and microcontroller along with programming languages. Designing a system involves properly incorporating its mechanical, electrical and software parts. During the development phase there is a step where we test the system's functionality & efficiency for validation, and this chapter deals with the compilation and discussion of all key areas related to the subject. The objective of this project is to facilitate efficient waste management while upholding environmental sustainability. For a more accurate approach towards waste sorting within this project, it's important to include machine learning algorithms as well as deep learning models.

2.2 The history of waste management

The late 1800s saw modern concepts including solid waste management being implemented across America, and as time passed in the 20th century more American cities initiated basic solid waste collection and disposal systems. Garbage disposal facilities had been made available to nearly all inhabitants of cities throughout America by approximately 1930 [9]. The increase in population and industrialization came an elevation in garbage creation that eventually necessitated improved waste management strategies [9]. Once upon a time people often trusted in the natural breakdown of things or casually left trash in the surrounding areas, but agriculture has led to the emergence of bigger communities which required a structured approach towards managing waste [10].

2.3 Solid Waste Management in Malaysia

The current state of solid waste management in Malaysia is relatively poor, characterized by a rapid increase in waste generation due to population growth, urbanization, and industrialization [11]. Improper waste management has resulted in detrimental consequences, such as soil and water pollution, as well as posing health hazards. However, addressing these challenges through the implementation of the 3R principles of Reduce, Reuse, and Recycle can help pave the way towards sustainable waste management practices [11]. Table 2-1 shows the solid waste of selected locations in peninsular Malaysia, Table 2-2 shows the forecast results of the amount of solid waste generated and Table 2-3 shows the forecast of SWG of various sectors.

Table 2-1: Solid Waste Composition of Selected Locations in Peninsular Malaysia[11]

Waste Composition	Kuala Lumpur	Saha Alam	Petaling Jaya
Garbage	45.7	47.8	36.5
Plastic	9.0	14.0	16.4
Bottles/Glass	3.9	4.3	3.1
Paper/Cardboard	29.9	20.6	27.0
Metals	5.1	6.9	3.9
Fabric	2.1	2.4	3.1
Miscellaneous	4.3	4.0	10.0

Table 2-2: Prediction of Total MSWG of Kuala Lumpur [11]

Year	Population of K.L. city Millions	MSWG Kg/Cap./day	MSWG Tons/day	MSWG Tons/year
2009	2.43	1.66	4029.85	1470895.25
2011	2.63	1.72	4534.78	1655194.70
2013	2.85	1.79	5102.97	1862584.05
2015	3.08	1.87	5742.35	2095957.75
2017	3.33	1.94	6461.85	2358575.25
2019	3.60	2.02	7271.50	2654097.50
2021	3.90	2.10	8182.59	2986645.35
2023	4.21	2.19	9207.84	3360861.60

Table 2-3: Prediction of Sectoral SWG of Kuala Lumpur (Tons/day)[11]

Year	Residential (48%)	Street Cleansing (11%)	Commercial (24%)	Institutional (6%)	Construction & Industry (4%)	Landscape (7%)
2009	1934.33	443.28	1025.97	241.79	161.19	282.09
2011	2176.69	498.83	1088.35	272.09	181.39	317.43
2013	2449.42	561.33	1224.71	306.18	204.12	357.21
2015	2756.33	631.66	1378.16	344.54	299.69	401.96
2017	3101.69	710.80	1550.84	387.71	258.47	452.33
2019	3490.32	799.86	1745.16	436.29	290.86	509.00
2021	3927.64	900.09	1963.82	490.96	327.30	572.78
2023	4419.77	1012.86	2209.88	552.47	368.31	644.55

2.4 Technique Solid Waste Management

The processing of waste is essential in optimizing the benefits of a solid waste management (SWM) system [12]. Solid waste management involves actions aimed at effectively handling waste produced from various sources. The objective of this activity is to collect, transport, and dispose of waste [12]. The solid waste management techniques include 3R (reduce, reuse, recycle). This method can reduce waste generation on focuses on minimizing waste by maximizing the resource efficiency[12]. Landfill is also the designated areas for specific disposal of solid waste. Compositing process also the method for solid waste management, it is a natural decomposition process which is organic waste[13].

Processing techniques can increase the efficiency of the system in solid waste management [14]. For example, wastepaper is often wrapped to reduce the amount of transport and storage before reuse. Compaction and shredding of waste is used to minimize transport costs and increase landfill efficiency. Additionally, materials that have a market value and are present in sufficient quantities in the waste stream can be recovered and recycled. These materials include paper, plastic, glass, metal, aluminum and other waste metals [14]

Soil drying is necessary before treatment in solid waste management. Systems that treat hazardous waste comprising materials like dioxins and other organics have limited performance data available [15]. Even though molten salt is often recycled inside the reactor chamber, there is a chance that wasted molten salt might be harmful and need to be disposed of carefully due to the volume of treated waste and ash created. Off-gas cooling causes liquid condensation, which produces oil/tar waste and contaminated water that may be considered hazardous waste and necessitates the use of the proper treatment, storage, and disposal procedures[15]

2.5 Related Previous Project

2.5.1 Intelligent Waste Separator

A prototype of the Intelligent Waste Separator (IWS), as per this paper's proposition employs a conventional bin combined with several smaller bins inside, and the whole system integrates multimedia technology. Whether it is organic or inorganic waste people can throw everything into the system [16] . Its capacity to identify which subset of refuse it falls under makes it adept at placing itself in the perfect waste bin, and the impact of garbage on all living beings is a universal problem. Grow NYC published a report which states that 80% of all worldwide solid waste comes from the United States[16]. Moreover, it is noteworthy that 70% of the total trash generated in this location serves only one purpose before disposal, while 45% undergo burial or combustion processes afterward[16]. Paper and plastics constitute a major portion of these wastes. A significant number of areas like Universities, Downtown areas, Malls, and Subway Stations have allocated exclusive containers specifically meant to collect certain categories of waste. However, disappointingly enough there exist individuals who choose to discard their waste improperly. As a result of this issue recycling becomes much more difficult if the waste should be separated at a high cost. The device uses a camera and sensors to detect different waste kinds and classify them into groups including plastic, paper, metal, and glass. The AI algorithms can swiftly and reliably detect and sort various forms of garbage after being trained on a collection of photos representing those wastes [16].

The author uses the RFID system. The process is initiated when the user interacts with the touch screen interface by pressing a button. A web camera, connected to the system, captures RGB images of the waste residues shape, which are then processed by a multimedia processor (MMP) to extract relevant features. The classification of the residues is performed using the first two Hu Invariant Moments (HIM) in combination with the k-Nearest Neighbor (k-NN) algorithm and Euclidean distance. Upon classification, the MMP sends a signal via the serial interface to open the corresponding gate for waste deposition. If the waste is not recognized, it is stored in the default container. Following waste deposition, users are encouraged to swipe their RFID card through the RFID reader to receive points based on the deposited waste. To register their RFID card, users can utilize the "Register Eco-ID" button provided on the graphical user interface (GUI). Figure 2-1 shows the block diagram of the system. It provides an overall understanding of the functioning of the IWS system and the interconnections among its various components[16].

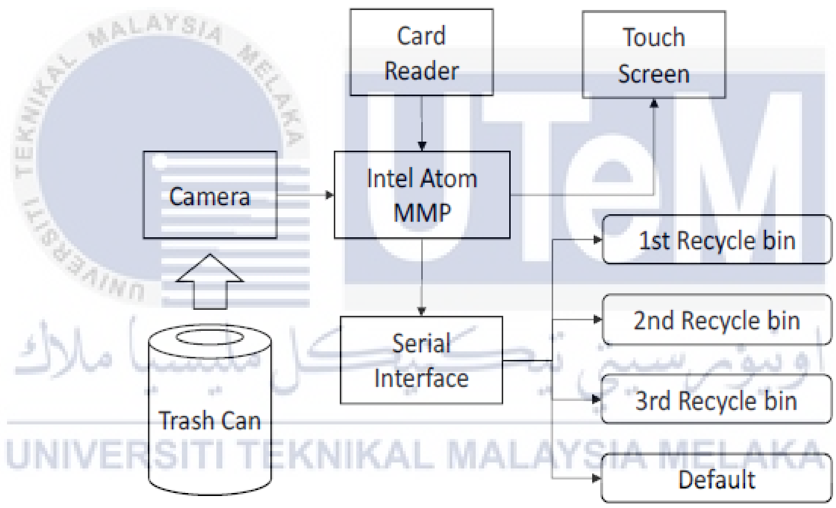

Figure 2-1: Block diagram of the system [16]

The current form of the system as a prototype has multiple restrictions, only separating single-use plastics like cutlery and identifiable plastics such as bottles or cans is what the system is restricted to do. Even though it takes practice, this skill enables you to separate different kinds of waste. Furthermore, users need to deposit their trash individually as the system is intended only for processing one segment of waste material at a given time. As a result of relying solely on the shape of wastes for object recognition, this system cannot detect damaged wastes[16].

To validate the current approach and make it better in future research we need to compare it with other classification methods. Additionally, the authors thought about changing the microcontroller for one capable of implementing more complex computer vision algorithms due to higher computing power.

The author's plan to propose the implementation of this functional prototype involves the presentation to the relevant university authorities for use in public areas, and their ability to display the performance of the waste separation system allowing the collection of important user input [16].

2.5.2 Garbage monitoring system using IoT

The development of a system that uses Internet of Things (IoT) technology to monitor and manage garbage collection in a smart city [17]. The technology sends data to a central computer over the Internet using sensors installed in trash cans to track the amount of rubbish. When the bin is full or has to be emptied, the server analyses the data and sends notifications to the waste management department [17]. The potential benefits of using IoT for garbage monitoring, including reduced labor costs, improved efficiency and accuracy, and better environmental management. By offering prompt and effective rubbish collection, the system can also aid in reducing the spread of illnesses. Development of IoT-based waste management systems could help address the growing problem of urban waste management and promote sustainable waste management practices [17].

i) Using Arduino Uno & ESP8266 (Wi-Fi Module)

The author uses the arduino uno as an open source hardware and software organization. Arduino is known for designing microcontroller kits for building automated devices that interact with real-world elements. It all started with the creation and development of Arduino at the Italian Institute of Interaction Design located in Ivrea. The release of hardware reference designs through the Creative Commons Attribution Share license enables their distribution and modification [17].

Using of the ESP8266 module enables the projects to have both Wi-Fi connectivity and internet access. Its ability to connect effortlessly with any microcontroller is what makes it the preferred choice for wireless IoT applications. Applying a voltage above 3.3V may result in damage and disrupt proper functioning of the module. Hence users are advised against doing so. However, enabling the Wi-Fi functionality in ESP8266 module requires connecting its two specific pins.e3 volts. The connection between ESP8266 and Arduino for communication is established using the TX and RX pins. A voltage divider is essential for proper implementation of the RX pin since it operates at 3.3v[17]. Figure 2-2 shows the component of Arduino Uno and Figure 2-3 shows the component of ESP8266(Wi-Fi Module).

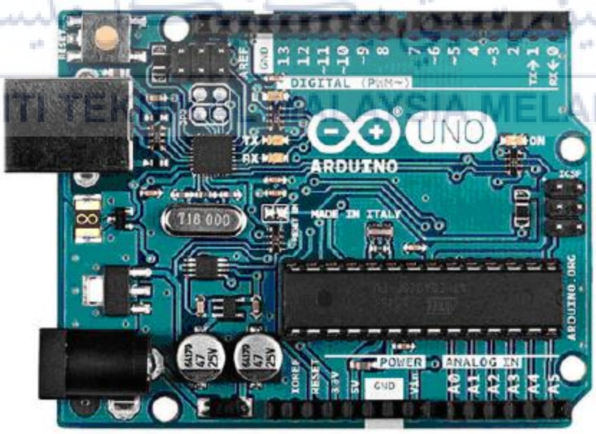

Figure 2-2: Arduino Uno[17]

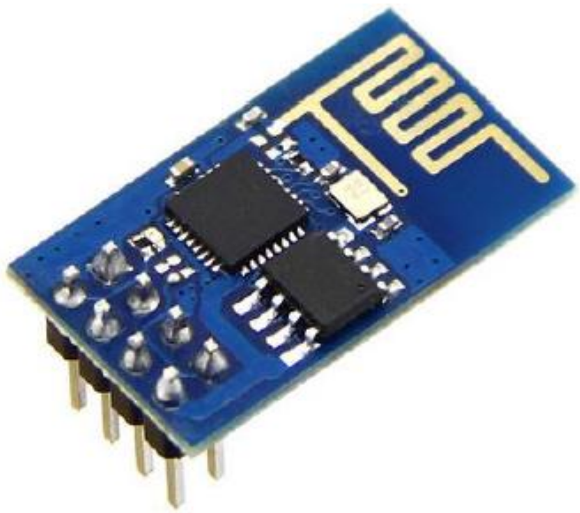

Figure 2-3: ESP8266 (Wi-Fi Module)[17]

ii) Using Ultrasonic Sensor

The author uses an ultrasonic sensor to make distance measurement more accurate and reliable. Ultrasonic sensors that have a wide measurement capability ranging from one inch to thirteen feet or two centimeters up to four hundred centimeters. Ultrasound waves carrying a frequency of 40KHz are emitted by this sensor into space and then echo back when they meet something.The number of pins available on the Ultrasonic Sensor is four[17].

The author connects the VCC and GND pins to the 5V and ground terminals in the Arduino board. Also, any digital pin available on the Arduino board can be used to connect with the Trig and Echo pins. Finally, to send the signal, the author uses a Trig while it receives through the Echo. The Trig pin needs to be set high for about 10 microseconds to generate an ultrasound signal, at which speed the 8-cycle sonic boom will start. After striking the target and bouncing back, the Echo pin stores the reflected signal. Figure 2-4 shows the component of ultrasonic sensor.

Figure 2-4: Ultrasonic Sensor[17]

The setup process for the EsP8266 starts with flashing its latest firmware version, efficiently communicating with the Blynk library while avoiding possible errors made possible by following these important steps. Once author are done with the flash programming it can add other parts to your setup. Using jumper wires to link various devices such as microcontrollers together with devices such as ultrasonic sensors or buzzers requires access to a breadboard. By acting as a connector between separate components, a breadboard is to easy to connect more inputs with a single pin on an Arduino. The Figure 2-5 shows the connection of hardware. It provides an illustration of how to connect all the components using breadboards and jumper wires as part of this project. The Figure 2-6 shows the connection circuit in this project.

