Faculty of Electrical Technology and Engineering

DEVELOPMENT OF SMART AUTOMATED FOLDABLE CLOTHES HANGER WITH INTERNET OF THINGS (IOT)

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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DEVELOPMENT OF SMART AUTOMATED FOLDABLE CLOTHES HANGER WITH INTERNET OF THINGS (IOT)

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A project report submitted
in partial fulfillment of the requirements for the degree of
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DEDICATION

This work is dedicated to:

The sake of Allah, my Creator, and my Master,

My great teacher and messenger, Nabi Muhammad SAW (May Allah bless and grant him), who taught us the purpose of life,

I extend my deepest gratitude to our parents, whose unwavering financial and moral support sustained us throughout the project's development. Their guidance taught us the value of perseverance, showing that even the most substantial tasks can be conquered when approached one step at a time,

I dedicate this project to all those who worked diligently to assist me in its completion.

ABSTRACT

Clotheslines have been used for centuries as a cost-effective and environmentally friendly alternative to clothes dryers. They are particularly popular in sunny and open areas where natural elements aid in the drying process. The rapid advancement of technology has revolutionized various aspects of our daily lives, including household chores. In this context, the smart automated foldable clothes hanger has emerged as an innovative solution, streamlining laundry management and enhancing convenience for users. The primary objective of this project is to achieve automatic control of the foldable clothes hanger through the Internet of Things (IoT), connecting hardware to smartphones via the Blynk application. The water sensor and light-dependent resistor (LDR) sensor are utilized to provide input or signals to the servo motor, responsible for controlling the hanger's rotation. The collected sensor data is then processed by the Arduino Uno R3 microcontroller and transmitted to a cloud server via Wi-Fi. By integrating the system with an IoT platform, users can remotely monitor and control the foldable hanger through a user interface accessible on mobile electronic devices, such as smartphones, by connecting to specific Internet Protocol (IP) addresses. The foldable clothes hanger autonomously folded when it detected the presence of water or the absence of light, offering notable benefits for individuals leading busy lifestyles.

ABSTRAK

Ampaian jemuran telah digunakan selama berabad-abad sebagai alternatif yang berpatutan kos dan mesra alam kepada pengering pakaian. Mereka terutamanya popular di kawasan dengan cahaya matahari yang mencukupi dan ruang terbuka, di mana elemen semula jadi membantu dalam proses pengeringan. Kemajuan pesat dalam teknologi telah mengubah revolusi pelbagai aspek kehidupan seharian kita, termasuk tugas-tugas rumah tangga. Dalam konteks ini, penggantungan pakaian automatik pintar telah muncul sebagai penyelesaian inovatif untuk menyelaraskan pengurusan cucian dan meningkatkan kemudahan pengguna. Objektif utama projek ini adalah untuk mencapai kawalan automatik bagi penggantungan pakaian lipat melalui Internet of Things (IoT), menghubungkan perkakasan ke telefon pintar melalui aplikasi Blynk. Penggunaan sensor air dan sensor pengesan bergantung pada cahaya (LDR) adalah untuk menyediakan input atau isyarat kepada motor servo, yang bertanggungjawab untuk mengawal putaran penggantungan lipat. Data sensor yang dikumpulkan kemudiannya diproses oleh pemacu mikro Arduino Uno R3 dan dihantar ke pelayan awan melalui Wi-Fi. Dengan mengintegrasikan sistem ini dengan platform IoT, pengguna dapat memantau dan mengawal penggantungan pakaian lipat dari jarak jauh melalui antara muka pengguna yang boleh diakses pada peranti elektronik mudah alih seperti telefon pintar, dengan menyambung ke alamat Protokol Internet (IP) yang spesifik. Penyangkut pakaian boleh dilipat secara autonomi apabila ia mengesan kehadiran air atau ketiadaan cahaya, menawarkan faedah ketara untuk individu yang menjalani gaya hidup sibuk.

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LIST OF SYMBOLS

°	-	Degree
℃	-	Degree celcius
%	-	Percent
<	-	Less-than
>	-	More than
+	-	Plus
-	-	Minus
*	-	Times
/	-	Divide
=	-	Equal
( )	-	Parenthesis
!	-	Exclamation mark
@	-	At sign
#	-	Hashtag

LIST OF ABBREVIATIONS

V	Voltage
kg	Kilogram
IoT	Internet of Things
mm	Millimeter
PID	Proportional Integral Derivative
UV	Ultraviolet
LDR	Light Dependent resistor
cm	Centimeter
mA	Milliampere
etc.	Etcetra
fig.	Eigure
no	Number
vs	Versus
ft	Feet
hr.	Hour
min.	Minutes
Ts.	Technologies
Dr.	Doctor

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CHAPTER 1

INTRODUCTION

1.1 Background

Using a clothesline is the most environmentally friendly approach to drying our clothes since it minimizes the release of greenhouse gases. Fresh and clean clothes are universally desired, and with the progress of technology, it is common for households to possess at least one washing machine. While washing machines facilitate the cleaning process by removing sweat and dirt from garments, after washing, we still need to allocate time to dry the clothes. Certain individuals prefer the conventional practice of hanging garments outdoors under the sun, while others hang them indoors or use dryers.

A clothesline could be attached from a post or any wall. Generally, it was made up of a string, rope, cord, or twine that was tied to two ends, which were the post or wall. Then the clothes were hung along the line. In most of the house, the clothesline can be seen in the backyard, balconies, or garden[1].

The primary energy source utilized for drying clothes is sunlight and the natural air circulation in the environment. Therefore, the effectiveness of the drying process largely relies on the prevailing weather conditions. The issue of uncertain weather has made it difficult for people to wash laundry as a regular duty at home. The majority of Malaysia's rainfall distribution is unpredictable and inconsistent at times[2]. This is because Malaysia is in equatorial and tropical area which having high rainfall throughout the year[3]. The country receives considerable amount of annual rainfall during these monsoon seasons, i.e., between 2000 to 4000 mm with 150 to 200 rainy days[4].

In addition, as the level of life has risen, so have the changes in cost costs. As a result, single-income households may find it difficult to meet their daily costs. To overcome this situation, both husband and wife have to work to generate more income[5]. Over the years women participation in the economy has increased rapidly and they constitute almost half of the total population[6]. Because people are too busy doing their everyday duties outside, clothing on the clothesline outside becomes soaked when it rains unexpectedly. This issue has made it difficult for people to perform laundry as a regular duty at home. This predicament has led many to seek remedies from the dobby. Yet, to do so in the long time can be costly in terms of energy and money. The best alternative to solving this problem is to innovate[2].

Hence, the creation of the Smart Automated Foldable Clothes Hanger represents a remarkable technological innovation aimed at streamlining and enhancing the task of arranging and storing clothing. This advanced device integrates sensors, motors, and electronic components to autonomously adapt the clothes' positioning and ensure efficient folding. The hanger's foldable design enables it to be conveniently stored in a compact manner when not in use, making it particularly suitable for individuals residing in limited living spaces or those seeking to maximize space utilization. The user-friendly nature of the hanger allows for effortless folding and unfolding, facilitated by the motorized mechanism.

1.2 Societal and global issue

The "Emissions Gap Report 2019"[7] report reveals that current global efforts to reduce greenhouse gas emissions fall far short of what is necessary to limit global warming to the targets set in the Paris Agreement.

One of the main conclusions drawn from the report is that countries must significantly increase their ambition in reducing emissions to close the emissions gap. The report states that even if all countries fully implement their current climate pledges, global temperature rise could exceed 3 degrees Celsius by the end of the century, leading to catastrophic consequences[8].

Developing an automated foldable clothes hanger with a microcontroller can reduce energy consumption and promote sustainable practices for laundry drying. Traditional methods like electric or gas-powered dryers consume significant energy, increasing bills and greenhouse gas emissions.

The automated hanger allows users to efficiently use natural drying methods. It detects weather conditions like rain or humidity and retracts the clothesline to prevent wetting. The microcontroller optimizes energy usage by operating only when necessary.

This project promotes energy-efficient and sustainable clothes drying, reducing the carbon footprint of household activities. It aligns with global climate change mitigation and encourages environmentally responsible practices. Raising awareness about energy efficiency and sustainability, it inspires others to adopt similar solutions for a positive societal and global impact. Addressing sustainability in household activities is vital for an environmentally conscious future.

1.3 Problem Statement

The problem statement articulates the issue or challenge a project intends to tackle. In this context, there are two challenges associated with doing laundry: unpredictable weather conditions and busy lifestyles. These factors significantly impact the efficiency and convenience of managing laundry tasks.

1.3.1 Unpredictable weather conditions

Malaysia is an equatorial country with a tropical climate that experiences a variety of climatic fluctuations such as rain, heat, and so on. Unpredictable weather circumstances, such as rainy days, might make it difficult for people to dry their garments outside these days. It is becoming more reliant on information technology to boost efficiency and facilitate daily work. When it rains, people frequently forget to lift their clothing from the clothesline.

1.3.2 Busy lifestyle

Working individuals struggled to remember this owing to a shortage of time to handle their work and daily activities. Most people in the country are familiar with the phenomena of flexibility in garment management at the clothesline. However, for individuals who are not at home throughout the day due to being somewhere else, such as the office, the management of clothing on the hanger becomes rigid, disrupting the concentration of their daily routine.

1.4 Project Objective

The are 3 objective which aim to be achieved at the end of the project:

a) To develop an automated foldable clothes hanger with Internet of Things (IoT).

b) To employ a suitable microcontroller and IoT monitoring system for data collection.

c) To analyze and evaluate the performance of the system.

1.5 Scope of Project

The scope of this project are as follows:

a) Construct hardware for automated foldable hanger that can hold up to 1.5kg load.

b) Utilize software that can be implemented as the controller for the movement.

c) Rotation limitation: 0° to 180°

d) Using the Internet of Things (IoT) application to monitor the process.

e) Speed motor limitation: 5RPM

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explored various aspects related to automated foldable clothes hangers. This comprised both present market items and ones that were still being researched. The section was divided into several parts, which included traditional clotheslines, automated clothesline systems, and, lastly, the comparison between each project. It also explored the different mechanisms, materials, and technologies employed to achieve automated folding functionality.

2.2 Traditional clotheslines

Traditional clotheslines are clotheslines which require no advance technology, non-mechanical and are widely use by the people. The 1830's was the year that marked the first known use of the word clothesline according to Merriam-Webster[9].

2.2.1 T-Poles

T-poles consist of two pillars extending from one edge to the other, providing sturdy support. These poles are typically installed permanently in yards or gardens. The clothesline poles hold 5 lines that can provide up to 125 feet of linear drying space with the recommended maximum distance between poles of 25 feet[10].

Figure 2.1 String attached from poles to another [10]

The advantage of T-poles is that it enables user to hang a lot of clothes on the string. However, the disadvantage is that it needs to be built and it would be the permanent structure on the ground and occupies a significant amount of space.

2.2.2 Umbrella

The umbrella clothesline structure comprises a central pole serving as its base. Extending outward from this center pole are four arms, forming a square shape. Strings or lines are then fastened from one arm to another, creating a network within the square configuration. When your clothes are done, collapse the arms of your umbrella clothesline to save space and foldaway for storage[11].

Figure 2.2 Umbrella clothesline when in use [11]

The benefits of using an umbrella clothesline include saving yard area and reducing rope stretching. The downsides are that it takes up less room than T-Pole clotheslines and can only hang certain sizes of items. In other words, this large blanket would require more area to hang.

2.3 Automated clothesline system

This section introduced several existing clothesline systems that were mostly changing or updating traditional clotheslines. The system which can detect the rain and bring the clothes to a sheltered place automatically with the capability to pull the clothesline or washing line hand-free[12].

2.3.1 Clever closelines

Clever Closeline is an automated clothesline system available in the market, representing a technological advancement of the umbrella clothesline. This system is equipped with a rain sensor that can detect rainfall. At the first drops of rain, a rain sensor activates a cover which deploys over your clothes, protecting them from the rain. When the rain stops, the cover automatically retracts allowing for the full benefits of UV drying and aeration[13].

Figure 2.3 The CleverCloselines [14]

The primary advantage of the Clever Clothesline is its automatic protection against wet laundry during rainy conditions. However, there are some drawbacks associated with this design. One limitation is the restricted hanging space for laundry. Due to the presence of the cover above the clothesline, the clothes cannot extend beyond the square area defined by the strings. If the clothes extend beyond this area, the rain cover be unable to shield them effectively, increasing the risk of them getting wet. Additionally, as depicted in Figure 2.3, there is a plastic cover surrounding the Clever Clothesline in the bottom picture. After finishing hanging their clothing, the owner must manually insert this plastic cover. If the user expects rain, they should cover their clothesline with a plastic cover to give extra protection.

2.3.2 Hooeasy Ceiling Type Cloth Drying Rack Automated Smart Clothes Drying

The Hooeasy product[15], available both in the market and online, is designed to be permanently attached to the ceiling, requiring indoor installation. Unlike traditional drying methods relying on sunlight, this appliance generates its own heat and light. Users can conveniently control it using a remote, adjusting the height of the drying bar to their desired level for hanging wet laundry. By pressing the remote-control button, the appliance automatically returns to its original position, ready for the clothes to dry. Users have the option to dry their clothes using fans and UV functionality. According to the provided information, the drying process typically takes at least three hours, although the exact duration depends on the moisture level in the surrounding environment.