Figure 2-5: Hardware components connection[17]

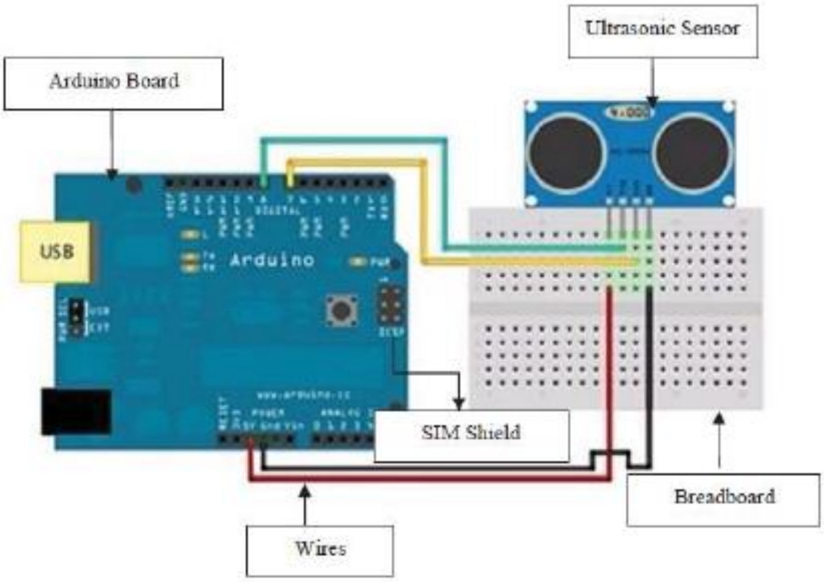

Figure 2-6: Circuit diagram[17]

Using a pre-built platform like the Blynk app allows this project to be connected to the Internet. Users must first download the Blynk app on their smartphone and register an account to access its range of features. The author evaluate how well the system is working by adjusting trash levels in the bin and observing notification activity based on Figure 2-7, and confirmation of operating system success relies on users checking notifications through the Blynk app based on Figure 2-8. The reliability of the output of the hardware components and the subsequent actions that depend on them have been guaranteed by proper security measures [17]

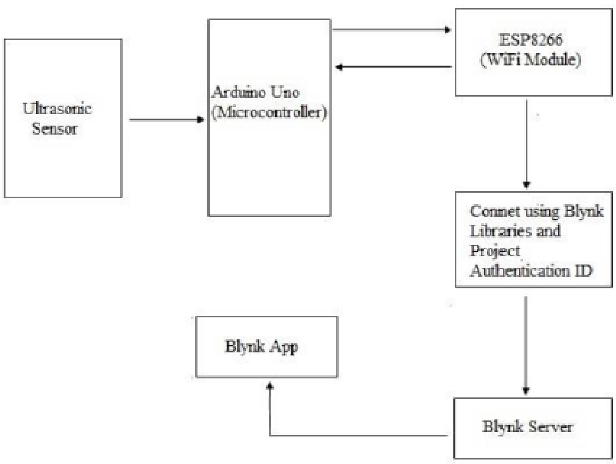

Figure 2-7: The block diagram of the project[17]

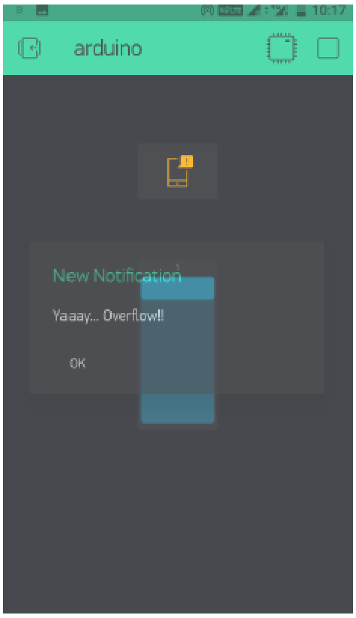

Figure 2-8: The experiment result in Blynk Apps[17]

2.5.3 Development of Automatic Smart Waste Sorter Machine

This project presents an innovative approach to waste management, which is a growing concern in many urban areas[18] It also give a thorough analysis of existing waste management procedures and the shortcomings of manual sorting and single-stream recycling as well as limits of conventional trash sorting techniques. The benefits of the smart waste sorting machine, such as reducing the environmental impact of waste disposal, improving resource recovery, and reducing the cost of waste management. The Automatic Sorter Machine for Smart Waste Management System working by using a 9V power supply[18].

The microcontroller and servo motor are synchronized to ensure optimal performance. Once material is placed on the system tray, the IR sensor detects it and the system is activated. The weight sensor then determines the weight of the trash, while the metal and glass sensors identify the material. If the material is identified as metal, a servo motor will deposit it into bin 3, and if it is identified as glass, it will be deposited into bin 4. If both sensors fail to detect the material, the LASER and LDR sensors activate. If the LASER passes through the material, it is determined to be transparent and deposited into bin 2. If the LASER is unable to pass through the material, it is identified as paper and deposited into bin 1[18]. The Figure 2-9 shows the over flow process in this project.

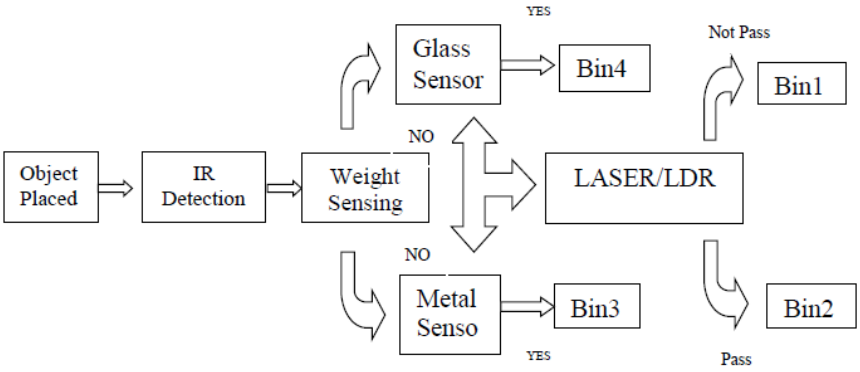

Figure 2-9: Sequential Logic Flow Chart [18]

Among other things that make up the sorting system are LDR and infrared sensors in addition to LASERs. These components are operated with the help of a microcontroller PIC 16f877A. The placement of garbage into its appropriate receptacle is carried out by utilizing the actuator known as Mighty Metal Gear Feather Servo. In order to track trash's sequence number and calculate certain waste types of total weight one can use the microcontroller[18]. Figure 2-10 shows the block diagram of the sorting system.

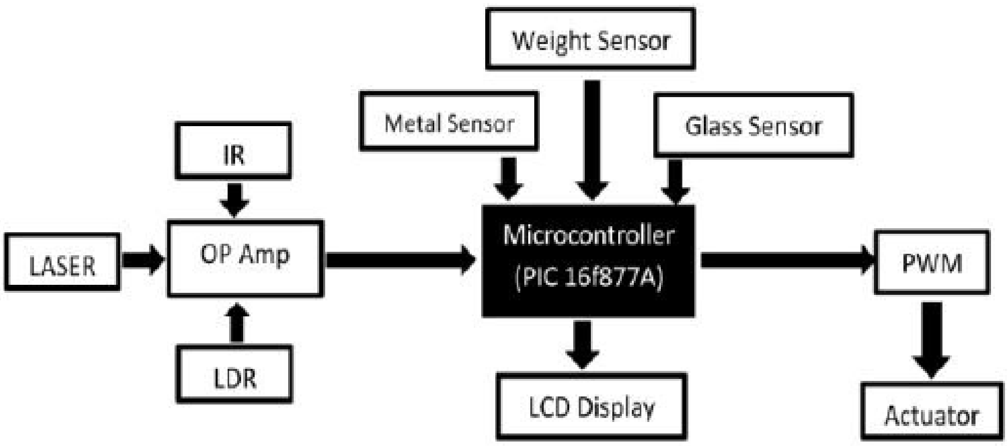

Figure 2-10: Block diagram of the sorting system in the project[18]

At the outset the sorting machine was only capable of partially operating with assistance and could categorize just a few kinds of garbage which is plastics as well as non-translucent paper goods. That being said, the author now moved onto a fully autonomous sorting system which has significantly increased the number of available bins[18]. A worldwide environmental concern regarding the disposal of glass is now being addressed by the author project that upgraded version featuring a new and improved glass sensor.

2.5.4 Automatic Trash Sorter Using Arduino And Sensors

The proposed solution to efficiently manage solid waste is by using a Waste Sorting System which is based on Arduino. Metal waste can be effectively separated from other wastes thanks to the application of an Inductive Proximity Sensor. [19]. Once the rubbish container reaches its maximum capacity an alarm will sound, and by using an automatic garbage sorter we can identify incoming waste by kind with an accuracy of around 80 percent.Opening an appropriate bin in response to sensor data is carried out by Arduino UNO which serves as a model's main brain receiving all that information, replacing full dustbins with clean ones and removing disposed trash is made possible by monitoring their levels[19]. The Arduino UNO acts as the central processor for the system, receiving sensor data and controlling the opening of the correct bin. To ensure continuous monitoring of bin levels, ultrasonic sensors are installed in the bins. This allows for real-time checking of the dustbin level. The system enables the monitoring of dustbin levels, the replacement of full bins with empty ones, and the proper disposal of filled trash based on the current needs[19]. The Figure 2-11 shows the block diagram of this project.

Figure 2-11: Block Diagram of the project[19]

With this innovative strategy in place, people will be motivated to properly discard their rubbish. Thanks to its reliance solely on sensors and not conveyor belts for mobility reasons, moving the bin from point A to point B will be simple [19].What makes this different from others is that it has an automatic mechanism for opening and closing a garbage bin, and dust levels are monitored routinely. Delaying the onset of many illnesses is possible by encouraging people to dispose of their waste properly and avoid overflowing dustbins, ensuring that the future is filled with brightness [19]. The lid of this container will opened using the servo motors. The output can be viewed in the serial monitor, providing real-time updates. In case the trash reaches its full capacity, the buzzer will be activated to alert the relevant authorities, prompting them to empty the respective bin. The Figure 2-12 shows the hardware of working model of the project.

Figure 2-12 : The hardware of working model[19]

2.5.5 Automatic Waste Segregator and Monitoring System

Automated trash segregator are made to filter garbage into three primary categories: metallic, organic, and plastic. This improves waste management efficiency. The majority of countries have accepted the "Waste management hierarchy" theory as the first stage in creating municipal solid waste management programmes[20]. It is always possible to separate the trash at the source itself, even in the presence of massive industrial waste segregators. The advantage of doing this is that it lessens the occupational risk for garbage employees. Also, instead of first going to the segregation plant and then the recycling plant, the separated trash might be transferred straight to the processing and recycling facility[20]. As its name suggests, a waste segregation device is used to divide garbage into 3 distinct groups: metallics, organics, and plastics. The management of the entire system falls under an Arduino Uno board's purview.Various electronic devices like electromagnets and ultrasonic sensors link up with the Arduino board, and a crucial part of the monitoring system is its GSM module. SMS messages sent by waste bins will be received by a computer via a GSM module [20]. The Figure 2-13 shows the block diagram of the waste segregator.

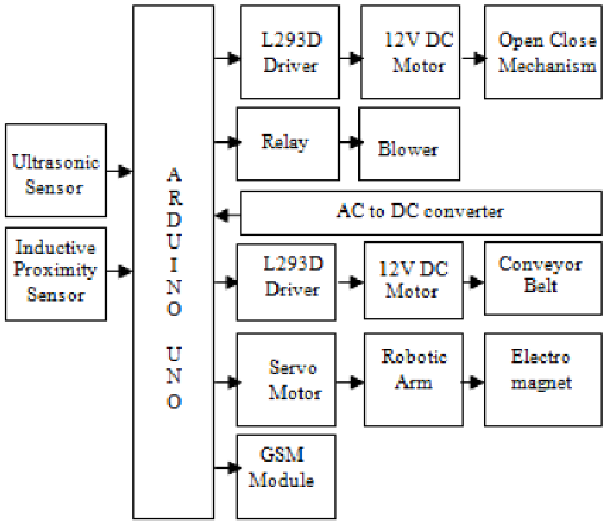

Figure 2-13: Block diagram of waste segregator[20]

The authors emphasize that the objective of the automated waste segregation & monitoring tool is to distinguish waste between three different types, namely metal objects such as cans or foil wrappers, plastic objects such as containers or bottles and bio-degradable waste including vegetable skins or food [20]. As more garbage accumulates every day and creates significant problems for us, it becomes important that we separate our waste. It has been shown that using a tested system to separate household waste is effective. The Table 2-4, Table 2-5 and Table 2-6 shows the test results for the garbage after it went through an automatic waste segregator and monitoring system. The proposed system manages and monitors the solid waste collection process to ensure efficiency and timeliness, and the use of practical and reliable technology in the system helps in monitoring and managing solid waste collection leading to environmental sustainability[20].

Table 2-4 : Result of Metallic Waste Separation by Subha T D, 2016 RMK Engineering College[20]

Sl. No.	Type of Metal Waste	Discarded or Not
1	Safety pin	Yes
2	Paper clip	Yes
3	Battery	Yes
4	Nail	Yes

Table 2-5: Result of Organic Waste Separation by Subha T D, 2016 RMK Engineering College[20]

Sl. No.	Types of Organic Waste	Discarded or Not
1	Kitchen waste	Yes
2	Leftover food	Yes
3	Vegetable peel/Fruit peel	Yes
4	Rotten fruits and Vegetables	Yes

Table 2-6: Result of Dry Waste Separation by Subha T D, 2016 RMK Engineering College.[20]

Sl. No.	Type of Dry Waste	Discarded or Not
1	Paper	Yes
2	Small bottles	Yes
3	Heavy cartons	No
4	Milk cover	Yes
5	Dry leaves	Yes
6	Clothes	Yes
7	Tetra pack	No

2.5.6 Automated Trash Sorting Design Based Microcontroller Arduino Mega 2560 with LCD Display and Sound Notification

Dealing with the mounting issue of accumulating garbage requires us to prioritize segregation as emphasized by the author. By using an automatic system for segregating wastes based on their type such as plastic or organic matter, we aim to improve our process.