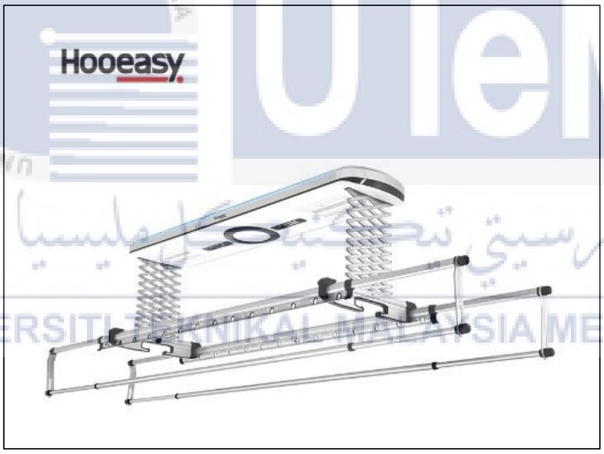


Figure 2.4 The ceiling type cloth drying rack automated smart clothes drying [15]

The primary benefit of the automatic cloth dryer is that users no longer need to hang their clothes outdoors, alleviating concerns about them getting wet in the rain. However, there are some limitations to consider. Firstly, the dryer relies solely on electrical energy for drying clothes, offering no alternative energy options. While this method consumes less electricity compared to traditional dryers, prioritizing environmental friendliness suggests that this appliance could be designed to offer alternative energy sources as a secondary choice.

2.4 Design and development of foldable clothesline

This review explores various design considerations, materials, mechanisms, and innovations related to foldable clotheslines. The main aim is to provide a comprehensive understanding of the design principles and best practices for developing efficient and user-friendly foldable clotheslines.

In the study of [16], the journal focuses on the design and development of a Prototype Automatic Clothesline and Air Dryer tool based on the Internet of Things (IoT). The tool aims to address the challenge of drying clothes efficiently while considering modern lifestyles and career priorities. It utilizes sensors such as rain, light, and humidity sensors to automate the process. Testing and analysis of the sensors, as well as the manual and automated modes of operation, were conducted to evaluate the tool's performance. The study concludes that the prototype successfully responds to various conditions, such as detecting rain or night, and effectively controls the clothesline and dryer fan. The average delays in motor and fan responses were measured, and the air dryer system proved capable of reducing air humidity in the storage room. The study builds upon previous research by integrating a remote-control system using Bluetooth and an Android application.

The study by Mohd Nasrulddin Abd Latif et al [2]. explores the design and development of a smart automated clothesline system. This study proposes an innovative solution that integrates Internet of Things (IoT) technology and sensors to automate the clothes drying process. The research focuses on the design and implementation of the system, including sensor selection, motor control mechanisms, and user interface. Practical testing and analysis demonstrate the effectiveness of the system in optimizing the clothes drying process. The study evaluates the performance of rain, light, and humidity sensors, confirming their accurate detection capabilities. The implementation of manual and automatic modes provides users with flexibility and convenience. This research contributes to the advancement of smart home systems, improving efficiency and energy conservation while enhancing convenience and productivity. The findings offer valuable insights for future smart home system design and development.

2.4.1 Servo DC Motor

The study by Hongwei Fang et al. [17] proposes a position servo control using the second discrete filter. The authors emphasize the advantages of this technique, which include reduced sensitivity to disturbances, improved stability, and enhanced robustness. By incorporating the second discrete filter into the control algorithm, the researchers aim to overcome common challenges associated with brushless DC motor position control. The evaluation of the proposed position servo control strategy demonstrates its effectiveness and performance benefits. The researchers compare the control system's response characteristics, including settling time, overshoot, and disturbance rejection, with conventional control methods. The results highlight the improved performance achieved using the second discrete filter, validating its potential as a reliable and efficient control technique.

2.4.2 DC Gear motor

Magnetic gear have some advantages such as no mechanical loss and maintenance-free operation that are not observed in conventional mechanical gears[18]. The report by

[19] delves into the design and analysis of a torque superimposition magnetic-geared motor. This technology integrates magnetic gearing principles with the concept of torque superimposition to enhance efficiency, reduce mechanical losses, and improve the performance of electric motors. The maximum transmission torque was observed to be 32% greater than that of the C-model. In addition, the motor may produce more torque than the maximum torque of the C-model than the maximum torque of the transmission, although the maximum torque of the C-model is less than the maximum torque of the transmission.

2.5 Internet Of Things (IoT) monitoring system

The integration of IoT technology with automatic foldable clotheslines enables remote monitoring, control, and data analysis, enhancing the user experience and efficiency of the drying process. By reviewing existing research and studies, this review aims to provide insights into the design principles, sensor technologies, data analytics, and user-centric considerations for developing an effective IoT monitoring system for automatic foldable clotheslines. The working process of the Internet of Things is shown below.

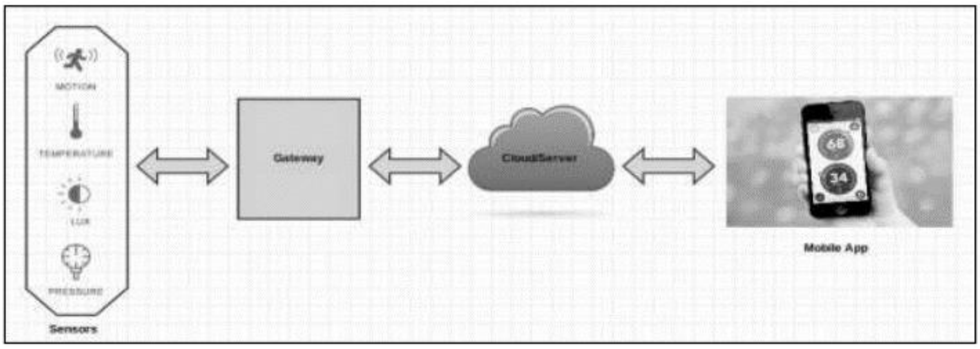


Figure 2.5 Working of Internet of Things [20]

2.5.1 Blynk application

The journal in [21] focused on an IoT-based weather monitor system for drying clothes. The review provides an overview of existing research in the field, emphasizing the integration of IoT technology to monitor and optimize drying conditions. It discusses the importance of monitoring weather parameters such as temperature, humidity, and wind speed in achieving efficient and effective clothes drying. The sensors such as Humidity and Temperature sensor, Rain sensor and Moisture sensor which are interfaced with the Node MCU. While the Blynk application module is used for displaying the readings obtained from the sensor like in Figure 2.5. The article highlights the potential benefits of an IoT-based system in terms of energy savings, convenience, and improved drying outcomes. It contributes to the field by synthesizing relevant literature and paving the way for the development of advanced weather monitoring systems for clothes drying.

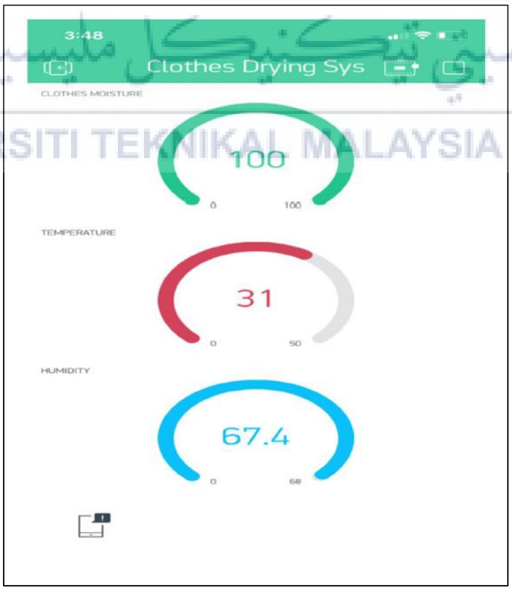


Figure 2.6 Interface in the Blynk application [21]

2.5.2 IBM Bluemix

The study in [22] concentrated on the development of an IoT-based weather station. The review explores existing research and advancements in the field, emphasizing the integration of IoT technology to collect and analyze weather data. It discusses various components and sensors used in weather monitoring systems, including temperature, humidity, and rainfall sensors. The article highlights the importance of real-time weather data for accurate forecasting, agricultural applications, and disaster management. When the sensor measurements are uploaded to the cloud, IBM Bluemix, the values are analyzed there and then an email, an SMS and a tweeter post is published whenever the threshold limit exceeds. Some of the sample results are as following:

Figure 2.7 Email received [22]

Figure 2.8 Twitter post published [22]

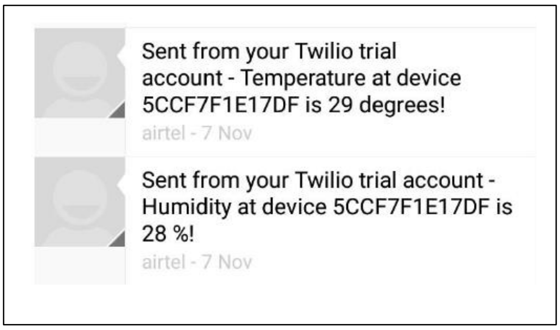


Figure 2.9 Messages received [22]

2.5.3 ThingSpeak

ThingSpeak is an open source Internet of Things application and API to store and retrieve data from the sensors using HTTP Protocol over the internet[20].

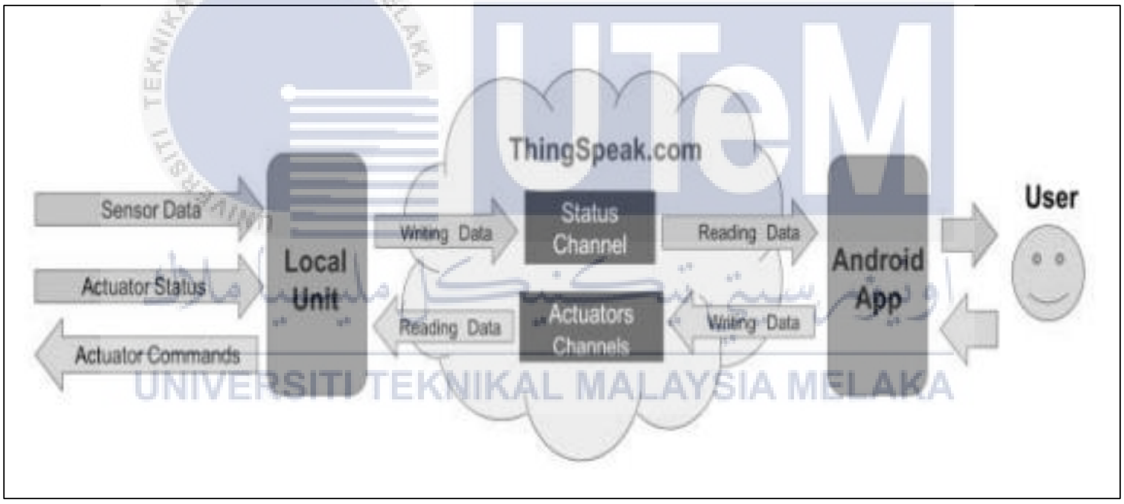


Figure 2.10 Working of ThingSpeak [20]

It is an IoT analytics platform service that enables aggregation, visualization, and analysis of real-time data streams in the cloud. ThingSpeak, which has APIs to collect data produced by sensors and APIs to read data from applications, plays a key role in the constant updating of data. We are using this cloud service for signal communication and signal data storage [23]. The paper is divided into two parts. Part of the paper is where you must program the thing to send data. And in the second part, another person needs to see the information. ThingSpeak sits in the middle and is good at doing both. Using accessible hardware, the paper builds a proof-of-concept IoT system for monitoring air temperature, humidity, soil moisture, soil moisture, etc. In addition, it can be modified with different sensors or actuators to build something for an individual purpose. Thus, the user has direct access to all environment parameters after completing the above procedure.

2.5.4 Telegram Bots

The Telegram is an optimal cloud-based instant messaging service with an application that can be combined with ESP8266 Wi-Fi module for any developer’s usage. The report in [24] focuses on the IoT-based Emergency Alert System Integrated with Telegram Bot. The report may discuss the integration of Telegram bot as an interactive platform for users to access energy-related information and control functionalities. This could involve the use of Telegram's API for data exchange, authentication mechanisms for secure access, and command-based interactions to retrieve energy usage data or perform specific actions such as turning devices on or off remotely. The developed system is capable of being put into action in a real-time setting such as a restricted public area, a private property, or a small home or office.