This technique assists in reducing environmental pollution levels as well as promoting the practice of recycling[21]. The proposed platform relies heavily on utilizing an Arduino Mega 2560 as its central controller, which operates as a main control unit that receives input from multiple sensors and controls the sorting mechanism.Users are able to view important information regarding waste separation in real time with the help of an LCD display.

Furthermore, the writer examines how sound notifications can be integrated into the system.When necessary actions like emptying of the trash can or something else needs user attention notifications are used, which has a positive impact on both the usability and effectiveness of the automatic waste sorting system. There are different parts to the hardware design that include a metal separator together with separate sections for wet and dry solid wastes which also includes an LCD screen as well as audible alarms[21]. The first step in the design process is to develop a block diagram that outlines all of the components' functionalities and stages. Systematically approaching development of the hardware facilitates efficient separation of different waste types along with incorporation of key features such as an LCD display and sound notifications. Figure 2-14 shows the block diagram of the system and Figure 2-15 shows the front view design of this project.

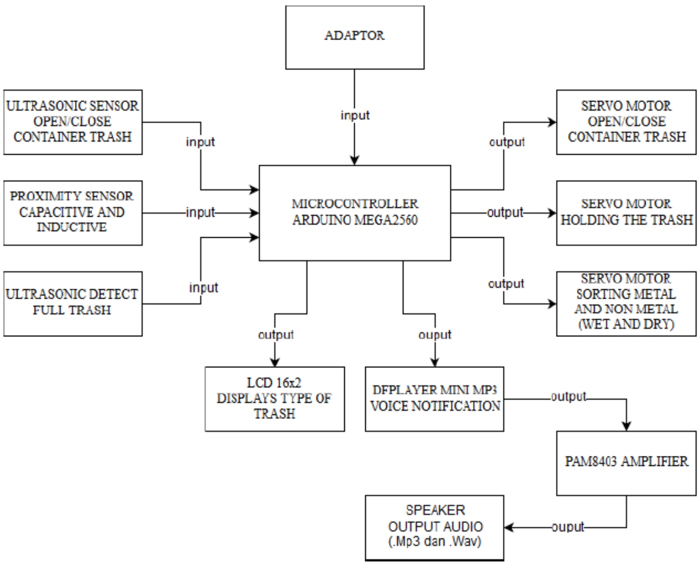

Figure 2-14: The block diagram of the system[21]

Figure 2-15: The front view design[21]

Inductive proximity and capacitive proximity sensor-based approach are focused upon by the author for enhancing waste selection. The constructed system efficiently discriminates different types of wet or dry metallic or non-metallic wastes based on their respective classifications where objects with size less than five centimeters are rejected[21]. The inductive proximity sensor operates at zero point eight millimeters maximum distance while the capacitive one works at twelve millimeter maximum distance. Figure 2-16 shows the circuit design of this project.

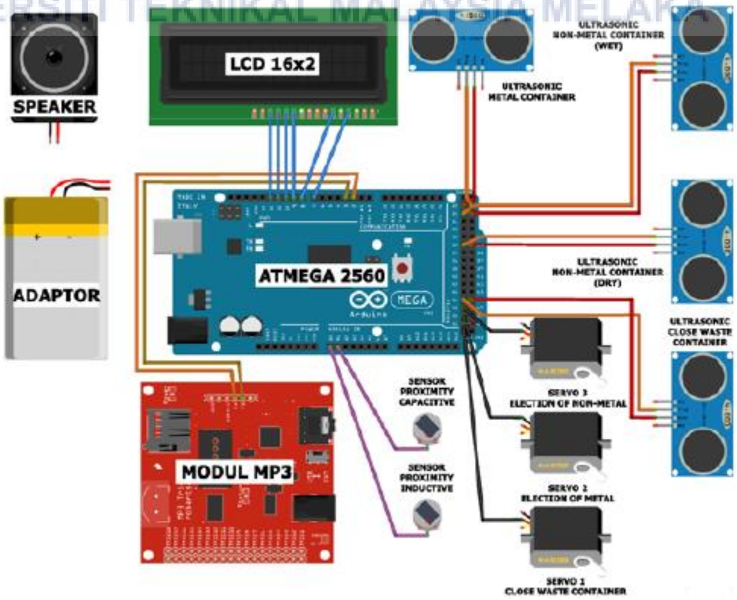

Figure 2-16: The circuit design[21]

According to the test results conducted it is evident that the sorted actions displayed one-hundred-percent efficiency in categorizing dry rubble whereas they demonstrated an efficiency level percentage with regards to wet rubble We conducted a series of tests on two different kinds of trash in various rubbish disposal sites that included testing them out five times each non-metal) using Both Inductive Proximity Sensor as well as Capacitive Proximity Sensor, the signal detected was efficient enough to calculate the distance from closest object. The opening mechanism of this bin uses an ultrasonic sensor that can detect objects or people between 10 and 20 centimeters away[21]. When activated if anything is detected it opens using a servo motor. When a capacitive proximity sensor or inductive proximity sensor detects metal or non-metal (dry and wet) waste materials an LCD display and sound alert will confirm the nature of the material[21].

The system includes the integration of second, third, and fourth ultrasonic sensors in each trash can to determine if the trash can is full or not. In the event that the trash can reaches its capacity, a sound notification is activated to inform users that the trash can is full. System testing represents the stage where all software components, developed as programs in the Arduino IDE, and the hardware, comprising a series of functional systems, are prepared for operation. This stage ensures that the software and hardware components work together seamlessly to achieve the desired functionality of the system[21]. Firstly, conducting tests to check if the trash can cover functions properly Ultrasonic sensors are able to sense the presence of humans by detecting objects near them around the waste bin. Table 2-7 shows the result of ultrasonic sensor testing.

Table 2-7: The result of ultrasonic sensor testing[21]

No	Distance Measuring Instrument using Ruler	Value
1	10	Open
2	20	Open
3	30	Closed
4	40	Closed
5	50	Closed

Second, testing will determine whether or not the sensor can successfully detect waste their classification into metals or either type of non-metal (wet or dry) is depicted in the display the LCD of the type of waste. Table 2-8 shows the result of sensor detection distance testing.

Table 2-8: shows the result of sensor detection distance testing[21]

Proximity Capacitive Sensor		Proximity Inductive Sensor	
Detection Distance (mm)	Description	Detection Distance (mm)	Description
0	Detected	0	Detected
4	Detected	2	Detected
8	Detected	4	Detected
12	Detected	6	Detected
16	Not Detected	8	Detected
20	Not Detected	10	Not Detected
24	Not Detected	12	Not Detected

The author successfully effectively sorting wet or dry metallic/nonmetallic wastes individually with a minimum requirement size of over five centimeters can be achieved through the use of this tool's operation as originally intended. The accuracy is reliant on two sensors which must meet specific ranges - an inductive proximity sensor that should have distance readings between 0mm up until 8mm while also having their capacitive counterpart operating between no less than 0mm-12mm. Table 2-9 shows the test result of the sorting system and Table 2-10 shows the result of the sound notification.

Table 2-9: Test result of the sorting system[21]

Sorting	Right Servo	Left Servo	LCD	Description
Metal	✓		✓	Corresponding
Non Metal		✓	□	Corresponding
Wet		✓	□	Corresponding
Dry	✓		□	Corresponding

Table 2-10: Result of the sound notification[21]

Types of Trash	Thank You Speech	Container Trash Full	Description
Metal	✓	✓	Corresponding
Wet	✓	✓	Corresponding
Dry	✓	✓	Corresponding

When it comes to sorting the various types of trash, metal always scores an exacting system hit rate at 100%. However, using this system for separating non-metallic-dry trash produces similar results. But when dealing with its 'wet' counterpart, the author more likely to achieve just an 80%. The author mentioned to detect an object that is near to equipment within different types of material(s) (non-metal or metal), then we need use both capacitive and inductive proximity sensors which can ensure precise detection. The system employs capacitive and inductive proximity sensors to collect input data, enabling the system to display the type of trash on an LCD screen. Ultrasonic sensors play a dual role in detecting whether the trash bin is full and measuring the proximity of nearby objects[21].

2.6 Advantage and disadvantage of previous project

Reference	Components	Advantages	Disadvantages
[16]	– RFID – Microcontroller – MMP (RS232 serial protocol) – NPN silicon power Darlington transistors – Uses two standard voltages (5v and 3.3v) – Two LEDs (green and red) – Motors	– The proper separation of waste is independent of human intervention. – It can be effortlessly trained to sort various types of waste.	– Currently processes waste items one at a time. – The system is only capable of efficiently separating aluminum, bottles, and plastic cutlery. – it relies on shape recognition for object identification
[17]	– Arduino Uno – ESP8266. – Ultrasonic Sensor	– Staff members have the flexibility to monitor the status of these bins using their mobile phones at any given time. – It can serve as a reference point for enhancing cleanliness	– Currently, this system is applicable to specific designated areas.

		standards in specific areas.	
[18]	– Microcontroller (PIC 16f877A) – IR sensor – Metal sensor (Capacitive proximity sensor E2K-C) – Glass sensor (Omron E3SCR67C) – Weight Sensor (MLC900 micro weight sensor) – Liquid Crystal Display (Alpha-numeric 16*4 LCD). – LDR sensor – servomotor (HS-65MG, Mighty Metal Gear Feather Servo)	– The sorter operates as a completely autonomous system. – Increase the amount of trash cans.	– The sorter is subject to servo rotation constraints. – The position pulse needs to be repeated as a command.
[19]	– Arduino UNO – Inductive proximity	– Reduce the amount of work that garbage	– Identifying waste by its kind is made more

	– Ultrasonic sensor – IR sensor – Buzzer – Servo motor	collectors and waste management centers have to do. – This illustration offers insight into the correct way to handle garbage.	efficient with a success rate of 80% by using a Garbage Sorter.
[20]	– Arduino uno – Ultrasonic sensor – Inductive proximity sensor – L293D Driver – Relay – 12V DC Motor – GSM Module	– Waste sorting at the primary stage enhances the effectiveness and productivity of waste management. – Regular clearing of dustbins as they fill up promotes a cleaner environment. – The system is environmentally friendly, promoting sustainable waste management practices. – The initial investment for installation is lower, resulting in cost savings.	– Waste separation can be a time-consuming process. – The size of the waste must not exceed the dimensions of the funnel for proper sorting.

[21]	– Microcontroller Arduino MEGA2560 – Ultrasonic sensor – Inductive Proximity sensor – Capacitive Proximity sensor – LCD 16x2 – PAM 8403 Amplifier – Speaker – Servo motor	– The device system effectively separates wet and dry waste, as well as metal and non-metal waste, individually, based on predetermined waste size criteria. – The separation success rate for non-metallic waste (dry) is 100%, while the separation of metal waste also achieves a 100% success rate.	– The functionality of this tool system relies on the inductive distance sensor being set within a range of 0-8 mm, and the capacitive distance sensor being set within a range of 0-12 mm from the object (residual).

2.7 Summary

In conclusion, the several pieces of literature above have yielded a greater understanding of trash sorting bins that address the growing problem of waste management. This literature involves the design and implementation of specialized bins that facilitate the proper sorting and disposal of different types of waste, including recyclable materials, organic waste, and general waste. As a result of thoroughly evaluating a wide range of literature studies, it becomes evident that the implementation of an appropriate and advanced technological project can effectively accomplish the objectives at hand. The insights and findings from these studies provide valuable guidance for designing and developing a project that can efficiently address the challenges associated with waste management. By leveraging the knowledge gained from the literature, a well-informed and strategically planned technological initiative can be devised to achieve optimal outcomes and contribute significantly to the field of waste management. For my project, it has been proposed that the system be built using hardware and software. The hardware will be constructed using contemporary tools like an Microcontroller ESP32, server motor MG996R, server motor TD8120MG and using 3 sensors which is IR sensor, Proximity sensor and water drop sensor to detect the material of metal and non-metal. The arduino IDE is used to run C programming code for software and Blynk application is linked to receive readings if the container is full by using ultrasonic sensor as input. The progress, concept, and objective of the creation of the automated sorting trash bin using arduino are all thoroughly in Chapter 3.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The chapter provides detailed explanations and descriptions of the project's processes. It begins by outlining the initial step, which involves developing the project's flowchart, followed by the creation of an appropriate block diagram in the subsequent section. The project's technique attempts to create an accurate and efficient waste sorting system using modern technology. The major goal is to create and put into place a solid system that can successfully separate various waste kinds based on specific requirements. Based on the findings from the research phase, a comprehensive system design was developed. This design incorporated the integration of various components to enable precise waste separation. Appropriate sensor selection and calibration were given focus in ensuring accurate detection and identification of various forms of waste. Also, discussed in this chapter is an illustration of how this project operates along with specific information about what tools will be necessary. Constructing flow charts increases understanding and improves overall comprehension of a project. In addition, the chapter discusses what is needed in terms of materials and methods to create a circuit association that covers all tasks related to it.

3.2 Project workflow

They guide our understanding and implementation of the planned project through using workflows, and a well-designed flowchart is crucial in achieving a successful outcome. A successful project frequently involves an essential analysis phase. Enhancing sequential projects data containing different journals and research material is possible through highly efficient top-quality projects. Regardless of its eventual outcome in terms of success or failure, the next step involves designing based on previous research followed by project implementation. The final stage involves conducting an analysis and evaluating data after the implementation was successful. Figure 3.1 shows the process of management workflow.