Figure 2.11 Notification and command via Telegram Bot [24]

2.6 Comparison between previous projects

Table 2.1 Shows the comparison between the previous projects stated above in terms of their features, advantages, and disadvantages of each project

No	Project title	Features	Advantages	Disadvantages
1	Hang-And-Go: A Smart Laundry Hanging System [5] Another same project- [25] [26] [27]	- Water sensor - Arduino - Lego EV3 brick - EV3 Software - LabVIEW 2012 - Canvas to cover clothes	- Detects the exact time it starts raining - Prevent the clothes from getting wet in the rain	- Occupies a significant amount of space - Expensive
2	Automatic Clothesline Retrieval Prototype with Humidity Alert System to Aid Clothesline Drawbacks for Reducing Laundry Worries[28] Another same project- [29]	- Temperature and humidity sensor - Micro servo SG90 - LDR sensor - Arduino UNO and IDE	- Able to hang many clothes - Detects the exact time it starts raining - Prevent the clothes from getting wet in the rain	- Difficult to install - Consumes a significant amount of electricity due to the movement of the clothesline - Difficult to install - Expensive

3	Design And Development of Smart Automated Clothesline[2] Another same project- [30]	- Water sensor - Servo - Arduino UNO - Arduino IDE	- Able to hang many clothes - Prevent the clothes from getting wet in the rain	- Difficult to install - Occupies a significant amount of space
4	Design And Implementation of Clothesline and Air Dryer Prototype Base in IoT[16] Another same project- [31] [32] [33]	- Rain sensor - Light sensor - Humidity sensor - Motor - Arduino NANO and IDE - Fans	- Detects the exact time it starts raining - Prevent the clothes from getting wet in the rain - Clothes can dry even raining due to dryer	- Difficult to install - Occupies a significant amount of space - Very expensive

2.7 Summary

The comparison of the mentioned projects reveals different features, advantages, and disadvantages associated with each system. The Hang-And-Go system and similar projects incorporate water sensors, Arduinos, Lego EV3 bricks, EV3 software, and canvas covers to detect rainfall and prevent clothes from getting wet. However, these systems tend to occupy significant space and can be expensive. The Automatic Clothesline Retrieval Prototype and its related project utilize temperature and humidity sensors, micro servo SG90, LDR sensors, and Arduino UNO to hang clothes, detect rain, and protect them from getting wet. Nonetheless, these systems are challenging to install, consume substantial electricity due to clothesline movement, and are costly. The Design and Development of Smart Automated Clothesline and the related project feature water sensors, servos, Arduino UNO, and IDE, offering the ability to hang clothes and prevent rainwater damage, albeit with installation difficulties and space requirements. Lastly, the Design and Implementation of Clothesline and Air Dryer Prototype, along with the referenced projects, incorporate rain, light, and humidity sensors, motors, Arduino NANO, IDE, and fans to detect rain, prevent clothes from getting wet, and enable drying even during rainy conditions. However, these systems face challenges in installation, occupy significant space, and are considered very expensive. The comparison highlights the various trade-offs in terms of installation complexity, space utilization, and cost associated with different automated clothesline designs.

In conclusion, the comparison of the mentioned projects demonstrates the diverse features, advantages, and disadvantages associated with automated clothesline systems. Each project offers unique functionalities such as rain detection, prevention of clothes getting wet, and the ability to hang and dry clothes efficiently. However, there are trade-offs to consider. Some systems occupy significant space and can be expensive, while others pose challenges in installation and consume a substantial amount of electricity. Despite these drawbacks, the projects provide innovative solutions to address the concerns of traditional clothesline drawbacks. The choice of a suitable automated clothesline system depends on specific requirements, such as available space, budget constraints, and installation feasibility. By carefully evaluating the features and drawbacks outlined in the comparison, individuals can make informed decisions when selecting an automated clothesline system that best suits their needs.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology for developing an automatic foldable clothesline covers a systematic approach to designing and implementing a functional and user-friendly solution. This section provides an overview of the key steps involved in the methodology, which includes the design objective, design concept, tools and apparatus, circuit design, methodology and flowchart of the program.

3.2 Research workflow

The research workflow played a crucial role in guiding the systematic and efficient execution of the project, ensuring its success, and meeting the desired objectives. Based on the project on developing an automated foldable clothes hanger, establishing a clear research workflow was essential for organizing and executing the different stages of the project effectively. This introduction provided an overview of the research workflow that was followed, outlining the key steps involved in conducting the project and achieving the desired outcomes.

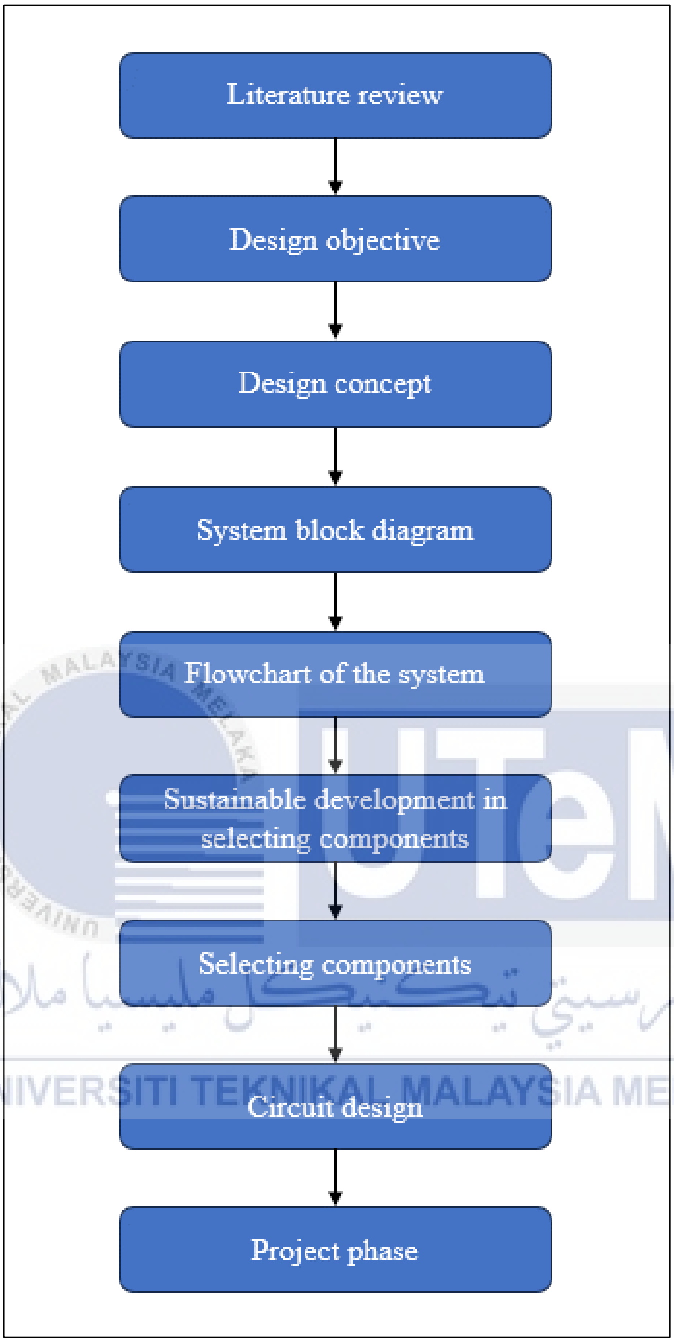


Figure 3.1 Research workflow

3.3 Design objectives

The smart automated foldable clothes hanger design was evaluated under certain criteria. The criteria used in evaluating the design concepts include the availability of materials/components, cost of materials, simplicity of the design, ease of use, and size of the system. The system is designed with easily available and less costly materials. The system must also be simple, easy to use and sizable for affordability, and to occupy less space in dormitories and homes.

3.4 Design concept

The foldable clothes hanger consisted of 3 aluminum steel rods connected by steel connectors, as shown in Figure 3.1 below. The gear motor was placed at each of the steel connectors to control the rotation of the aluminum steel rod. Therefore, it could be bent or folded to fit everywhere in the house. The microcontroller was in a box placed on top of the aluminum steel. Sensors like the water and LDR sensor were placed on top of the box.

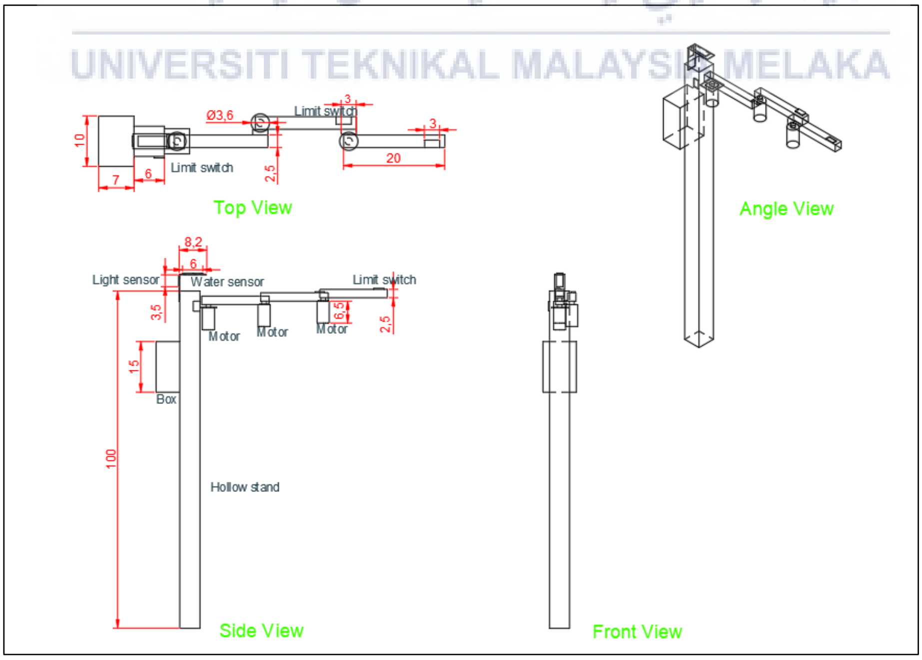


Figure 3.2 Concept design of the project

The advantages of this foldable clothes hanger are space-saving. The foldable design allows the clothes hanger to be compact and easily folded when not in use. This feature is particularly useful for individuals with limited balcony or also room space, as it saves storage space.

3.5 System block diagram

A block diagram assists in the planning of the project. It's like a flowchart, but with a more basic format. Block diagrams are frequently used to show the intake, process, and output of design projects while also reducing the parts and resources used.

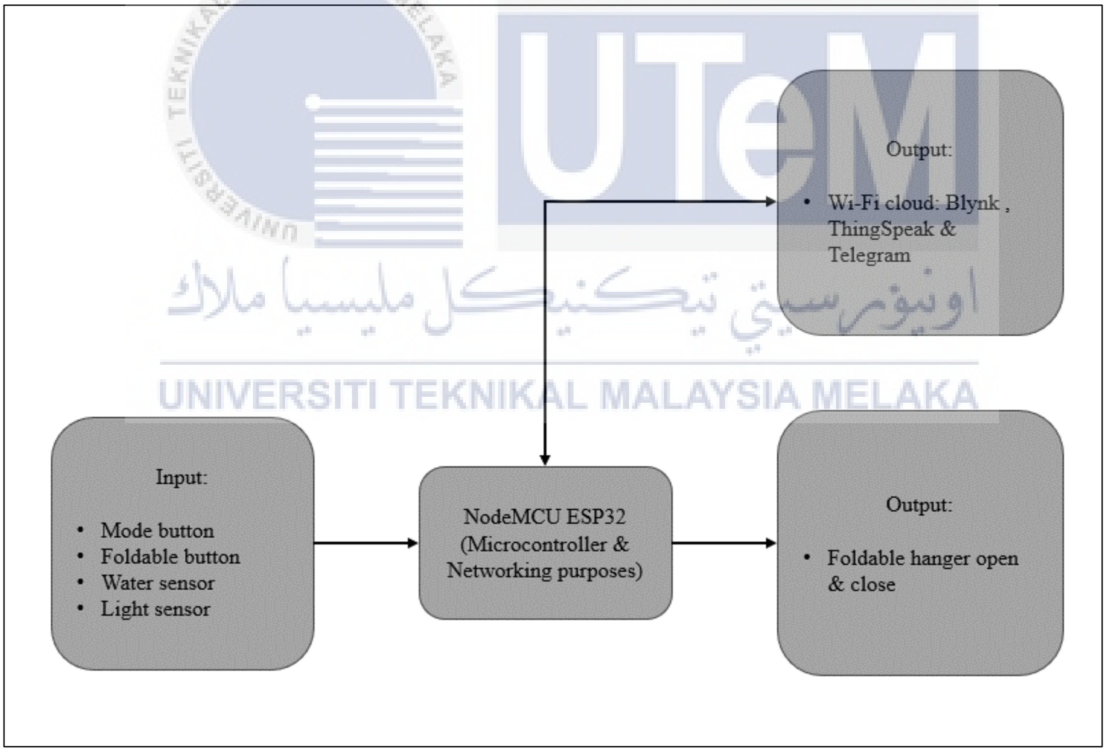


Figure 3.3 System block diagram

Figure 3.2 shows the block diagram of the microcontroller and fully explains the project concept from input to output. The main component of this project, an Arduino Nano

R3 microcontroller, is used to control the input and output data of all other components. Collects and transfers data, collects and delivers commands. Select buttons, water sensors, and light sensors are available for input. Each of these components has unique features such as water sensors that can detect the presence of water, and ESP8266 node MCUs are used for cloud networking and data collection. Data is uploaded from the Arduino Nano R3 to the cloud via the ESP8266 nodeMCU, then the data is transferred to the output to the cloud, and the data is saved from the cloud to an app on your phone, laptop, or tablet. Another output works according to a program whose components are selected by data. Command the collapsible hanger when it detects the presence of water.