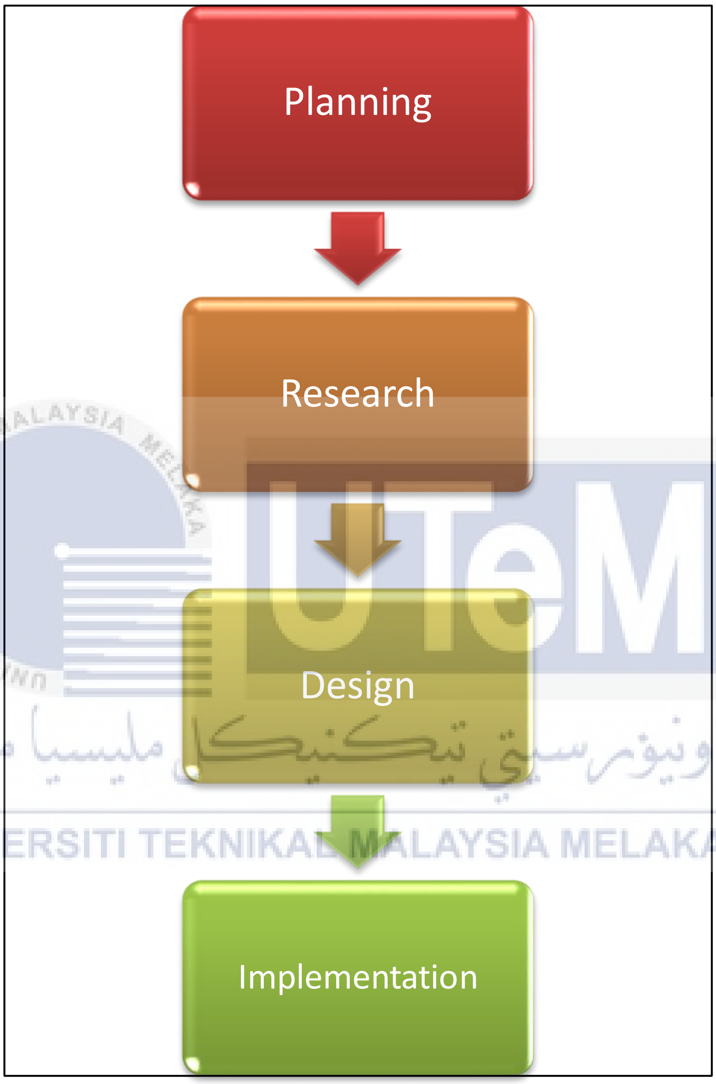

Figure 3-1: The project work process

3.2.1 Flowchart of overall PSM 1

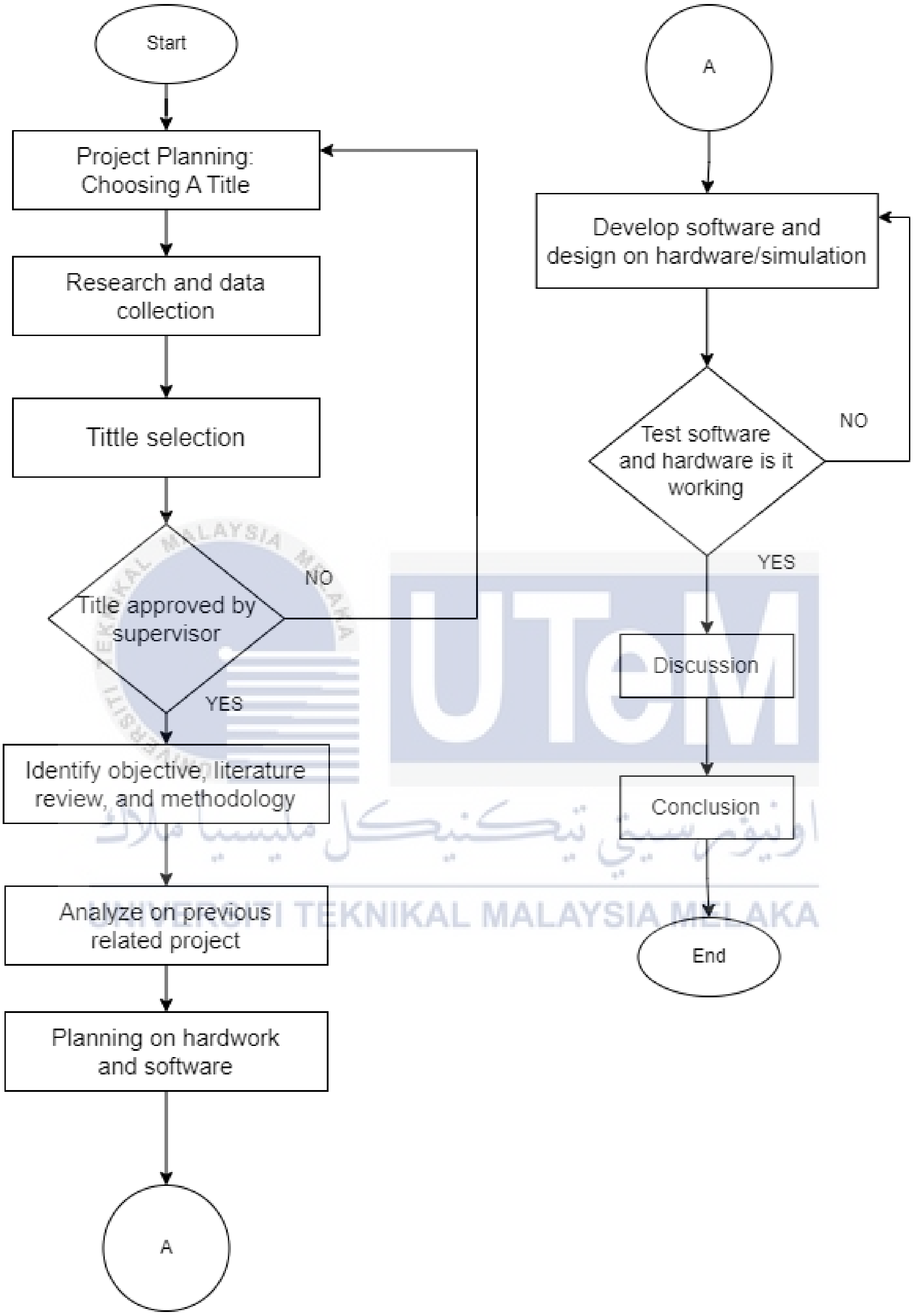

Figure 3-2:Flowchart of the overall PSM 1

3.3 Data Collection

Gathering essential information through a data collection process is crucial for evaluating the project's success rate, while the literature review holds significance in supplying pertinent data and information. To obtain extensive information about existing knowledge and research related to the project as well as set up parameters for data collection process it is necessary to conduct a literature review Discovering gaps and putting together a hypothetical basis can guide the following data collection steps.

ESP32 is assigned as a primary control device that has a responsibility to keep all essential information according to our project's methodology. The function of this microcontroller is to serve as a centralized hub for managing and saving data. Also, data acquired through an IoT-connected mobile application will be kept in a dedicated cloud server for this reason.

Developing a system using Blynk app alongside the Microcontroller ESP32 and Wi-Fi module makes it easier to capture data, enabling wireless connectivity and communication is made possible through a combination of an ESP32 microcontroller serving as its primary component with support from a Wi-Fi module. The intuitive application called Blynk is used to control and monitor the process of collecting data in a user-friendly manner.

In order to effectively develop this project, it is imperative to utilize all the data gathered from various sources. Additionally, scrutinizing antecedent endeavors would confer wider perspectives on purposes, tactics, and products of endeavor, thus promoting well-informed decisions.

3.4 Design

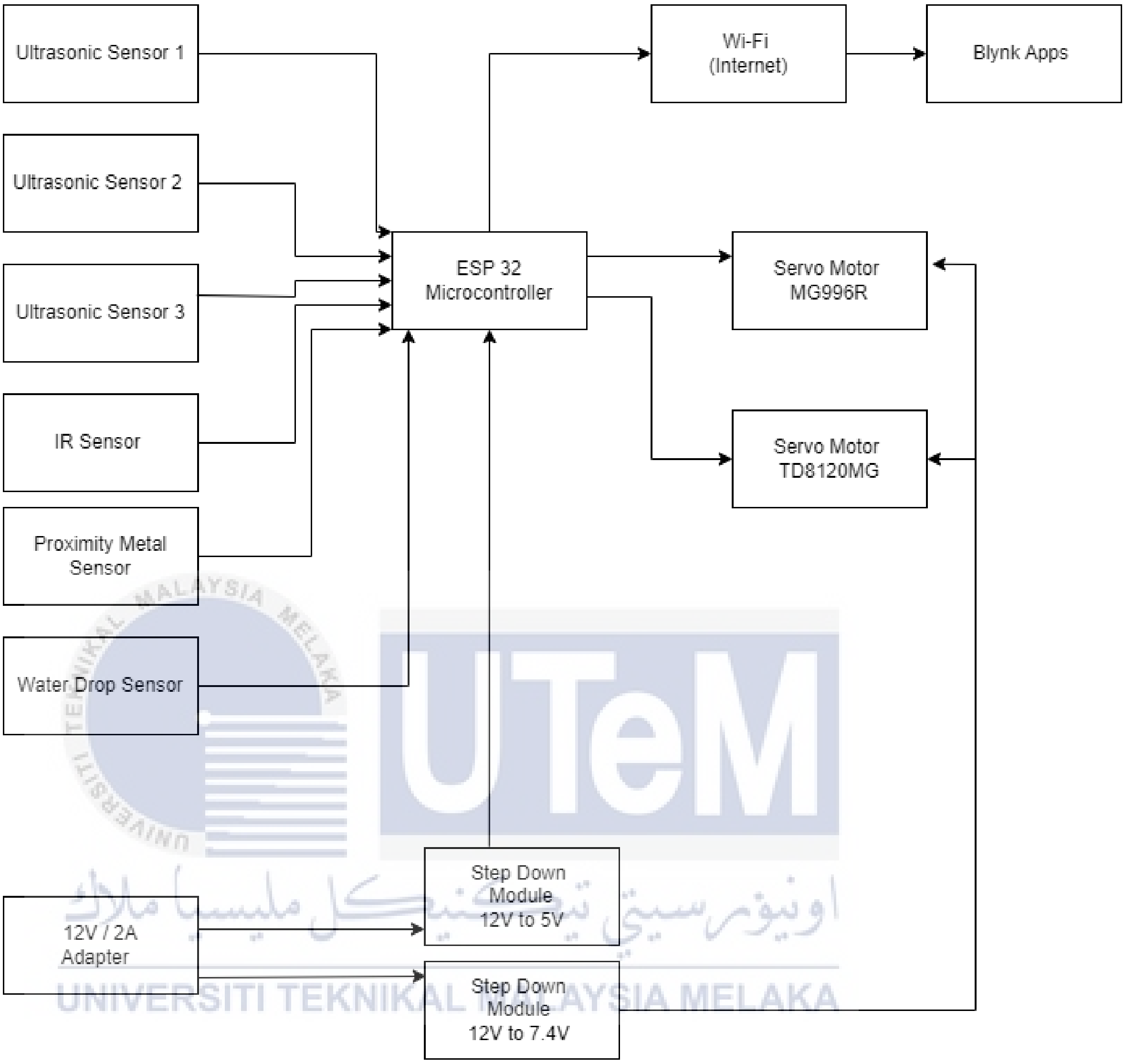

Figure 3-3: Project system block diagram

Figure 3-3 may display the block diagram for microcontroller ESP32 for automated trash sorting bin. This particular block diagram shows how the system works by physically connecting the hardware. The system's central processing unit is the ESP32. Connections to input devices such a IR sensor, metal sensor and water sensor. The Blynk programme will display the reading from the microcontroller ESP 32. The wifi (internet) allowing Blynk app with the collected data from ultrasonic sensor. Each component serves a distinct function and is essential to the project's success.

3.5 Hardware Specification

In order to achieve the desired outcomes, our project utilizes a range of hardware components. These include the ESP32 microcontroller, which is equipped with IR sensors and Ultrasonic sensors. Additionally, we have incorporated a water drop sensor, proximity metal sensor arrays, as well as a High voltage Motor driver Stepdown Module, Servo Motor (MG996R), and Servo Motor (20KG TD8120MG). The success of the project hinged on proper hardware implementation. Using ESP32 as its base point of reference allows for seamless integration of various functions in this hardware implementation. Without a hardware implementation, the device cannot function as intended.

3.5.1 Arduino Microcontroller ESP3

Figure 3-4 : Microcontroller ESP32

As illustrated in Figure 3-4, this project employs ESP32 as microcontroller. The many features including wireless connectivity make the ESP32 chip suitable for numerous applications. Developing a of an automated based trash sorting bin system based on the

Internet of Things is possible with ESP32 boards. The system incorporates sensors that collect data which are sent wirelessly to a web-based dashboard for further analysis. Additionally, mobile app based control is made possible through the use of ESP32's which have built-in Wi-Fi and Bluetooth capabilities[22]. The waste level in bins can be easily managed through an intelligent garbage management system that uses ESP32 microcontrollers. Differentiating between various kinds of waste including recyclables and non-recyclable material is among tasks handled by the system; wireless transmission makes it possible for us to analyse these details in a centralised database.

Espressif has developed a plugin called The Microcontroller Core to facilitate the seamless integration of ESP32 microcontrollers and the Arduino IDE platform for coding purposes. This plugin greatly assists in the development process. ESP32 chips become capable of running task-based applications when they are supported by FreeRTOS systems provided with the help of Microcontroller cores. ESP32's first-core continuously loops through programs after being initialized by setup function setting up microcontroller. Additionally, the use of this environment offers advantages such as hassle-free setup and a friendly user group[22].While it is effective on simpler endeavors more elaborate ones may not be as transparent or sustainable. The embedded system block scheme is depicted in the Figure 3-5.

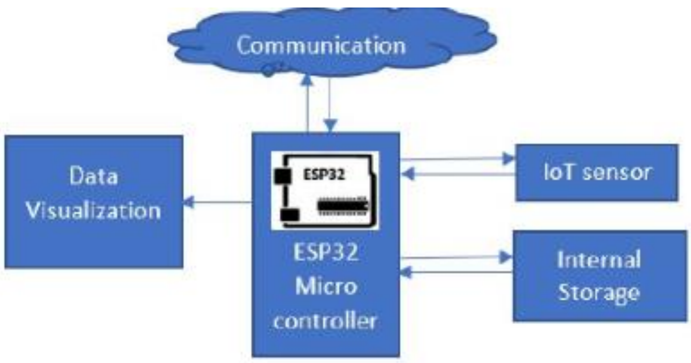

Figure 3-5: Block diagram of ESP32 system[22]

3.5.2 IR sensor

Figure 3-6 : IR sensor [23]

Figure 3-6 illustrates the IR Sensor. An effective way to sort objects based on their properties in a bin is by using an IR sensor which plays a vital role. By using an IR sensor in our sorting system we can determine if items are present or not. An infrared emitter and a detector make up the hardware for this particular infrared sensing device, and the detection of a reflection or interruption of infrared light relies on both the transmitting and receiving functions of the IR device.Detection of altered signal occurs when an object comes into view and obstructs the path between infrared light beams on a sensor. The sorting of data is started by applying this change[23].

Commonly employed in a sorting system are strategically located IR sensors either on a conveyor belt or specific points throughout. When items move on the conveyor belt they trigger a signal from the IR sensor which alerts to the control system. Objects are sorted into the correct bin based on data received from sensors triggering an appropriate response from our control system[23]. With its ability to detect objects in real-time accurately and dependably, the IR sensor enables automated sorting to be done effectively. Thanks to its ability to recognize predetermined criteria like color or shape-based categories, it quickly and accurately sorts objects.

3.5.3 Proximity Sensor (metal sensor)

Figure 3-7: Proximity Sensor (metal sensor)

A device (metal sensor) that detects metal is used to identify the presence of metallic objects in the sorting system Figure 3-7 shows the Proximity Sensor for metal sensor. When a metal item is detected by the proximity sensor, it activates corresponding action on the sorting mechanism. The operation of the proximity sensor relies on electromagnetic field principles and an electromagnetic field surrounds the sensor's detection zone. A simple disturbance such as a metal object entering this specific region can cause great changes to the behavior of the sensors that depend on it Arranging a metal proximity sensor for use in a sorting bin project means placing it at one particular point along either the conveyor belt or within the device used for separating items. Once things begin to move on the conveyor belt, a metallic indicator detects their presence and communicates with the regulating unit.

Once notified by a metal proximity sensor's reflection of an object within its range ,the control system enables an associated separation method that places said item into its proper container or disregards it completely. The metal proximity sensor allows for precise sorting of materials by enabling the system to distinguish between metallic and non-metallic objects based on their material characteristics, which enhances automation processes by providing a reliable method for identifying and classifying metal objects within the sorting bin project.

3.5.4 Water Drop Sensor

Figure 3-8: Water Drop Sensor

Figure 3-8 illustrates one tool which is water drop sensor that proves essential for any sorting bin project is the water drop sensor which has many functions, including identification of any leakage or spillage of liquids within recycling bin. This equipment has capabilities for both alert generation as well as re-routing fluids.Besides identifying non-water based objects accurately, the sensor can also identify items with a considerable amount of water. Maintenance and cleaning tasks can be scheduled based on the presence of water or liquid residue by monitoring humidity levels for environmental control. The functioning of the water drop sensor in a sorting bin project is contingent upon not only what items are being sorted but also upon the needs of that specific undertaking.

3.5.5 Ultrasonic Sensor

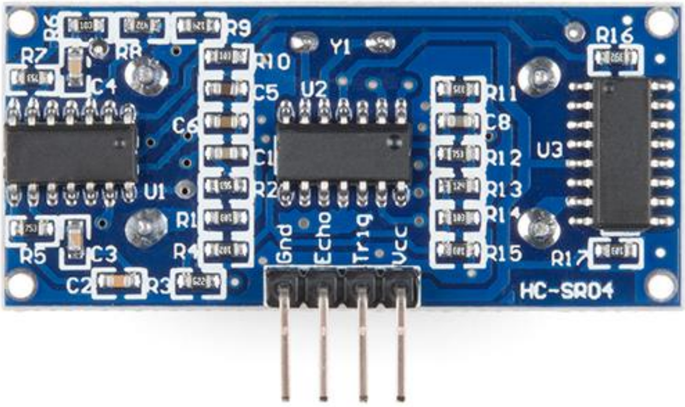

Figure 3-9: Ultrasonic Sensor[24]

Figure 3-9 shows the component of ultrasonic sensor. The ultrasonic sensor requires a 5V power source to generate high-frequency sound waves that are directed towards objects in order to calculate distance traveled during their round trip. By measuring differences in time taken for signals to reach an object and return back to a sensor, the distance between two points can be calculated. The sorting process cannot function properly without taking into account this fundamental distance information [24].

In order to achieve appropriate functionality in a sorting bin project, it is usual to position an ultrasonic sensor carefully either along its conveyor belt or within its sorting system. The ultrasonic sensor monitors objects within a specific area by detecting their movement and measuring the distance between the sensor and the objects. With access to this information about an object's position, the control system can make informed sorting decisions.

First, start communication with the sensor by sending an initial trigger pulse that lasts for at least 10 microseconds Prompting this action causes the emission of eight sound waves of 40 kHz by the HC-SR04 followed by waiting for a rising edge output to occur at its Echo pin. After detecting a rising edge signal on Echo pin, timer is initiated while waiting for its corresponding falling edges. Upon capturing a falling edge, the timer's counter gets read, which represents the amount of time that passed as a result of sound waves leaving from and returning to a sensor after bouncing off an object. The ultrasonic sensor is capable of calculating the distance to an object by measuring the time it takes for the sensor's signals to travel back and forth [24]

3.5.6 12V/2A Adapter

Figure 3-10: 12V/2A Adapter

Figure 3-10 shows the 12V/2A Adapter. The use of an adapter that can provide stable power with a voltage rating of 12 volts and current rating of 2 amperes is essential in any given project as the purpose is to ensure that each linked component receives an even and properly controlled flow of electricity free from variations in voltage. By having a 2A capacity for its electrical current output and reaching certain standards outlined by project component requirements, the adapter can provide satisfying results. In addition to this, the adapter may come with safety features to keep all your components safe including those that are most vulnerable to power fluctuations. For diverse ventures requiring an effective output at maximum current levels up to 2A and using only a single source of power at its disposal. Its versatility becomes incomparable.

3.5.7 Stepdown Module

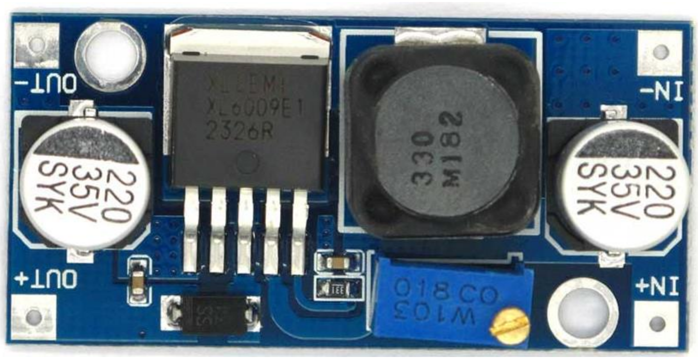

Figure 3-11: Stepdown Module[25]

Figure 3-11 shows the Stepdown Module. A buck converter or voltage regulator that goes by the name of step-down module effectively transforms high input voltages into low output ones, and the chief objective of this is to maintain consistent and properly regulated electrical power supply for various components or devices. The technique of switching is applied in this module which results in optimal efficiency by minimizing energy loss as well as heat generation. Additionally, the product's protection features and measures for regulating voltages effectively ensure that there is no deviation in the output voltage despite any variations in input voltage or situational loads[25].

Applications requiring versatility may benefit from using the compact and lightweight design of step-down modules, which have a broad input power supply range that can be adjusted to different needs with numerous safeguards like inbuilt limitation of currents. By converting voltages with efficiency while also providing stability and security improvements for electronic systems, the main task at hand for a step-down module comes into sight. There are some step-down modules that provide us with customizable options for their output voltage setting which we can adjust according to specific demands of different components or subsystems present in our sorting bin. This adaptability makes sure that various electronics used in the sorting process perform optimally while maintaining compatibility[25].

3.5.8 Servo Motor (MG996R)

Figure 3-12: Servo Motor (MG996R)

As illustrated in Figure 3-12 the servo motor MG996R's peak performance occurs when reaching its limit of 11kg/cm in terms of self-stop function. For precision control and actuation of the sorting bin system, the MG966R servo motor is used.The machine's rotation enables it to carefully move several mechanical parts at specific angles thanks to its maximum range capability of 180 degrees. In most cases, the operating voltage for this is +5V. According to the current reading, electricity production is yielding an amperage level of 2.5A and a voltage level of 6V. MG996R servo motor's robust design coupled with its ability to support high loads is why it is so popular. Additionally, this machinery is designed to handle hefty loads and provide adequate torque that allows it to move or manipulate objects found in the sorting bin. With an impressive weight-bearing capacity alongside exceptional sturdiness,this product is the best option for tough sorting tasks[26]

3.5.9 Servo Motor (20KG TD8120MG)

Figure 3-13: Servo Motor (20KG TD8120MG)

Figure 3-13 shows the precise actuation and control within the bin sorting system is made possible with installation of TD8120MG servo motor. Thanks to its unique function of rotating at precise angles, it ensures controlled movements of mechanical components such as gates and arms which are essential for facilitating the sorting process.The strong torque rating of 20KG for the TD8120MG servo motor makes it an efficient choice when it comes to handling and manipulating items within a sorting bin, and positioning mechanics is easier and more efficient thanks to the precision offered by the servo motor. The TD8120MG servo motor has the capability to operate smoothly with many frequently utilized microcontrollers and control systems in bin sorting Thanks to its easy integration feature it becomes possible to have seamless communication and control between the motor as well as other electronic components or modules in the sorting system[27].

3.6 Implementation

3.6.1 Project Implementation : Wiring and connection

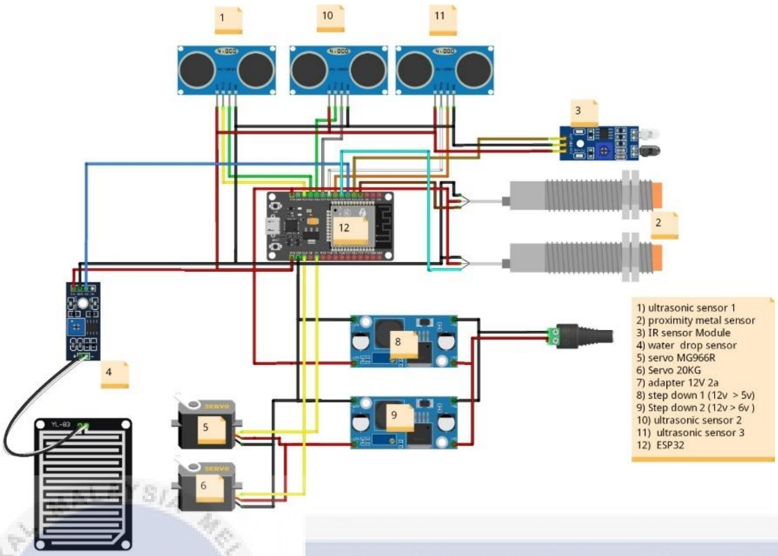

Figure 3-14: Circuit drawing for automated based trash sorting bin using fritzing.

The figure above demonstrates the whole connection of the automated based trash sorting bin system. Programming the ESP32 microcontroller requires the Arduino IDE. The microcontroller and the servo motors (MG996R and 20KG TD8120MG) should be powered by a 12V adapter. To supply the correct voltages, two step-down modules are used. The first module decreases the voltage from 12V to 5V for the microcontroller ESP32, while the second module decreases the voltage from 12V to 6V for the servo motors. This 6V voltage is optimal for operating the servo motors, which require a minimum of 5V and a maximum of 7V. Since the power supply is shared, it is important to split the power appropriately.

For the detection process, five sensors are used: an ultrasonic sensor, an IR sensor, a water level sensor, and 2 proximity sensors. Three ultrasonic sensors are connected to the microcontroller's pins, with each sensor's trig pin connected to different pins (D13, D14, and D26) and the echo pins connected to D12, D27, and D25 respectively. The IR sensor has three ports, one connected to D35, one to ground, and one to the microcontroller's VCC. The proximity sensor's output is connected to pin D34 and D33, and the water drop sensor is connected to pin D32. The output is controlled by two servo motors, with the MG996R servo motor connected to pin D4 and the 20KG TD8120MG servo motor connected to pin D5.

Before making any connections, it is important to understand the specifications of each board to avoid short circuits or malfunctions. The ESP32 microcontroller operates at 5V, so the IR sensor is supplied with 3V from the microcontroller, the proximity sensor and water level sensor use 5V, and ultrasonic sensors are connected in series with a 3V source pin from the ESP32. The ESP32 connects to the Blynk cloud server via Wi-Fi and transmits the collected data to the Blynk application interface.