3.6 Flowchart of the system program

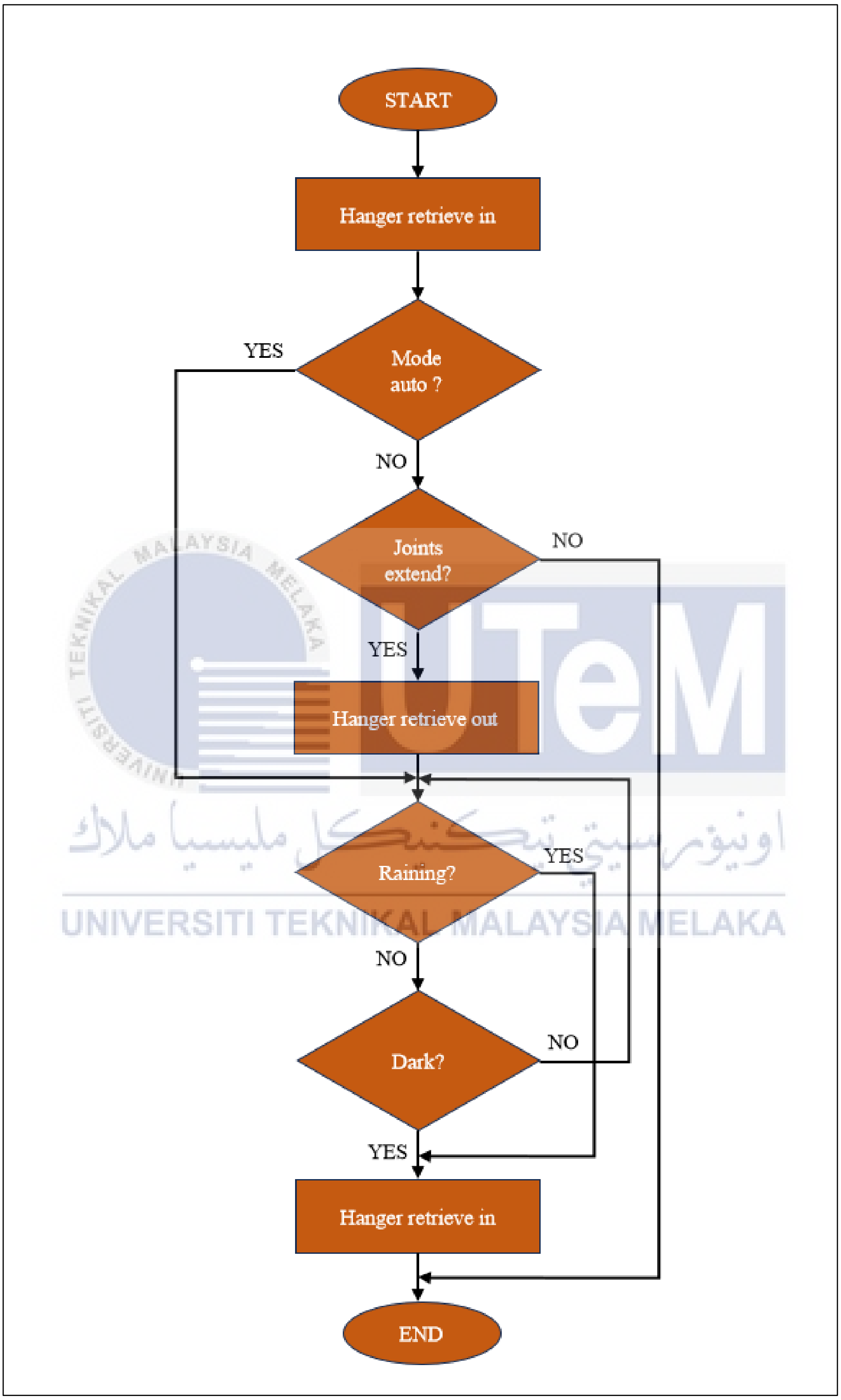


Figure 3.4 Flowchart of the system program

Smart Automated Foldable Clothes Hanger would run as the above flowchart. The process of the algorithm is explained is extended in following steps:

a) Once the program started, the foldable hanger automatically retrieve in since that's its the initial state.
b) Next, select the 'manual' button, allowing the user to take control of the foldable hanger manually.
c) After the foldable hanger extends, the user can select the 'automatic' button, indicating that they no longer need to control the foldable hanger manually.
d) The foldable hanger then automatically retrieve in if there is water present, such as rain, or in the absence of light.
e) The foldable hanger then automatically extend if there is no water present and there is sufficient light.

3.7 Selecting components for sustainable development

When selecting components for sustainable development in smart automated foldable clothes hanger project with IoT, one important factor to consider is the energy efficiency of the components used. Energy-efficient components can help reduce overall energy consumption and make this project more sustainable. For example, choosing high-efficiency electric motors for the hanger's folding mechanism can significantly minimize power usage while still providing the necessary torque. Look for motors compliant with energy efficiency standards such as NEMA Premium or ENERGY STAR [34], as they consume less energy and contribute to a greener solution.

According to the Environmental Protection Agency (EPA) [35], the average American family does around 300 loads of laundry each year, consuming approximately 13,500 gallons of water and generating about 400 loads of drying. This substantial water and energy consumption can be reduced by implementing smart automated foldable clothes hangers with IoT technology. By developing an efficient and automated clothes hanger system, it can help promote sustainability in the laundry process. The integration of IoT technology can enable features such as load sensing, which detects when the hanger is at full capacity, minimizing unnecessary energy usage. Additionally, incorporating smart algorithms to optimize the folding and drying process can save time and energy, making the overall system more sustainable and eco-friendlier.

By choosing to work on a smart automated foldable clothes hanger with IoT, this can contribute to the development of a solution that addresses the resource-intensive nature of laundry and helps promote sustainability in everyday household tasks.

3.8 Project components

A project component refers to a distinct part or element of a project that contributes to its overall completion and success. Components can vary based on the nature of the project, but they generally encompass tasks, activities, resources, and deliverables that are essential to achieving project goals. To complete this project, we're utilizing the ESP32 as the microcontroller, along with water and LDR sensors, a gear motor, limit switches, a relay module, and a step-up booster.

3.8.1 ESP32

The ESP32 microcontroller serves as the cornerstone of my automated foldable clothes hanger project, leveraging its multifaceted capabilities. With its integrated Wi-Fi, the ESP32 enables seamless connectivity to the internet, facilitating the integration of IoT platforms like Blynk, ThingSpeak, and a Telegram bot. This microcontroller's robust processing power efficiently manages various sensors such as light sensors, water sensors, and limit switches, interpreting their data to make informed decisions. Additionally, its ample GPIO pins offer extensive interfacing possibilities with components like gear motors, crucial for the automated folding mechanism. Overall, the ESP32 acts as the central intelligence unit, processing sensor data, orchestrating motor control, and enabling remote monitoring and control through internet-based platforms, rendering the clothes hanger both automated and remotely accessible.

3.8.2 Water sensor module

The water sensor can serve as a vital component for detecting moisture or wetness on the clothes placed on the hanger. Once integrated, this sensor can identify whether the clothes are damp or wet, triggering specific actions within the system. The brick is mainly comprised of three parts: An Electronic brick connector, a 1 MΩ resistor, and several lines of bare conducting wires [36]. This sensor are used to detect the presence of water which comes from the rain.

- Operating current: < 20mA
- Sensor Type: Analog
- High sensitivity
- Detection Area: 40mmx16mm

- Production process: FR4 double-sided
- Operating temperature:10℃-30℃
- Humidity: 10% -90% non-condensing
- Compatible with Arduino

3.8.3 LDR sensor module

The LDR was used to detect the presence of light and it also functions to measure the intensity of light. The basic operation of LDR when there was light, the resistance of LDR become low according to the intensity of light. In this project, the sunlight is taken over by light-emitting diode (LED) as the intensity of light[29]. The greater the intensity of light, the lower the resistance of LDR. The sensor has a potentiometer knob that can be adjusted to change the sensitivity of LDR towards light.

- Able to detect ambient brightness and light intensity.
- Adjustable sensitivity (via blue digital potentiometer adjustment)
- Operating voltage 3.3V-5V
- Digital switching outputs (0 and 1) -D0
- With fixed bolt hole for easy installation
- Small board PCB size: 3cm x 1.6cm
- Uses LM393 comparator chip

3.8.4 Gear motor 12V 5RPM

The 12V 5RPM gear motor stands as the pivotal mechanical force within the framework of the automated foldable clothes hanger project. Its deliberate 5RPM rotational speed enables precise and gentle movements essential for the folding and unfolding mechanism, ensuring a controlled motion that safeguards both clothes and the hanger's structure. Renowned for its torque multiplication through gears, this motor offers the strength necessary to effortlessly manage the mechanical load involved in handling clothes without strain. Integrated seamlessly with sensors or limit switches, it becomes the catalyst for automation, responding to triggers like sensor-detected dryness to initiate the folding or unfolding action accurately. Its compatibility with control systems allows for precise positioning, guaranteeing the hanger achieves the intended fold or unfold state reliably. With its user-friendly attributes such as minimal noise and vibrations, this motor enriches the overall user experience, making it an ideal fit for home environments. Moreover, its alignment with standard 12V power supplies ensures a seamless integration process, providing a stable and suitable power source. In essence, this gear motor serves as the bedrock, delivering controlled motion and reliability essential for the automated foldable clothes hanger's functionality.

3.8.5 Limit switches

Limit switches serve as essential checkpoints in your automated foldable clothes hanger, pivotal for both control and safety. Placed strategically along the hanger's movement path, these switches detect specific positions. Once triggered, they communicate with the microcontroller or motor controller, signaling the attainment of predetermined locations. Their primary role lies in ensuring the system's safety by preventing the motor or mechanism from overextending or surpassing intended positions. When synchronized with the gear motor, limit switches enable precise control over the hanger's movement, guaranteeing accurate stopping points during the folding and unfolding process. Crucially, these switches aid in system calibration, establishing reference points that ensure consistent and reliable operation. Ultimately, limit switches act as guardians within the system, offering crucial positional feedback that safeguards against mechanical mishaps while ensuring precise and reliable functionality of the automated foldable clothes hanger.

3.8.6 Relay module

A relay module is an electronic device used in various applications to control high-power circuits with low-power signals. It works as an electrically operated switch, allowing a low-voltage signal to control a separate, higher-voltage circuit. Relay is the core component that physically opens or closes the circuit based on the input it receives. It's typically composed of an electromagnet that, when energized, moves a set of contacts to make or break the connection. The relay is triggered or activated when the input signal reaches a higher voltage level (e.g., 5V or 3.3V, depending on the system's logic levels). When the input voltage is at this high level, the relay switches its state, either turning on or turning off the connected high-power circuit.

3.8.7 Step up booster

A step-up booster, also known as a boost converter or voltage booster, is an electronic device used to increase a lower input voltage to a higher output voltage. It efficiently transforms a lower voltage (5V) to a higher voltage (35V), providing the necessary power for components or devices requiring the elevated voltage to function optimally. When certain components or mechanisms, such as motors or specialized sensors, demand a higher voltage than what's readily available (5V), the step-up booster ensures they receive the required voltage level for proper operation.

3.9 Circuit design

A circuit diagram, also known as a schematic diagram or electrical diagram, is a graphical representation of an electrical circuit. It uses symbols to represent the various components and connections within the circuit. The circuit of the project is shown below in Figure 3.15.

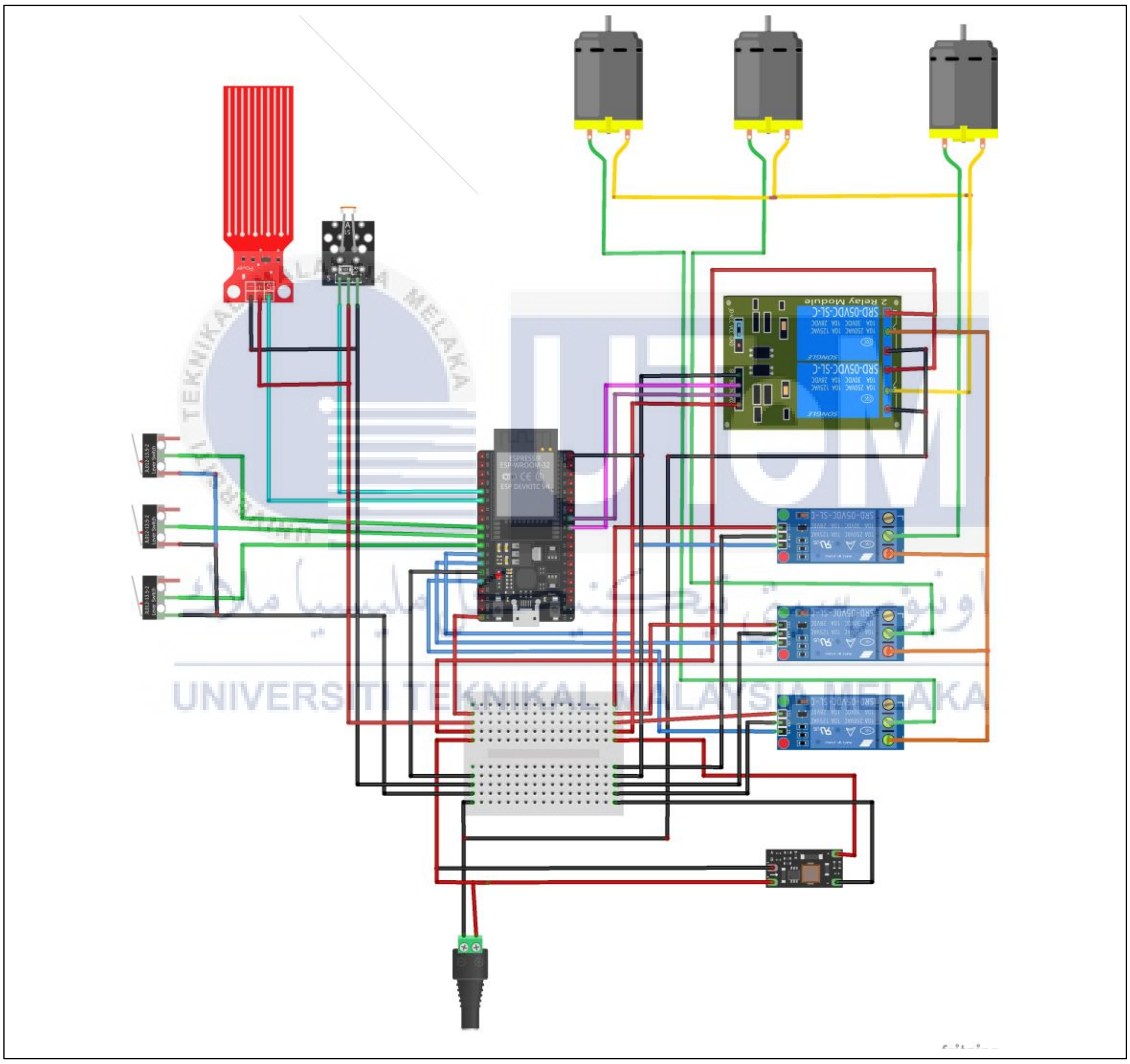


Figure 3.5 Circuit design for the project

Based on Figure 3.5, we obtained the power supply using an adapter. The supply was then divided into two parts, directing to the ESP32 and the step-up booster. All the relays in this project used the supply from the step-up booster. This choice was made to ensure that we had sufficient voltage for the motor. In addition to the ESP32, the voltage was also utilized for limit switches, water sensors, and an LDR sensor.

3.10 Project phase

A project phase is a distinct stage or step within the project lifecycle that groups together related activities and tasks. Utilizing aluminum steel as the project's base ensures a blend of durability and lightweight characteristics. Shaping it into a square (30cmx30cmx5cm) enhances both stability and ease of construction. This configuration optimizes load distribution and reinforces structural integrity, achieved through precise welding techniques for a robust and unified foundation.

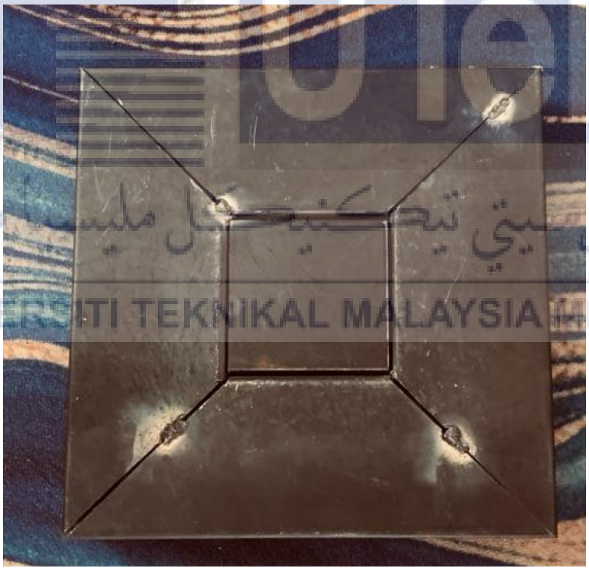


Figure 3.6 Base of the project

Integrating the pre-cut hollow stand (6cmx6cmx95cm) with the welded base forms a cohesive structure. Attaching the stand securely to the base bolster’s stability and support, guaranteeing precise alignment and fastening to fortify the overall foundation integrity of the project.

Figure 3.7 Combining base and the hollow stand

Incorporating three pieces of 20cmx2.5cmx2.5cm aluminum as hanger supports enhances the project's functionality. These pieces serve as versatile support or suspension points as required. Moreover, they are affixed to the V-shaped aluminum, acting as triggers for limit switches and introducing a mechanism for motor-controlled movement.

Figure 3.8 A piece of aluminum as the supports for the hanger

The use of 3D-printed drawings as hangers in this project presents a contemporary and adaptable method. These customized 3D-printed hangers attach to the supports, measuring 13cmx2cmx2cm with a hole diameter of 1cm.

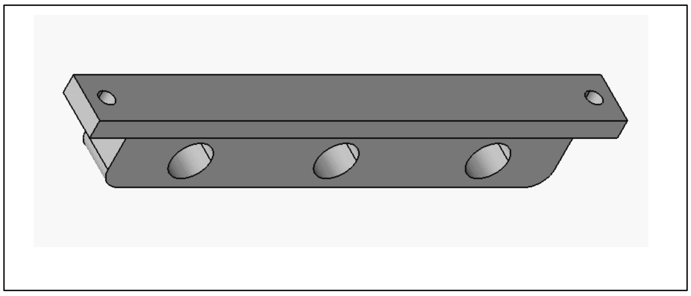


Figure 3.9 Sketching a 3D for the hangers

Figure 3.10 3D printed hangers

Subsequently, we assembled all components including the motors, limit switches, and sensors into a unified system, culminating in the completion of the entire project.

Figure 3.11 Limit switch for motor 1

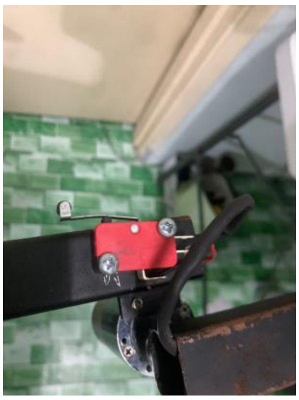


Figure 3.12 Limit switches for motor 2

Figure 3.13 Limit switch for motor 3

Figure 3.14 Motor 1

Figure 3.15 Motor 2

Figure 3.16 Motor 3

After integrating all elements, this marks the ultimate presentation of the combined project components. The culmination of efforts and collaboration results in a cohesive and comprehensive final product, ready for assessment or implementation.

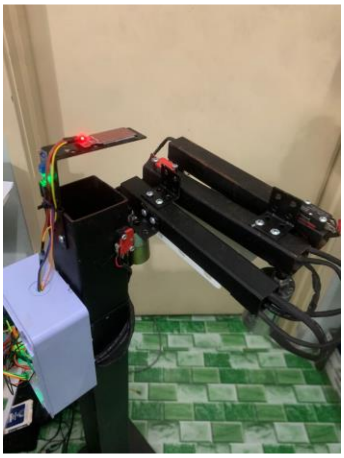


Figure 3.17 At initial condition (Retrieve in)

Figure 3.18 Retrieve out state

3.11 Summary

The project sets out to craft an automatic foldable clothesline, prioritizing functionality and sustainability. Its comprehensive methodology spans design objectives, concept intricacies, and meticulous component selection, all geared towards fashioning a user-friendly solution. Acknowledging the importance of research workflows and sustainable practices, the project highlights the role of energy-efficient components in curbing water and energy consumption within household laundry routines. Through detailed design concepts, illustrated via block diagrams and flowcharts, the project employs aluminum rods, motors, microcontrollers, and sensors to maximize space-saving benefits and enhance practicality. With an exhaustive breakdown of pivotal components, including microcontrollers, sensors, and motors, the project advances through assembly phases, culminating in a cohesive and deployable automated clothesline solution that seamlessly blends innovative design with an eco-conscious focus.

This project's meticulous approach encompasses both functionality and environmental impact. Its methodical strategy covers the spectrum from design intricacies to component choices, emphasizing user convenience and sustainability. Through careful consideration of research workflows and eco-friendly components, it aims to revolutionize household laundry by reducing water and energy consumption. By leveraging advanced design concepts and essential elements like microcontrollers and sensors, the project progresses through assembly phases to yield a practical and space-efficient automated clothesline solution. The project's fusion of innovative design and eco-awareness positions it as a potential game-changer in the realm of sustainable household solutions.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results derived from the conducted survey. Additionally, it includes the outcomes of developing a Smart Automated Foldable Clothes Hanger, covering aspects such as motor performance speed, water sensor, and LDR sensor.

4.2 Quantitative survey

This section presents the analysis of the results obtained from a survey of 117 respondents conducted online through the Google Forms platform. The majority of respondents participated in this survey during the National Day celebration held at the KL Convention Center on August 31st, 2023.

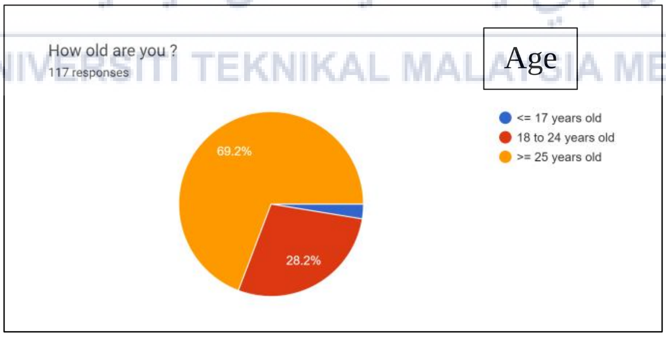


Figure 4.1 Age of the respondent

The chart above illustrates the age distribution of respondents in the survey. Out of 117 participants, 69.2% are aged 25 and above, 28.2% fall between 18-24 years old, and the remaining respondents are 17 years old or younger. The demographic of individuals aged 25 and above tends to be more accessible on the streets and active online, facilitating easier internet access, which aligns with the online nature of this survey.

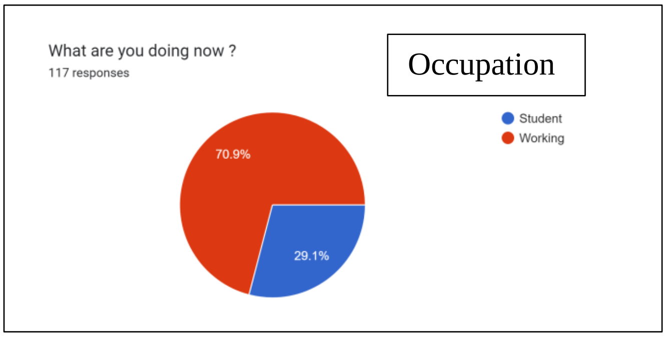


Figure 4.2 Occupation of the respondent

The data indicates that among the 117 respondents, 70.9% are employed, while the remaining respondents are students. This suggests that many employed individuals allocate their holiday time to partake in National Day celebrations with their children.

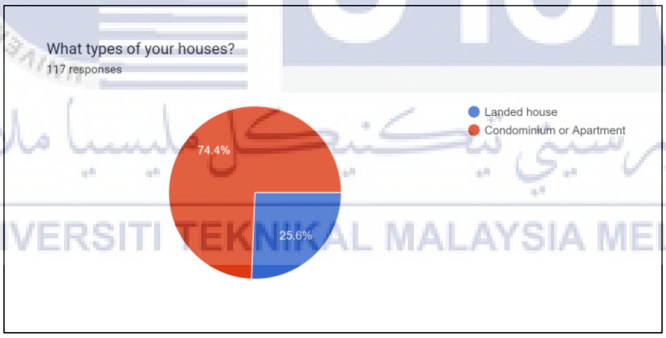


Figure 4.3 Types of houses of the respondent

According to the chart, 74.4% of respondents reside in condominiums or apartments, whereas 25.6% live in landed houses. This trend is primarily attributed to the respondents predominantly residing in Kuala Lumpur, a city characterized by a dense population and a prevalence of condominiums and apartment buildings due to space constraints. These accommodations accommodate larger populations efficiently within the city.

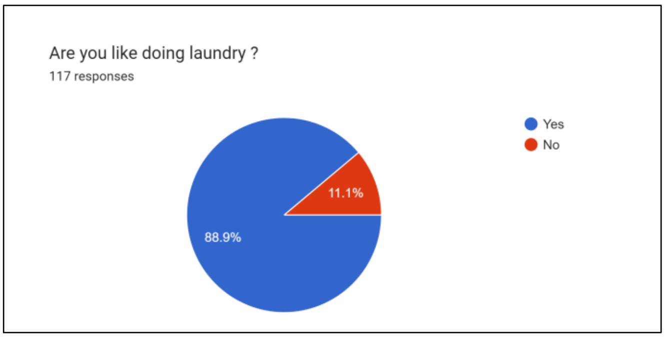


Figure 4.4 Respondents like doing laundry

Out of the 117 respondents, 88.9% express a preference for doing their laundry. This inclination is largely influenced by the fact that most of them are married with children, necessitating regular laundry chores. Conversely, 11.1% of respondents do not enjoy doing their laundry.