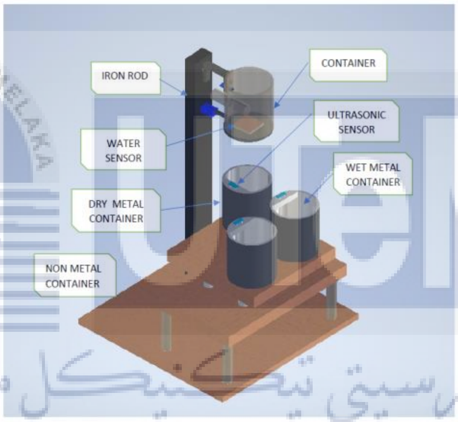

Figure 3-15: Drawing for automated based trash sorting bin

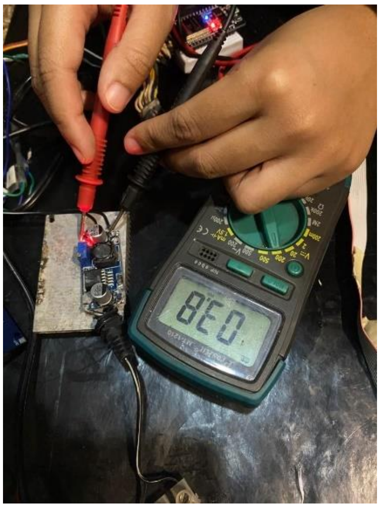

Figure 3-16 : Install and Test wiring continuity and voltage of each sensor

3.6.2 Flowchart of the system

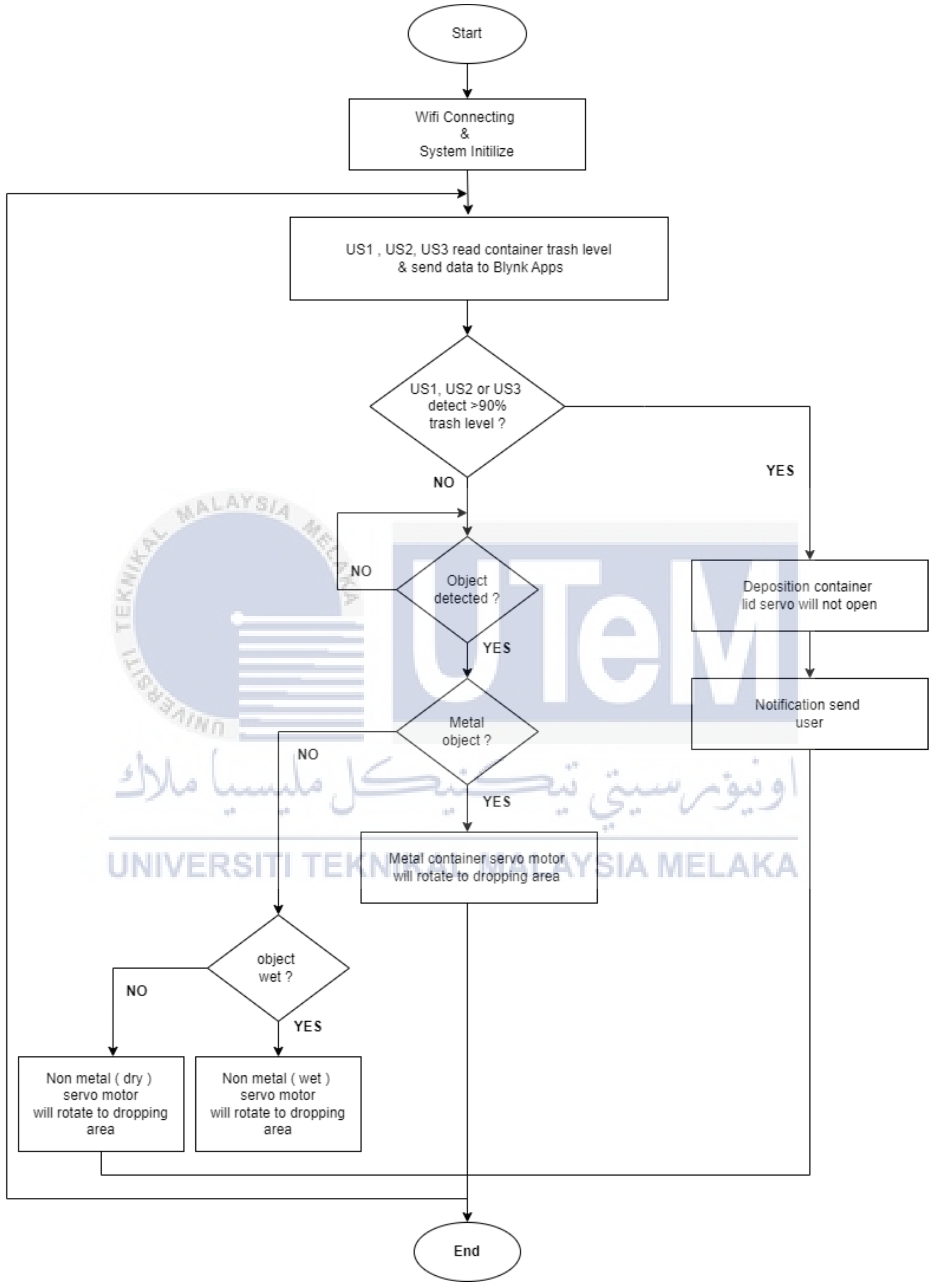

Figure 3-17: The flowchart of the project process

Figure 3-17 show this project initiates the process by connecting to Wi-Fi and initializing the system. The ultrasonic sensors (US1, US2, and US3) will measure the trash level in the container and transmit the data to the Blynk Apps. If the trash level, as detected by the ultrasonic sensors, exceeds 90%, the servo motor controlling the deposition container lid will remain closed, and a notification will be sent to the user. If the trash level is not detected to be over 90%, the sensor will identify the material of the object, distinguishing between metal and wet substances. If a metal object is detected, the metal container servo motor will rotate towards the dropping area. In the case of a wet object, the servo motor will rotate towards the wet container for disposal. If neither metal nor wet object is detected, the servo motor will rotate towards the dry container for disposal. Figure 3-17 shows the flowchart of the project process.

3.7 Software Configuration

3.7.1 Arduino IDE

The Arduino IDE is a versatile application that can be used on various operating systems, including Windows. Its main function is to interpret and compile C code, which is then loaded onto Arduino boards to create programs. Additionally, the Java-powered IDE streamlines the application uploading and installation process onto the Arduino board. Computer languages that perform designated duties include sets of commands known as programming languages. With the use of these languages one can write scripts which execute designated algorithms. Syntax and semantics are two main pillars of any given programming language. The generating of C programming code involves making use of the Arduino IDE software as shown in Figure 3–18.

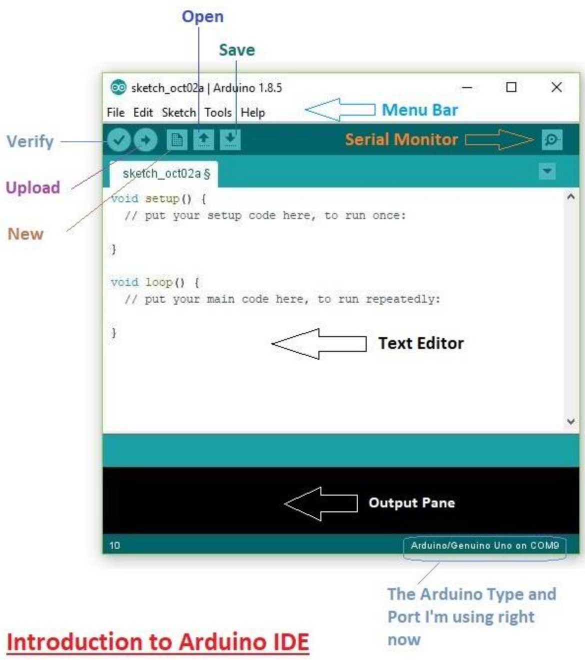

Figure 3-18: Arduino IDE program[28]

3.7.2 Cloud Server (Blynk)

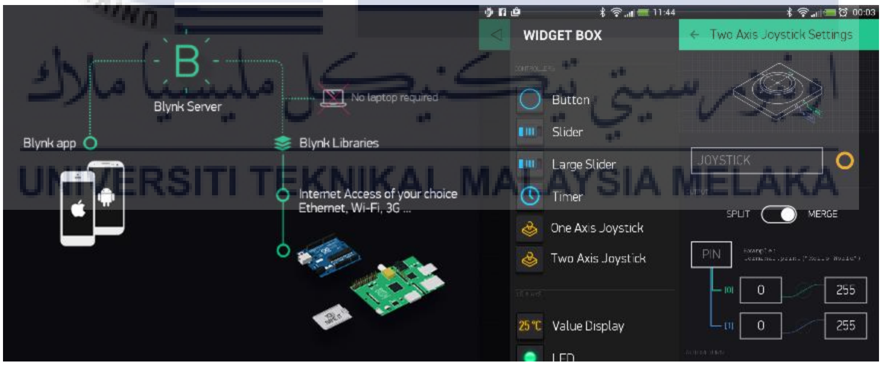

Figure 3-19: Blynk application[29]

Through utilizing iOS or Android applications a user can access remote control features for Arudino, Microcontroller and Rapsberry PI circuits using the Blynk platform. With the help of a sophisticated dashboard provided for users they can easily create personalized interfaces by customizing different widgets.With no limitation to specific boards or shields use cases, Blynk provides great flexibility. Blynk can manage Internet of

Things (IoT) devices online and remotely regardless if the connection to internet on the Microcontroller side happens through Wi-Fi, Ethernet, or an ESP32 WiFi module chip. Demonstrating remote device control and use of phone hotspots is shown through a depiction in Figure 3 -19 by the Blynk App.

3.8 Summary

In summary, the implementation of the trash sorting bin using the microcontroller ESP32 is feasible when all hardware and software components are correctly interconnected and meet the specified requirements. Careful attention will be given to addressing any encountered errors or challenges so as to achieve the project's objectives successfully. Discovering suitable methodologies for gathering required data has been one of the most challenging aspects of executing the sorting bin project. Consequently, findings pertaining to this issue form a major part of Chapter 4. The collection and analysis of data for the sorting bin system is explored in detail within this chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This section will present and discuss the findings and outcomes of the project titled "Design and Development of an Automated Trash Sorting Bin Using ESP32." The model's execute and design will also be presented, along with the creation of the software setup using a microcontroller and the Blynk program. Finally, a comprehensive discussion of the project's outcome will be provided in the concluding part of this chapter.

4.2 Hardware Development

The ESP32 serves as the project's core microcontroller and serves as the internal hardware development's "brain", allowing it to interface with other devices. the ESP32 and servo motors (MG996R and 20KG TD8120MG) need to be powered by a 12V adapter. The first module reduces the voltage from 12V to 5V for the microcontroller ESP32, while the second module lowers the voltage from 12V to 6V for the servo motors. Three ultrasonic sensors are connected to the microcontroller's pins, with each sensor's trig pin connected to different pins (D13, D14, and D26), and the echo pins connected to D12, D27, and D25, respectively. The IR sensor has three ports—one connected to D35, one to ground, and one to the microcontroller's VCC. The proximity sensor's output is connected to pins D34 and D33, and the water drop sensor is connected to pin D32. The output is controlled by two servo motors, with the MG996R servo motor connected to pin D4 and the 20KG TD8120MG servo motor connected to pin D5. The ESP32 microcontroller operates at 5V, supplying 3V to the IR sensor, while the proximity sensor and water level sensor use 5V. The ultrasonic sensors are connected in series with a 3V source pin from the ESP32. The hardware development that was created and tested throughout the project is shown in Figure 4-1.

Figure 4-1 : Complete Circuit Development

4.3 Blynk Application Development

The Blynk Application was utilized in developing the core software for the IoT-based system of automated bin sorting, usage notification, and monitoring. Employees can use the Blynk application on their smartphones to access the system. Employees can track whether the trash bin is full or not using the Blynk application, as shown in Figure 4-2 and Figure 4-3. The Blynk program is available for free download from the Apple Store or the Google Play Store. Additionally, the Blynk application requires a Google account for activation. A token will be provided by the Google account for the activation of the Blynk application. The Wi-Fi Module code connects Blynk apps to the Automated Sorting Trash Bin System via the token.

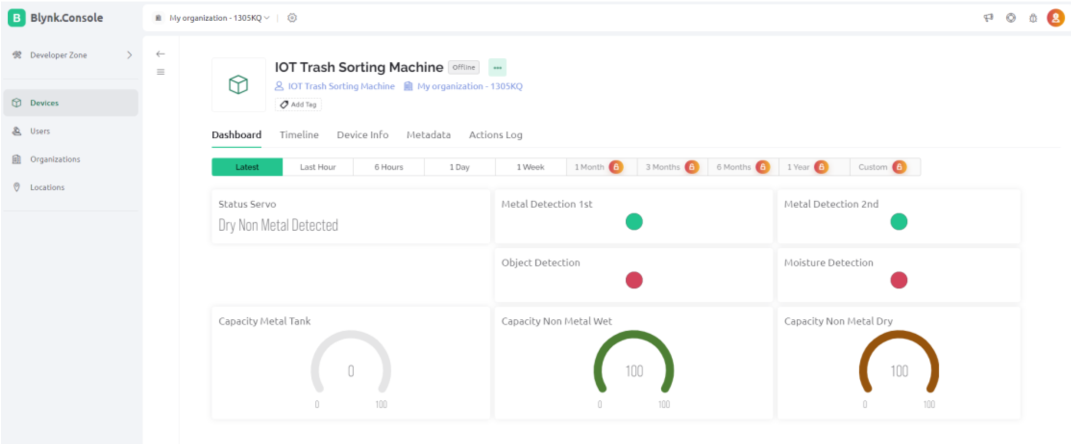

Figure 4-2 : Blynk interface via website

Figure 4-3 : Blynk interface via mobile

4.4 Prototype Development

4.4.1 Automated Based Trash Sorting Bin Prototype

The model of the Automated Trash Sorting Bin Using ESP32 is demonstrated in one trash bin, as seen in Figure 4-4 above. All hardware components were integrated into specific locations. The ultrasonic sensor is positioned on top of the container, while the proximity metal sensor, water drop sensor, and IR sensor are placed on the top lid of the system to detect objects. The MG996R servo motor is utilized to open the lid of the container. Additionally, the 20KG TD8120MG servo motor is placed at the bottom of the system to rotate the container.

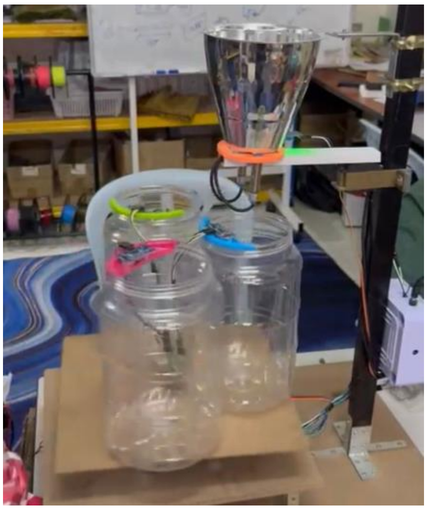

Figure 4-4: Automated Trash Sorting Bin

4.4.2 Monitoring Automated Sorting Trash Bin using mobile

To connect to the Blynk Apps, ensure a stable internet connection on mobile or laptop to link with the system. This automated trash sorting bin provides monitoring for two aspects which is the status of the container, whether it is full or not, and the status of the detected material. The metal object status is shown in Figure 4-5, the wet object status in Figure 4-6, and the dry object status in Figure 4-7

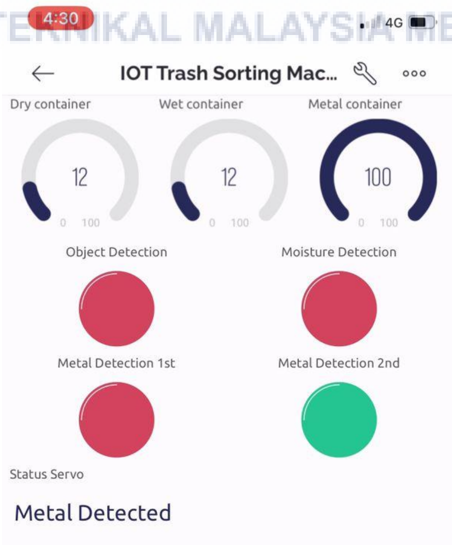

Figure 4-5 : View the status of metal container from a mobile device

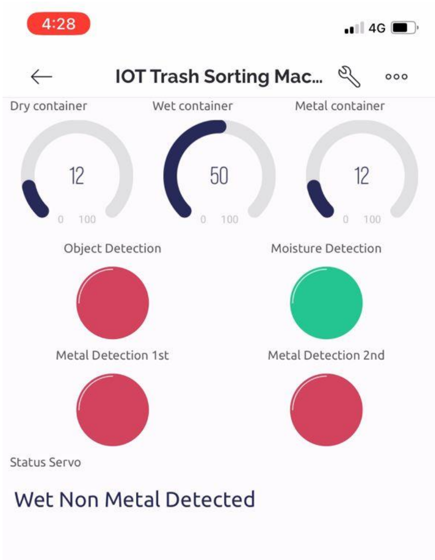

Figure 4-6 : View the status of wet container from a mobile device

Figure 4-7 : View the status of dry container from a mobile device

4.5 Data Analysis

The comparison results for three different materials of the automated trash sorting bin system are shown in Table 4-1, Table 4-2 and Table 4-3. These sensors include Proximity metal sensor, Water drop sensor, IR sensor and Ultrasonic sensor. After analyzing this project's examination, it is found that the accuracy in identifying the types of waste objects, namely, metal, wet, and dry waste, is approximately 90-100 percent. However, it is important to note that there are instances where detection may be compromised due to excessive voltage usage and the sensitivity of the sensors. The system's high sensitivity, while beneficial in most cases, can lead to occasional challenges, especially under conditions of intense electrical activity. Figure 4-8 shows the performance of percentage of accuracy, time taken and distance for waste detection.