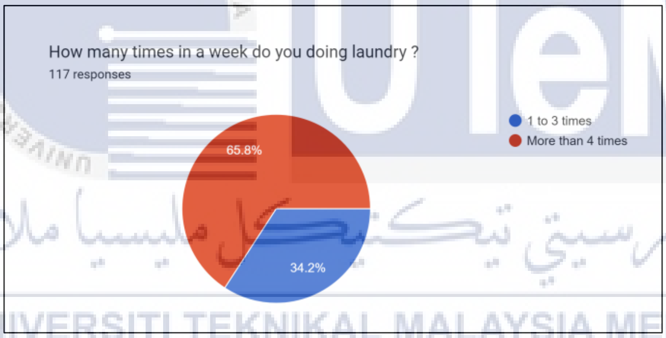


Figure 4.5 How many times respondents doing laundry

Among 117 respondents, 65.8% do laundry more than four times a week, whereas 34.2% do it less than three times a week. The higher frequency is primarily attributed to households with children, as kids often use more than three outfits a day, leading to increased laundry demands. Failing to manage this frequency could result in unwashed clothes developing unpleasant odors.

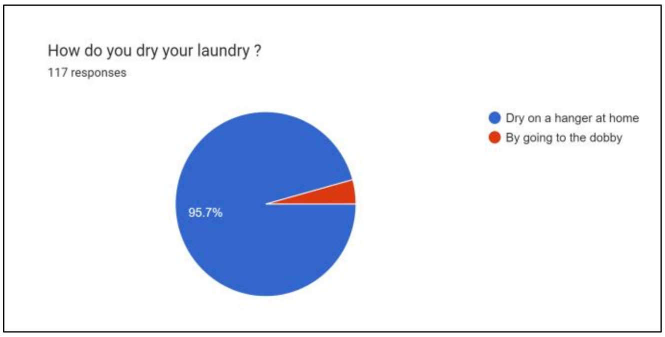


Figure 4.6 How respondents dry their laundry

As per the chart, 95.7% of respondents prefer drying their laundry at home using a hanger, while the remaining respondents opt for the laundromat. This inclination stems from a desire to avoid waiting at the laundromat, allowing them to utilize that time for household tasks or spend it with family. Consequently, they favor drying their clothes at home using a clothes hanger.

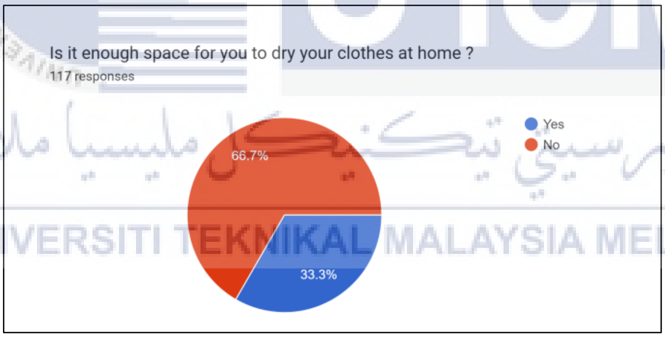


Figure 4.7 Is repondents have enough space to dry their clothes

Among the 117 respondents, 66.7% indicated a lack of sufficient space to dry their clothes at home, while the remaining 33.3% reported having adequate space. This shortage of space is notably prevalent among respondents residing in condominiums or apartments, where the balcony areas tend to be smaller in comparison to the larger balconies commonly found in landed houses, providing ample space for laundry activities.

Figure 4.8 Challenge that respondent faces when do laundry

Of the 117 respondents, 69.2% indicated facing the challenge of being occupied with work commitments, resulting in leaving their laundry unattended. Additionally, 29.9% cited weather-related challenges. This situation arises predominantly from respondents being occupied with work, often away from home, leading to leaving laundry unattended on balconies. Consequently, when left unattended, the clothes are vulnerable to rain exposure, causing them to become wet and develop unpleasant odors. This issue persists if the clothes are not promptly removed from the balcony.

4.3 Performance tests

This section delved into the performance testing conducted on the prototype and presented the gathered results. A variety of data was collected, analyzed, and interpreted to provide insights into the prototype's performance. This comprehensive approach allowed us to assess not only its reliability but also its performance during tests and the accuracy of sensor readings.

4.3.1 Reliablility

In that reliability test, we assessed the foldable hanger's durability from no load to its maximum load of 1.5kg. We tested it by gradually adding weight, starting from no clothes, and increasing until we reached its full capacity, which accommodated up to 9 clothes.

Table 4.1 SAFCH hanging no load

 Figure 4.9 Hanging no load	 Figure 4.10 Foldable hanger able to retrieve in with no load

Table 4.1 illustrates that the SAFCH successfully performs 'retrieve in' and 'retrieve out' actions even when no load is hanging. This demonstrates the functionality of our project, showcasing its ability to fulfill its tasks effectively.

Table 4.2 SAFCH hanging 3 clothes (0.5kg)

 Figure 4.11 Hanging 3 clothes which 0.5kg load	 Figure 4.12 Foldable hanger able to retrieve in with 0.5kg load

Table 4.2 demonstrates our testing of the SAFCH by hanging an equivalent of 3 clothes, weighing 0.5kg, which the SAFCH successfully holds. Moreover, it adeptly executes 'retrieve in' and 'retrieve out' actions without encountering any issues, showcasing its smooth operation under this load.

Table 4.3 SAFCH hanging 6 clothes (1kg)

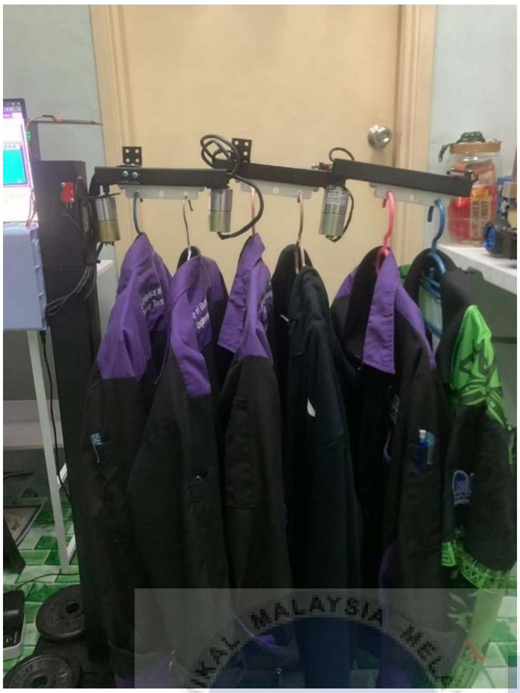
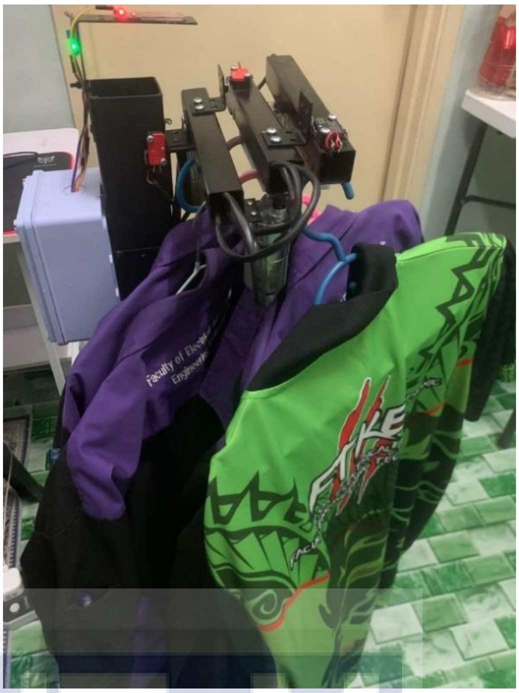
 Figure 4.13 Hanging 6 clothes which 1kg load	 Figure 4.14 Foldable hanger able to retrieve in with 1kg load

Table 4.3 illustrates our testing of the SAFCH by suspending an equivalent of 6 clothes, weighing 1kg, which the SAFCH successfully supports. However, the rotation of the foldable hanger tends to slow as the load increases. Despite this, there are instances of successful rotation where the foldable hanger can rotate fully.

Table 4.4 SAFCH hanging 9 clothes (1.5kg)

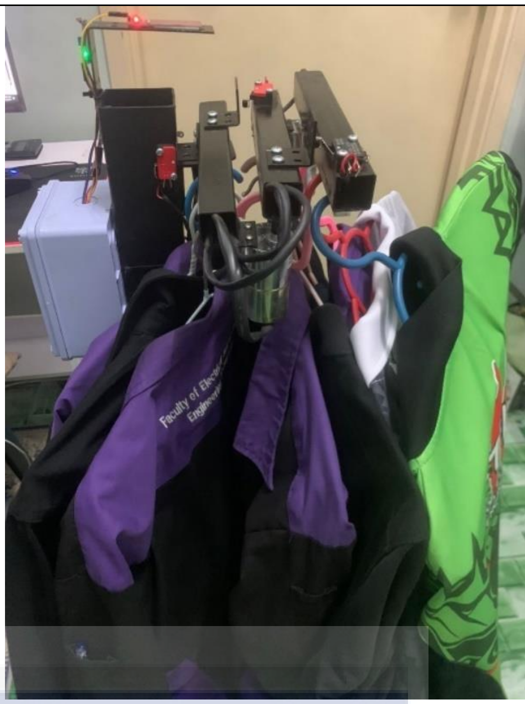
 Figure 4.15 Hanging 9 clothes which 1.5kg load	 Figure 4.16 Foldable hanger able to retrieve in with 1.5kg load

Table 4.4 displays the testing of the SAFCH by suspending an equivalent of 9 clothes, which represents the full capacity for the prototype, weighing 1.5kg. The SAFCH successfully supports this weight. However, the rotation of the foldable hanger becomes slower compared to the 1kg load. This decrease in rotation speed is attributed to the increased load, making it harder for the motor to rotate efficiently. Moreover, while the rotation is ultimately successful, it takes a longer time due to clothes getting stuck in between, hindering the hanger's ability to move freely.

These observations suggest that the hanger can support its maximum designed load, yet the decrease in rotation speed and the issue of clothes getting caught may need further attention for improving the functionality and efficiency of the SAFCH prototype.

Consideration of motor capacity and potential adjustments to prevent clothes from obstructing the hanger's movement could be areas for further exploration and refinement.

4.3.2 Performance of the motor

The testing is conducted to observe the motor's speed performance in revolutions per minute (RPM) under no-load conditions.

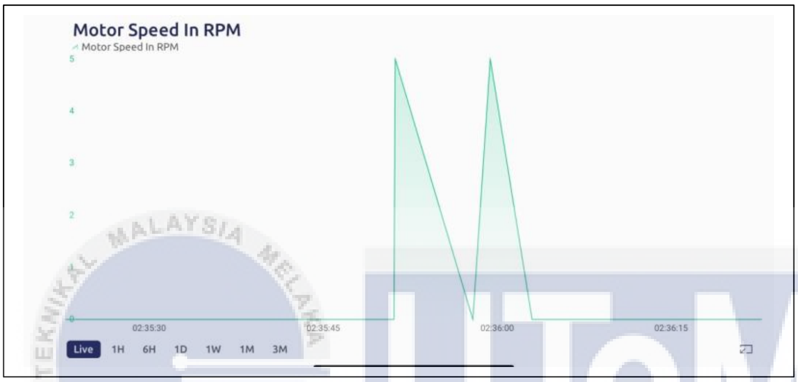


Figure 4.17 Motor speed in RPM in Blynk apps without a load

Based on the chart above, it depicts the motor speed rotation over time. The chart indicates that the motor consistently operates at its maximum speed, which is 5 rotations per minute (5RPM) as shown.

Figure 4.18 Smart Automated Foldable Clothes Hanger without a load

Table 4.5 Shows the time taken of motor speed to retrieve in without a load

Time taken	Retrieve out (seconds)	Retrieve in (seconds)
1st trial	6.80	7.10
2nd trial	6.80	7.09
3rd trial	6.70	7.09
4th trial	6.90	7.11
5th trial	6.70	7.10
Average time taken	**6.80**	**7.10**

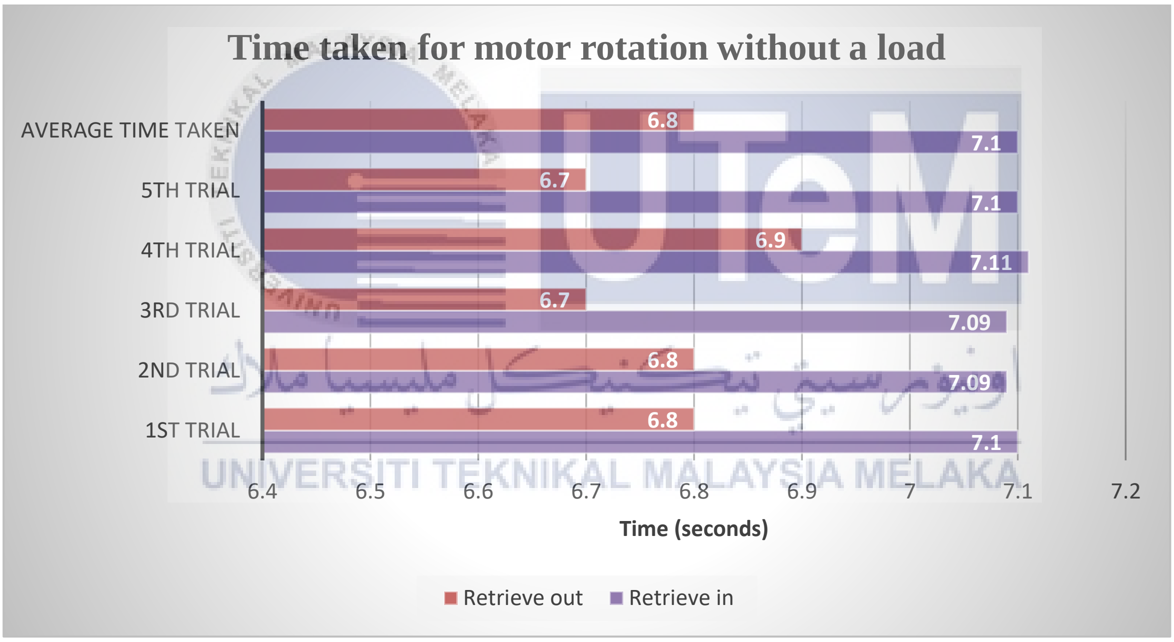


Figure 4.19 Time taken for motor rotation without a load

The graph in Figure 4.19 illustrates the time taken for motor rotation without a load. According to the average time required for the motor to facilitate the unfolding of the hanger, it is approximately 6.80 seconds, while the retrieval process takes about 7.44 seconds.

Next, the testing is carried out in which we can see the performance of the speed motor in RPM without a 1.5kg load which are the maximum load.

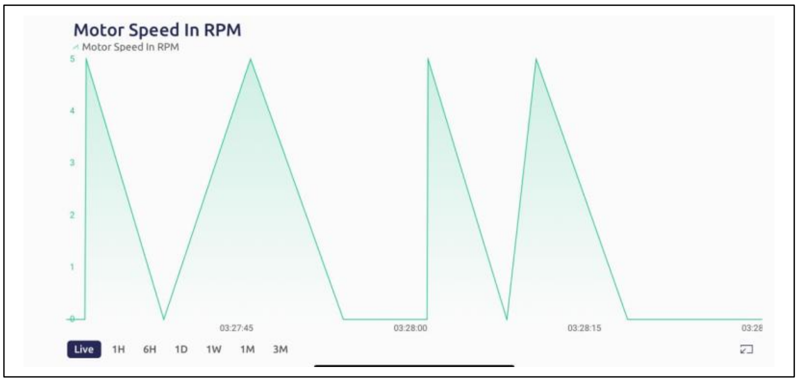


Figure 4.20 Motor speed in RPM in Blynk apps with 1.5kg load

Based on the chart, the second peak signifies the foldable hanger retracting or pulling clothes in. The prolonged duration of this action is notably due to the increased load. The chart illustrates that when dealing with a heavier load, the retrieval process takes a longer time, possibly indicating the motor's effort to manage the additional weight while retracting the clothes.

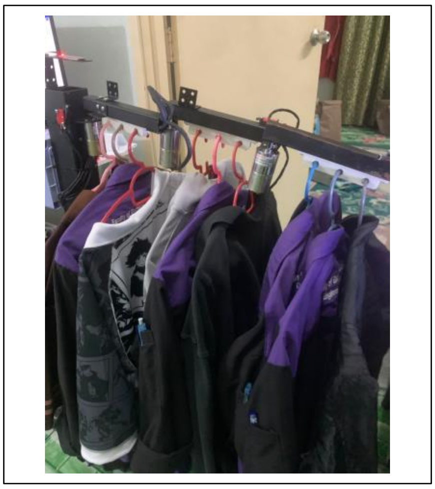


Figure 4.21 Smart Automated Foldable Clothes Hanger with 1.5kg load

Table 4.6 Shows the time taken of motor speed to retrieve in with 1.5kg load

Time taken	Retrieve out (seconds)	Retrieve in (seconds)
1st trial	7.30	7.45
2nd trial	7.28	7.42
3rd trial	7.32	7.46
4th trial	7.26	7.43
5th trial	7.30	7.44
Average time taken	7.29	7.44

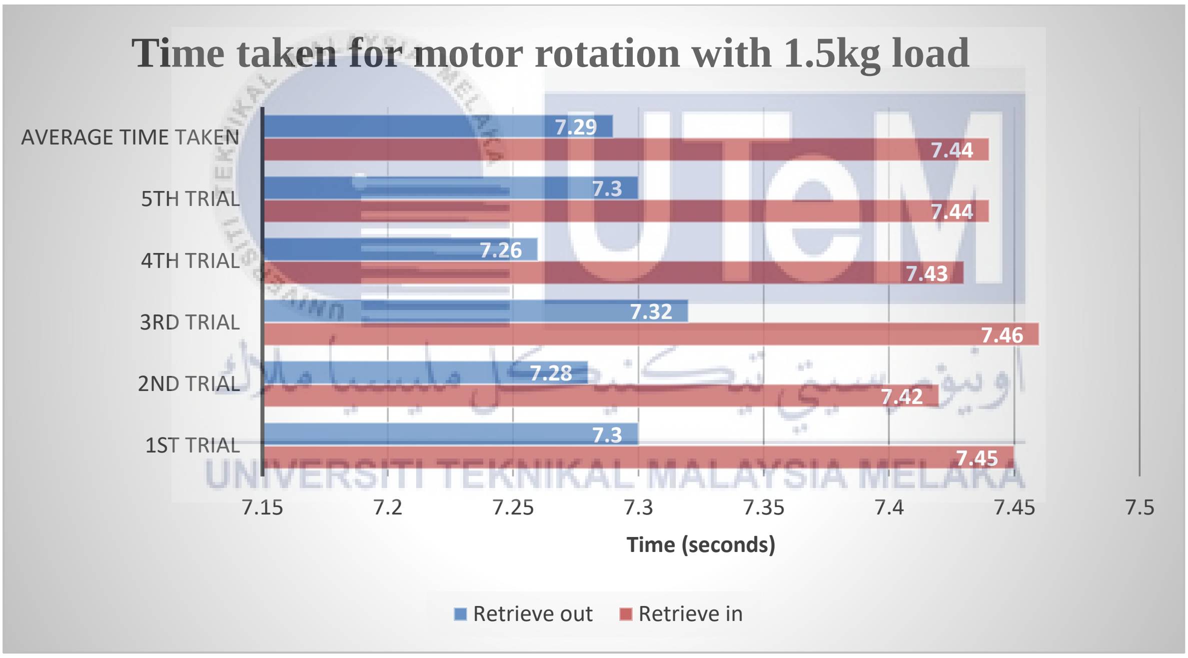


Figure 4.22 Time taken for motor rotation with 1.5kg load

The graph in Figure 4.22 illustrates the time taken for motor rotation with a 1.5kg load. Based on the average time required for the motor to facilitate the unfolding of the hanger, it is approximately 7.29 seconds, while the retrieval process takes about 7.44 seconds.

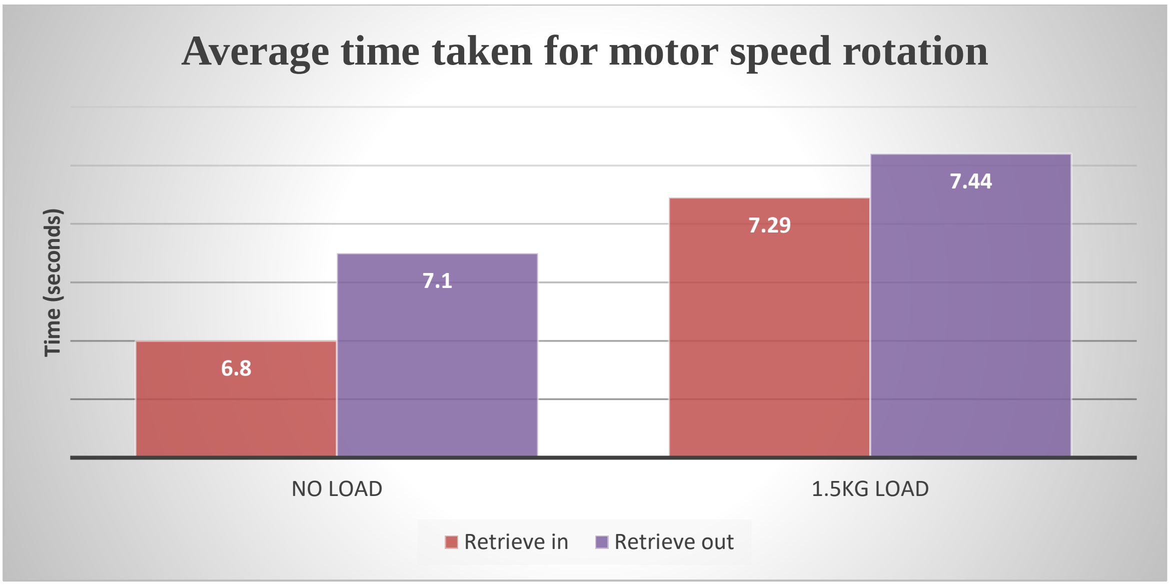


Figure 4.23 Bar charts of the average time taken for motor rotation

Based on Figure 4.23, the average time taken when the clothes hanger is without a load is 6.8 seconds, while with a 1.5kg load, it increases to 7.29 seconds. The reason for this difference lies in the additional weight the hanger carries. The load creates resistance and adds complexity to the hanger's movement, resulting in a slightly longer operation time. While the average time taken to retrieve items is 7.10 seconds without a load, it increases to 7.44 seconds with a 1.5 kg load. This difference in retrieval time parallels the earlier findings, as the additional weight of 1.5 kg further influences the hanger's efficiency in retrieving items. Consequently, it is essential to consider the impact of load on the overall performance of the clothes hanger system.

4.3.3 The LDR sensor

The testing is conducted to observe the LDR sensor's responsiveness under varying light conditions. It aims to assess how effectively the sensor detects and responds to changes in ambient light levels.

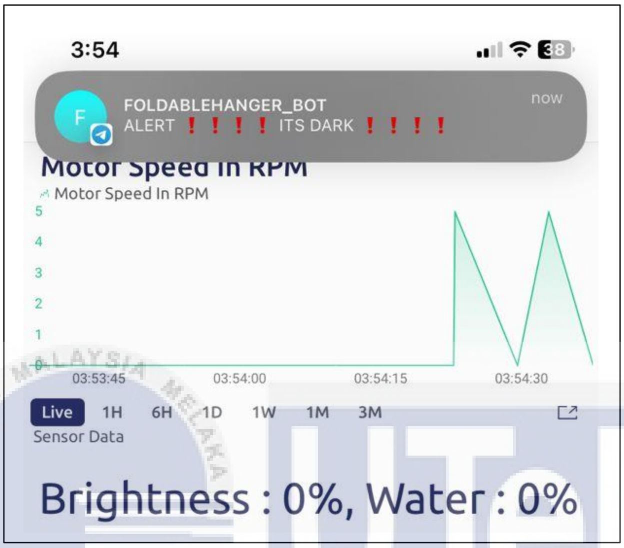


Figure 4.24 Real-time result of LDR sensor in Blynk apps

Figure 4.24 displays real-time data from the LDR (Light Dependent Resistor) sensor in the Blynk app. This functionality can be utilized by users to detect changes in light levels, distinguishing between conditions such as sunlight or darkness. The sensor's readings, as visualized in the figure, provide users with immediate information about the ambient light, enabling them to discern variations in light intensity and make informed decisions or trigger actions based on these light conditions.

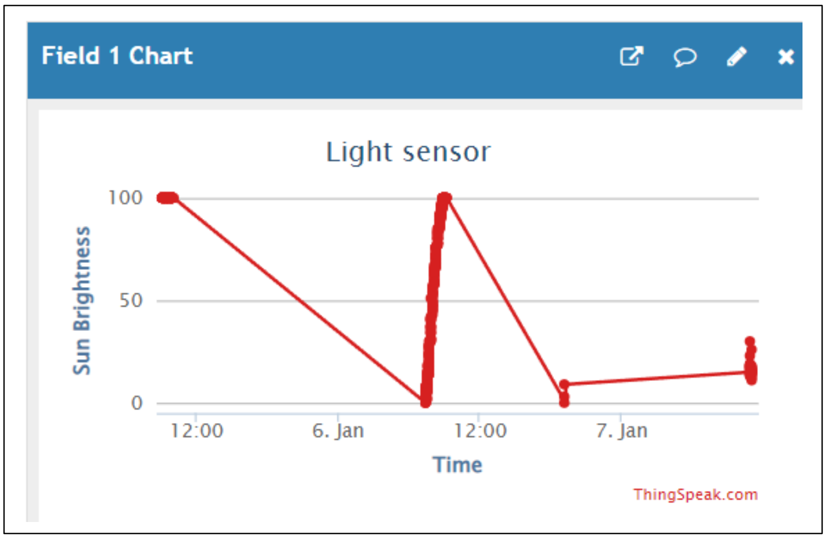


Figure 4.25 LDR sensor graph in ThingSpeak apps

Through Blynk apps, updating the percentage of light presence becomes convenient, allowing for immediate adjustments in real-time. On the other hand, utilizing ThingSpeak apps like in Figure 4.25, provides the benefit of visualizing this data through graphs, simplifying the process of data collection, and enabling a more comprehensive understanding of light presence percentages over time. This graphical representation facilitates in-depth analysis and identification of trends.