Table 4-1: Result of Metal waste separation

No	Types of Metal Waste	Discarded or Not	Time	Description
1	Screw	Yes	0:0:4	Successfully
2	Nail	Yes	0:0:3	Successfully
3	Battery	Yes	0:0:4	Successfully
4	Pin	Yes	0:0:2	Successfully

Table 4-2: Result of Wet waste separation

No	Types of Wet Waste	Discarded or Not	Time	Description
1	Wet Cotton	Yes	0:0:4	Successfully
2	Wet Tissue	Yes	0:0:5	Successfully
3	Wet Paper	No	-	Unsuccessfully

Table 4-3: Result of Dry waste separation

No	Types of Dry Waste	Discarded or Not	Time	Description
1	Small Bottles	Yes	0:0:3	Successfully
2	Paper	Yes	0:0:2	Successfully
3	Leaf	Yes	0:0:3	Successfully
4	Poly	Yes	0:0:3	Successfully

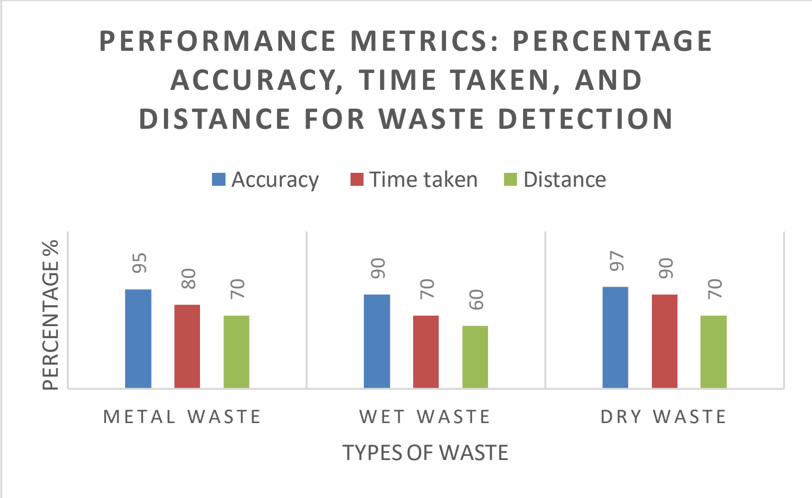

Figure 4-8 : Performance of percentage of accuracy, time taken and distance for waste detection

4.6 Discussion

The primary objective of this project was to develop an automated trash sorting bin that could effectively separate waste into different compartments or containers. This was motivated by the fact that traditional methods of garbage sorting rely heavily on physical effort from humans, often resulting in incorrect sorting and an increased amount of litter ending up in landfills instead of being recycled. The accumulation of unsorted waste without any recycling measures in place can lead to environmental pollution as dumpsites become filled. From the time the title was developed and offered, the entire project development process lasted a full six months. After then, depending on the components employed, research was conducted to locate earlier projects that were comparable to the current one. After developing an idea, this project was completed successfully with few errors, and a prototype was built using the components employed. Even though there are numerous projects that are like this one that have been done before and are still being done today, this prototype was done differently because it was designed and developed using components that were already available, like the ESP32 Wi-Fi module, Proximity metal sensor, IR sensor, Water drop sensor and Ultrasonic sensor.

During the development of the project, various faults and issues were encountered, including a challenge in locating the appropriate coding and addressing errors that required numerous debugging steps. Other issues arose from the necessity to change the components from the initial concept due to the incompatibility of their abilities. Additionally, the system was developed at a time when obtaining every component and combining them into a single module was feasible. This approach significantly reduced the complexity and expense of completing the project. According to the results and analyses of the experiments, a critical challenge emerged in accurately detecting waste types. The test results revealed some unsuccessful detections, particularly with wet objects. There were instances where the detection of the type of object took additional time.

4.7 Summary

The project's outcomes demonstrated the successful application of an automated trash sorting bin utilizing the ESP32 system. The incorporation of sensors such as ultrasonic sensors and IR sensors enabled the detection of object motion. The ESP32 microcontroller efficiently processed sensor data and provided real-time feedback through the Blynk Apps. The automated trash sorting bin effectively distinguished between different waste management categories, as confirmed through rigorous testing and analysis. The Blynk Apps displayed the status of the container and the type of waste detected by the IR sensor for motion. Additionally, the Blynk Apps indicated container fullness based on distance measurements between objects. The inclusion of auditory notifications through the Blynk Apps enhanced user situational awareness. In summary, the research was successful in designing and developing a prototype for an automated trash sorting bin, utilizing the ESP32 microcontroller. This product enables consumers to easily and safely separate waste. Chapter 5 discusses the challenges and potential future improvements.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter describes the creation of the design and development of an automated trash sorting bin using ESP32 and the achievements based on the objectives. This chapter also covers the challenges encountered during the completion of this project. Furthermore, it presents and elaborates on proposals for future work that can be undertaken to enhance and expand the project. Recommendations aimed at improving the efficacy of this project will be incorporated, taking into account its advantages and disadvantages.

5.2 Conclusion

In conclusion, the design and development of an automated trash sorting bin for consumers represents an innovative and comprehensive solution towards achieving a more sustainable future. This solution aims to reduce waste ending up in landfills and promote recycling. The integration of ESP32, ultrasonic sensors, IR sensors, proximity metal sensors, water drop sensors, and Blynk has enabled the automated trash sorting bin to offer various functionalities. These include detecting the motion of objects, separating the waste into different containers, and alerting when a container is full by incorporating IoT to notify designated smartphones when the garbage reaches a specific fill level. This project embraces a user-centric design approach and marks a significant milestone in assistive technology. Its primary objective is to enhance the accuracy and efficiency of waste sorting processes.

5.3 Future Recommendations

For further improvements, making a accurate identification and sorting of a broader scope of waste materials can be achieved by exploring the integration of more advanced sensors like spectroscopy or chemical sensors. Additionally, given that the project utilizes an adapter or battery, recommending the installation of a solar panel on the trash bin for future purposes. Next, adopting real-time data monitoring can help to manage waste effectively by tracking the fill level of each compartment allowing us to collect them at an optimal time. Aim to design a highly adaptable and scalable system that can support increased quantities and varied categories of refuse. The integration of an automated cleaning mechanism within the bin is recommended for future to maintaining proper hygiene levels and preventing cross-contamination between different waste types. With attention given towards these upcoming changes, the automated garbage separation bin could become even more useful as it becomes increasingly efficient and easy- to-use, leading to an improved approach towards managing waste effectively and making tomorrow's world with better environmental sustainability.

REFERENCES

[1] J. K. Debrah, D. G. Vidal, and M. A. P. Dinis, “Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review,” *Recycling*, vol. 6, no. 1, pp. 1–21, Mar. 2021, doi: 10.3390/recycling6010006.

[2] S. Adzimah and A. Simons, “Design of Garbage Sorting Machine,” *American Journal of Engineering and Applied Sciences*, vol. 2, pp. 428–437, May 2009, doi: 10.3844/ajeassp.2009.428.437.

[3] M. GmbH, “Global Recycling The Magazine for Business Opportunities & International Markets,” 2023.

[4] Vasarhelyi K, “The Hidden Damage of Landfills.” Accessed: May 22, 2023. [Online]. Available: https://www.colorado.edu/ecenter/2021/04/15/hidden-damage-landfills

[5] H. I. Abdel-Shafy and M. S. M. Mansour, “Solid waste issue: Sources, composition, disposal, recycling, and valorization,” *Egyptian Journal of Petroleum*, vol. 27, no. 4, pp. 1275–1290, Dec. 2018, doi: 10.1016/J.EJPE.2018.07.003.

[6] EPA, “Managing and Reducing Wastes: A Guide for Commercial Buildings,” United States Environmental Protection Agency. Accessed: May 22, 2023. [Online]. Available: https://www.epa.gov/smm/managing-and-reducing-wastes-guide-commercial-buildings

[7] K. Pardini, J. J. P. C. Rodrigues, O. Diallo, A. K. Das, V. H. C. de Albuquerque, and S. A. Kozlov, “A smart waste management solution geared towards citizens,” *Sensors (Switzerland)*, vol. 20, no. 8, Apr. 2020, doi: 10.3390/s20082380.

[8] J. Singh, R. Laurenti, R. Sinha, and B. Frostell, “Progress and challenges to the global waste management system,” *Waste Management and Research*, vol. 32, no. 9, pp. 800–812, Sep. 2014, doi: 10.1177/0734242X14537868.

[9] Tarasfoundation, “A Short History of Solid Waste Management,” Ocean Sentinels Club, Waste and Litter. Accessed: May 23, 2023. [Online]. Available: https://taras.org/2020/10/10/a-short-history-of-solid-waste-management/#:~:text=In%20the%20United%20States%2C%20the,cities%20offered%20garbage%20collection%20services.

[10] Rihn A, “A Brief History Of Garbage And The Future Of Waste Generation,” Waste Industry, MSW. Accessed: May 23, 2023. [Online]. Available: https://www.roadrunnerwm.com/blog/history-of-garbage

[11] Sreenivasan J, Kadiresu I, Govindan M, and Chinnasami M, “Solid Waste Management in Malaysia – A Move Towards Sustainability,” *Waste Management*,

Oct. 2012, Accessed: May 23, 2023. [Online]. Available: https://www.intechopen.com/chapters/40529

[12] Envpk, "Solid Waste Management Techniques," Best Environmental Website Of Pakistan. Accessed: May 24, 2023. [Online]. Available: https://www.envpk.com/solid-waste-management-techniques/

[13] "Types of Solid Waste Disposal and Management," Pulp and Paper Technology. Accessed: May 25, 2023. [Online]. Available: https://www.pulpandpaper-technology.com/articles/types-of-solid-waste-disposal-and-management

[14] "Waste processing technique," BrainKart.com. Accessed: May 25, 2023. [Online]. Available: https://www.brainkart.com/article/Waste-processing-technique_4032/

[15] R. Yadav, "Solid waste management," *Pollut Res*, vol. 34, no. 1, pp. 93–102, 2015, doi: 10.5958/2395-3381.2016.00015.0.

[16] A. Torres-García, O. Rodea-Aragón, O. Longoria-Gandara, F. Sánchez-García, and L. E. González-Jiménez, "Intelligent waste separator," *Computacion y Sistemas*, vol. 19, no. 3, pp. 487–500, 2015, doi: 10.13053/CyS-19-3-2254.

[17] A. Anitha, "Garbage monitoring system using IoT," in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, Dec. 2017. doi: 10.1088/1757-899X/263/4/042027.

[18] M. Mahmudul Hasan Russel, M. Hasan Chowdhury, M. Mehdi Masud Talukder, M. Hasan Russel, M. Shekh Naim Uddin, and A. Newaz, "Development of Automatic Smart Waste Sorter Machine Analysis Of Biodiesel Produced From Utilized Cooking Oil And Make A Comparison Between Conventional Fossil Fuel View project Wireless Biotelemetry View project Development of Automatic Smart Waste Sorter Machine," 2013. [Online]. Available: https://www.researchgate.net/publication/271964625

[19] V. C. Assistant Professor, U. Scholar, and T. C. Arvind, "Automatic Trash Sorter Using Arduino And Sensors Sushmitha M", [Online]. Available: http://ymerdigital.com

[20] K. Balakrishnan, S. K. Krishna, and T. Subha, "Automatic Waste Segregator and Monitoring System," 2016. [Online]. Available: www.stmjournals.com

[21] E. W. Vetricha Wulandari, "Automated Trash Sorting Design Based Microcontroller Arduino Mega 2560 with LCD Display and Sound Notification," in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, Jan. 2020. doi: 10.1088/1757-899X/725/1/012054.

[22] M. Babiuch, P. Foltynek, and P. Smutny, "Using the ESP32 microcontroller for data processing," in *Proceedings of the 2019 20th International Carpathian Control Conference, ICCC 2019*, Institute of Electrical and Electronics Engineers Inc., May 2019. doi: 10.1109/CarpathianCC.2019.8765944.

[23] Robocraze, “IR Sensor Working,” Robocraze. Accessed: Jun. 05, 2023. [Online]. Available: https://robocraze.com/blogs/post/ir-sensor-working

[24] ElectronicWings Homepage, “HC-SR04 Ultrasonic Sensor Guide with Arduino Interfacing.” Accessed: Jun. 05, 2023. [Online]. Available: https://www.electronicwings.com/sensors-modules/ultrasonic-module-hc-sr04

[25] Basanta S, “Buck Converter: Basics, Working, Design & Application,” Electronics. Accessed: Jun. 05, 2023. [Online]. Available: https://how2electronics.com/buck-converter-basics-working-design-application/

[26] “MG996R Servo Motor,” Components. Accessed: Jun. 09, 2023. [Online]. Available: https://components101.com/motors/mg996r-servo-motor-datasheet

[27] The RealPars Team, “Servo Motors Advantages And Disadvantages.” Accessed: Jun. 09, 2023. [Online]. Available: https://realpars.com/servo-motors-advantages/

[28] Achyuth ynd, “Simple Wi-Fi Controlled LED Using Nodemcu in Access Point(AP) Mode.” Accessed: Jun. 09, 2023. [Online]. Available: https://www.instructables.com/Simple-Wi-Fi-Controlled-LED-Using-Nodemcu-in-Acces/

[29] Gerrit Coetzee, “App Control With Ease Using Blynk.” Accessed: Jun. 09, 2023. [Online]. Available: https://hackaday.com/2016/03/10/app-control-with-ease-using-blynk/

APPENDICES

Appendix 1

```
//CODE_FOR_TRASH_SORTING_BIN//

#define BLYNK_TEMPLATE_ID "TMPL6AHnt7AGA"
#define BLYNK_TEMPLATE_NAME "IOT Trash Sorting Machine"
#define BLYNK_AUTH_TOKEN "26EVttvkdeWsVxOEEWq-nxQD8hZlrBjj"

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

BlynkTimer timer;

// You should get Auth Token in the Blynk App.
// Go to the Project Settings (nut icon).
// Your WiFi credentials.
// Set password to "" for open networks.
char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "HUAWEI-B310-0A17"; // hotspot
char pass[] = "QQFRLJ0MDB3"; //password

#define BLYNK_GREEN     "#23C48E"
#define BLYNK_RED       "#D3435C"

#define vPin_capMetalTank           V0
#define vPin_capNonMetalDry         V1
#define vPin_capNonMetalWet         V2
WidgetLED vPin_objectDetection    (V3);
WidgetLED vPin_metalDetection1st  (V4);
WidgetLED vPin_moistureDetection  (V5);
#define vPin_servoCap               V6
#define vPin_servoSorting           V7
#define vPin_statusServo            V8
WidgetLED vPin_metalDetection2nd  (V9);

String statusServo = "";

void initVirtualPin() {
  vPin_objectDetection.on();
  vPin_metalDetection1st.on();
```

```
  vPin_metalDetection2nd.on();
  vPin_moistureDetection.on();

  vPin_objectDetection.setColor(BLYNK_GREEN);
  vPin_metalDetection1st.setColor(BLYNK_GREEN);
  vPin_metalDetection2nd.setColor(BLYNK_GREEN);
  vPin_moistureDetection.setColor(BLYNK_GREEN);
}
//==========================================================================
==
// Lib for Ultrasonic
#include <NewPing.h>
//1st Ultrasonic
#define TRIGGER_1st_PIN  13
#define ECHO_1st_PIN     12
#define MAX_DISTANCE_1st 200
NewPing sonar_1st(TRIGGER_1st_PIN, ECHO_1st_PIN, MAX_DISTANCE_1st);
int cm_1st;
int percentageMetalTank;

//2nd Ultrasonic
#define TRIGGER_2nd_PIN  14
#define ECHO_2nd_PIN     27
#define MAX_DISTANCE_2nd 200
NewPing sonar_2nd(TRIGGER_2nd_PIN, ECHO_2nd_PIN, MAX_DISTANCE_2nd);
int cm_2nd;
int percentageNonMetalDry;

//3rd Ultrasonic
#define TRIGGER_3rd_PIN  26
#define ECHO_3rd_PIN     25
#define MAX_DISTANCE_3rd 200
NewPing sonar_3rd(TRIGGER_3rd_PIN, ECHO_3rd_PIN, MAX_DISTANCE_3rd);
int cm_3rd;
int percentageNonMetalWet;
//==========================================================================
==
// Define 1st Proximity Metal Sensor
#define proximitySensor1stPin 34
int proximitySensor1st = 0;
bool metalDetected1st = false;
bool nonMetalDetected1st = true;

// Define 2nd Proximity Metal Sensor
#define proximitySensor2ndPin 33
int proximitySensor2nd = 0;
bool metalDetected2nd = false;
bool nonMetalDetected2nd = true;
```

```
// Define Ir Sensor
#define irSensorPin 35
int IrObject = 0;
bool detected = false;
bool notDetected = true;

// Define Water Drop Sensor
#define waterDropSensorPin 32
int moistureValue = 0;
bool dryDetected = true;
bool wetDetected = false;

void initPinMode() {
  pinMode(proximitySensor1stPin, INPUT);
  pinMode(proximitySensor2ndPin, INPUT);
  pinMode(irSensorPin, INPUT);
  pinMode(waterDropSensorPin, INPUT);
}
//==========================================================================
==
// Servo Motor Setup
#include <Servo_ESP32.h>

static const int servoPin_cap  = 4; //printed G14 on the board
static const int servoPin_sort = 15; //printed G14 on the board

Servo_ESP32 capServo;
Servo_ESP32 sortServo;

int angleCap  = 0;
int angleSort = 0;

int angleStep;
int angleStepM;
int angleStepNMW;
int angleStepNMD;

int stateServo = 0;

void initServo() {
  capServo.attach(servoPin_cap);
  sortServo.attach(servoPin_sort);

  angleCap   = 0;
  angleSort  = 0;

  capServo.write(angleCap);
```

```
  sortServo.write(angleSort);
  delay(250);
  capServo.detach();
  sortServo.detach();
}
//============================================================================
==
void setup() {
  Serial.begin(9600);
  Blynk.begin(auth, ssid, pass);
  initVirtualPin();
  initPinMode();

  timer.setInterval(1000L, read_3Ultrasonic);
  timer.setInterval(1000L, readAllSensor);
  timer.setInterval(1000L, readServoFunction);
  timer.setInterval(1000L, virtualLedIndicator);

}
//============================================================================
==
void loop() {
  Blynk.run();
  timer.run();
}
//============================================================================
==
void read_3Ultrasonic() {
  cm_1st = sonar_1st.ping_cm();
  cm_2nd = sonar_2nd.ping_cm();
  cm_3rd = sonar_3rd.ping_cm();

  // mapping capacity
  percentageMetalTank = map(cm_1st, 26, 2, 0, 100);
  percentageNonMetalDry = map(cm_2nd, 26, 2, 0, 100);
  percentageNonMetalWet = map(cm_3rd, 26, 2, 0, 100);

  // correction factor for percentage
  correctionFactor();

  Serial.println("Ultrasonic 1st : " + String(cm_1st) + "cm, " +
String(percentageMetalTank) + "%, Ultrasonic 2nd : " + String(cm_2nd) + "cm,
Ultrasonic 3rd : " + String(cm_3rd) + "cm");
  Blynk.virtualWrite(vPin_capMetalTank, percentageMetalTank);
  Blynk.virtualWrite(vPin_capNonMetalDry, percentageNonMetalDry);
  Blynk.virtualWrite(vPin_capNonMetalWet, percentageNonMetalWet);
}
```

```
//========================================================================
==
void readAllSensor() {
  proximitySensor1st = digitalRead(proximitySensor1stPin); // metal sensor
1st
  proximitySensor2nd = digitalRead(proximitySensor2ndPin); // metal sensor
2nd
  moistureValue = digitalRead(waterDropSensorPin);         // moisture
sensor
  IrObject = digitalRead(irSensorPin);                     // ir sensor
module

  Serial.println("Proximitity Metal 1st : " + String(proximitySensor1st) + "
,Proximitity Metal 2nd : " + String(proximitySensor2nd) + " ,Moisture : " +
String(moistureValue) + " ,Object : " + String(IrObject));

  // 1st decision detect object
  if (IrObject == detected ) {
    // decision for metal object
    if ((proximitySensor1st == metalDetected1st || proximitySensor2nd ==
metalDetected2nd) && (moistureValue == dryDetected || moistureValue ==
wetDetected)) {
      statusServo = "Metal Detected";
      stateServo = 1;
      //metalSorting();
    }
    // decision
    else if ((proximitySensor1st == nonMetalDetected1st ||
proximitySensor2nd == nonMetalDetected2nd) && moistureValue == dryDetected)
{
      statusServo = "Dry Non Metal Detected";
      stateServo = 2;
      //nonMetalDrySorting();
    }
    else if ((proximitySensor1st == nonMetalDetected1st ||
proximitySensor2nd == nonMetalDetected2nd) && moistureValue == wetDetected)
{
      statusServo = "Wet Non Metal Detected";
      stateServo = 3;
      //nonMetalWetSorting();
    }
  } else {
    // do nothing here
  }
  Blynk.virtualWrite(vPin_statusServo, statusServo);
}
//========================================================================
==
```

```
void virtualLedIndicator() {
  // Virtual LED Indicator
  // decision
  if (proximitySensor1st == metalDetected1st) {
    vPin_metalDetection1st.setColor(BLYNK_GREEN);
  } else {
    vPin_metalDetection1st.setColor(BLYNK_RED);
  }
  // decision
  if (proximitySensor2nd == metalDetected2nd) {
    vPin_metalDetection2nd.setColor(BLYNK_GREEN);
  } else {
    vPin_metalDetection2nd.setColor(BLYNK_RED);
  }
  // decision
  if (moistureValue == wetDetected) {
    vPin_moistureDetection.setColor(BLYNK_GREEN);
  } else {
    vPin_moistureDetection.setColor(BLYNK_RED);
  }
  // decision
  if (IrObject == detected) {
    vPin_objectDetection.setColor(BLYNK_GREEN);
  } else {
    vPin_objectDetection.setColor(BLYNK_RED);
  }
}
//============================================================================
==
void readServoFunction() {
  if (stateServo == 1) {
    metalSorting();
    stateServo = 0;
  } else if (stateServo == 2) {
    nonMetalDrySorting();
    stateServo = 0;
  } else if (stateServo == 3) {
    delay(2500);
    //nonMetalWetSorting();
    openCap();
    delay(2500);
    closeCap();
    stateServo = 0;
  } else {
    // do nothing here
  }
}
```

```
//=============================================================================
==
void metalSorting() {
  Serial.println("Masuk");
  sortServo.attach(servoPin_sort);
  for (angleStepM = 0; angleStepM <= 90; angleStepM += 5) {
    sortServo.write(angleStepM);
    delay(10);
  }
  delay(2500); // stay in position 90 degree for 2.5s
  openCap();
  for (angleStepM = 90; angleStepM >= 0; angleStepM -= 5) {
    sortServo.write(angleStepM);
    delay(10);
  }
  closeCap();
  sortServo.detach();
  Serial.println("Keluar");
}
//------------------------------------------------------------
void nonMetalDrySorting() {
  Serial.println("Masuk");
  sortServo.attach(servoPin_sort);
  for (angleStepNMD = 0; angleStepNMD <= 180; angleStepNMD += 5) {
    sortServo.write(angleStepNMD);
    delay(10);
  }
  delay(2500);
  openCap();
  for (angleStepNMD = 180; angleStepNMD >= 0; angleStepNMD -= 5) {
    sortServo.write(angleStepNMD);
    delay(10);
  }
  closeCap();
  sortServo.detach();
  Serial.println("Keluar");
}
//------------------------------------------------------------
void nonMetalWetSorting() {
  Serial.println("Masuk");
  sortServo.attach(servoPin_sort);
  for (angleStepNMW = 0; angleStepNMW <= 20; angleStepNMW += 5) {
    sortServo.write(angleStepNMW);
    delay(10);
  }
  delay(2500);
  openCap();
  for (angleStepNMW = 20; angleStepNMW >= 0; angleStepNMW -= 5) {
```

```
    sortServo.write(angleStepNMW);
    delay(10);
  }
  closeCap();
  sortServo.detach();
  Serial.println("Keluar");
}
//============================================================================
==
// Open slider n sorting servo
void openCap() {
  capServo.attach(servoPin_cap);
  for (angleStep = 0 ; angleStep <= 90 ; angleStep += 5) {
    capServo.write(angleStep);
    delay(10);
  }
  capServo.detach();
  delay(2500);
}
//------------------------------------------------------------
void closeCap() {
  capServo.attach(servoPin_cap);
  for (angleStep = 90 ; angleStep >= 0 ; angleStep -= 5) {
    capServo.write(angleStep);
    delay(10);
  }
  capServo.detach();
}
//============================================================================
==
void correctionFactor() {
  // for percentage Non-Metal Wet Tank
  if (percentageNonMetalWet >= 100) {
    percentageNonMetalWet = 100;
  }
  else if (percentageNonMetalWet <= 0) {
    percentageNonMetalWet = 0;
  }
  else {
    percentageNonMetalWet = percentageNonMetalWet;
  }
  //------------------------------------------------
  // for percentage Non-Metal Dry Tank
  if (percentageNonMetalDry >= 100) {
    percentageNonMetalDry = 100;
  }
  else if (percentageNonMetalDry <= 0) {
    percentageNonMetalDry = 0;
```

```
  }
  else {
    percentageNonMetalDry = percentageNonMetalDry;
  }
  //-------------------------------------------------
  // for percentage Metal Tank
  if (percentageMetalTank >= 100) {
    percentageMetalTank = 100;
  }
  else if (percentageMetalTank <= 0) {
    percentageMetalTank = 0;
  }
  else {
    percentageMetalTank = percentageMetalTank;
  }
}
//END CODE//
```

GANTT CHART FOR FINAL YEAR PROJECT 1 & 2

ACTIVITY (FYP 1)	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Meet with supervisor	■	■	■	■			■	■		■	■	■	■	■
Research literature review & gather information	■	■	■	■	■	■								
Submission of loogbook progress						■						■		
Proposal writing		■	■	■										
Report writing			■	■	■	■	■	■	■	■	■	■		
Submission of draft report											■	■		
Submission of report													■	
Preparation for presentation													■	
Presentation														■
ACTIVITY (FYP 2)	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Meet with supervisor	■	■	■	■						■	■	■	■	■
Planning prorotype	■	■	■	■	■	■								
Submission of loogbook progress						■						■		
Testing prorotype								■	■	■	■			
Data analysis									■	■	■	■		
Writing chapter 4 and 5						■	■	■	■	■	■	■		
Submission of draft report													■	
Presentation														■
Submission of final report														■