Furthermore, interpreting the data using MATLAB offers additional advantages. MATLAB allows for a more detailed and nuanced representation of the graph, providing a clearer and more elaborate visualization. This level of detail aids in a more precise analysis, enabling researchers or users to delve deeper into the nuances of light presence trends and make more informed conclusions.

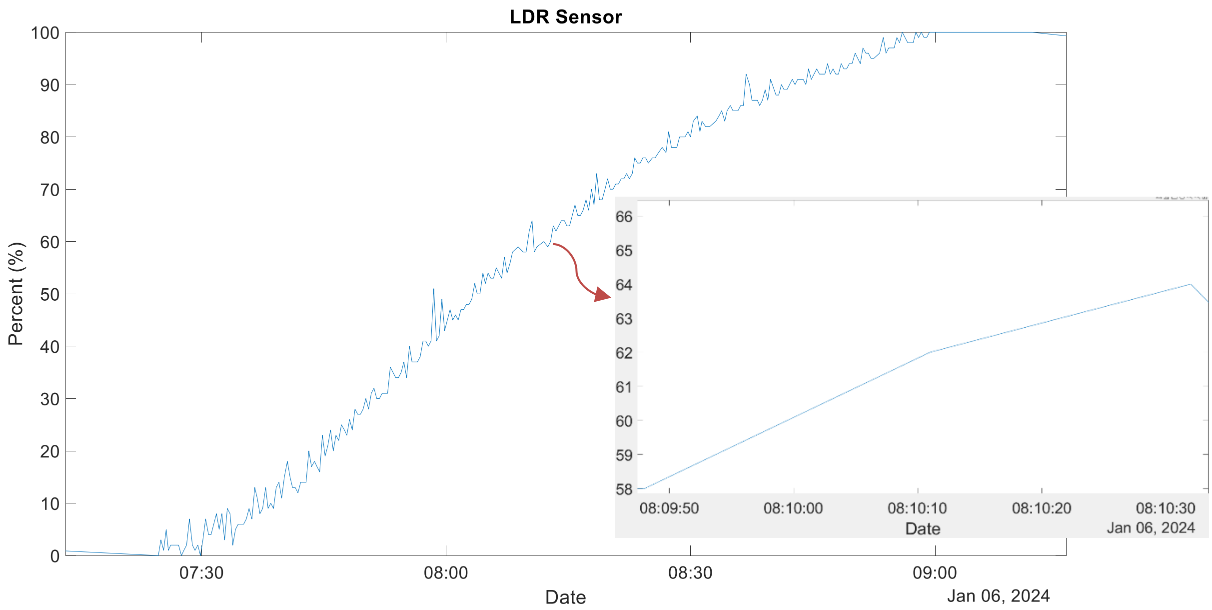


Figure 4.26 LDR sensor graph in MATLAB interpret from ThingSpeak apps

Figure 4.26 displays the percentage of brightness recorded by the LDR sensor between 7:30 am and 9:00 am on 06 January 2024. The graph depicts a rising trend in brightness, indicating an increase in the surrounding light levels during this time frame. The specific percentage details are depicted in the zoomed-in graph on the right-hand side. It illustrates an increase in the numbers from 58% to 64% of brightness occurring between 8:09:50 am and 8:10:30 am.

4.3.4 The water sensor

The testing is specifically undertaken to assess the water sensor's sensitivity and reaction time in detecting varying levels of moisture or water presence. This evaluation aims to gauge how promptly and accurately the sensor registers changes in moisture content, crucial for its effective application in monitoring and alerting systems.

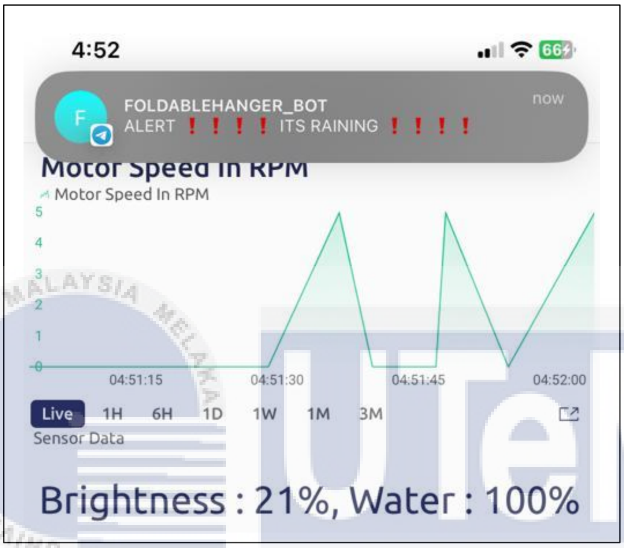


Figure 4.27 Real-time result of water sensor in Blynk apps

Figure 4.27 shows real-time data from a water sensor in the Blynk app, which users can use to identify the presence of water. This feature allows users to monitor water levels in various settings, providing timely alerts or notifications in case of water presence, enabling prompt action or preventive measures.

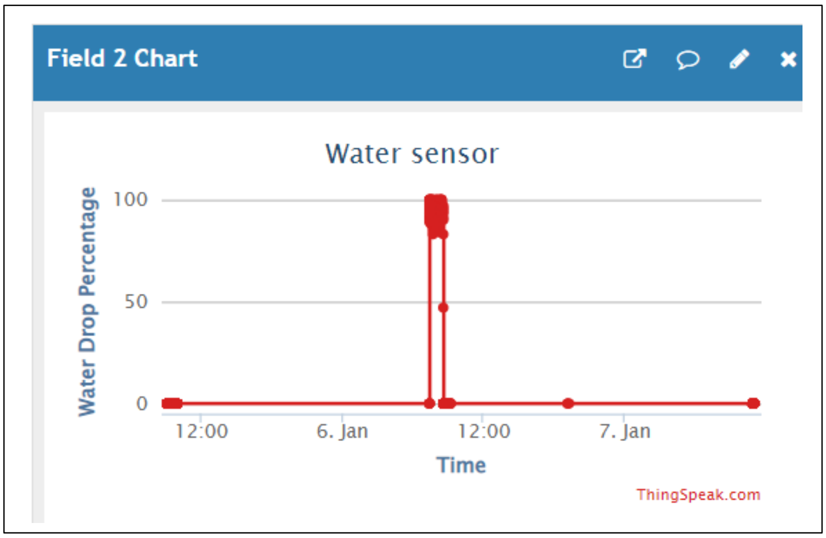


Figure 4.28 Water sensor graph in ThingSpeak apps

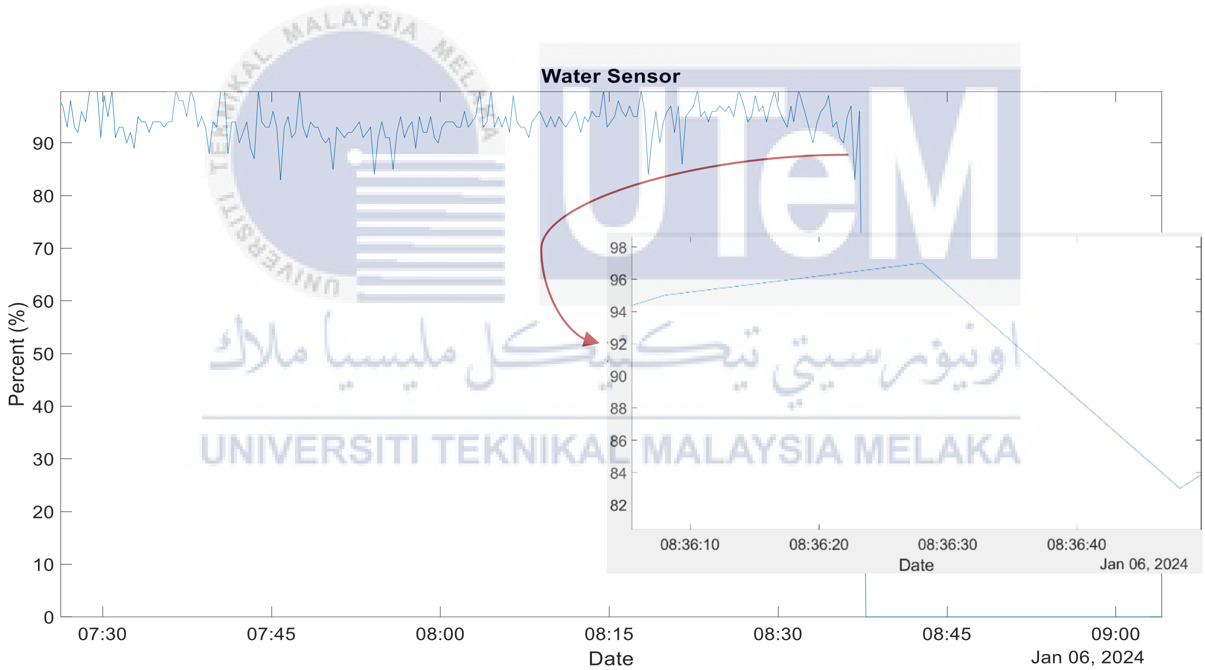


Figure 4.29 Water sensor graph in MATLAB interpret from ThingSpeak apps

Figure 4.29 illustrates the recorded percentage of water presence captured by the water sensor from 7:30 am to 9:00 am on 06 January 2024. The graph portrays a declining trend, indicating a reduction in water levels during this period, possibly attributed to the near cessation of rainfall. A more detailed depiction of these specific percentage changes is available in the magnified view on the right-hand side of the graph. This zoomed-in section delineates a decrease from 95% to 83% in water levels, occurring precisely between 8:36:10 am and 8:36:50 am.

4.4 Notification

The notification system embedded within the smart automated foldable clothes hanger project plays a pivotal role in keeping users informed about environmental shifts. Utilizing sensors to detect rain and low light conditions, this system promptly triggers Telegram notifications upon detection of these changes. These notifications, set to be dispatched every 5 seconds, ensure users receive consistent updates regarding rain presence or darkness. This feature aims to empower users with real-time information, enabling them to make informed decisions about managing their clothes or adjusting the hanger's operation in response to weather fluctuations or diminishing light conditions. The notification report highlights the system's efficiency in providing timely cues, enabling users to proactively address environmental alterations for better garment care and hanger functionality.

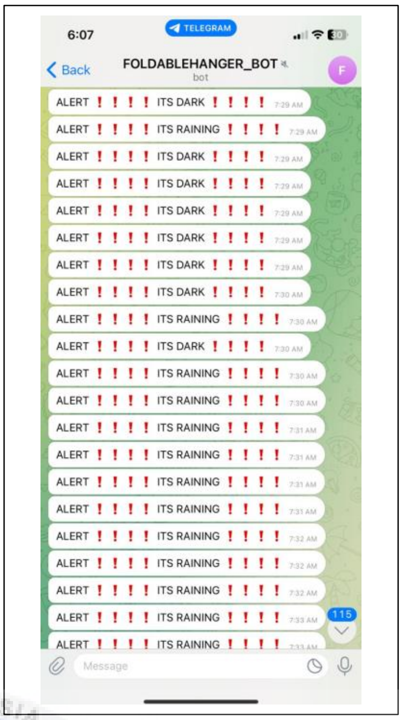


Figure 4.30 Telegram notification

In Figure 4.30, notifications were observed between 7:29 am and 7:33 am on 06 January 2024, indicating dark and rainy conditions. Initially, the notifications conveyed darkness and rainfall. However, by approximately 7:30 am, the SAFCH detected increased brightness, likely from the sunrise. Despite this, the continued rainfall prompted SAFCH to send notifications indicating ongoing rainy conditions.

4.5 Summary

The findings from a survey involving 117 respondents and the development outcomes of a Smart Automated Foldable Clothes Hanger. The survey revealed that most participants were aged 25 and above, employed, living in condos/apartments, and preferred doing laundry at home due to frequent chores and space limitations. The hanger underwent rigorous performance tests, showcasing its ability to handle loads up to 1.5kg, although issues arose with reduced rotation speed and occasional clothes obstruction at maximum capacity. The motor functioned consistently at 5RPM without a load and increased to an average of 7.29 seconds for retrieval with a 1.5kg load. Both the LDR and water sensors exhibited accurate responsiveness to light and moisture changes, with real-time data visualization aiding in comprehensive analysis. Additionally, a notification system integrated into the hanger effectively alerted users about environmental shifts like darkness and rainfall, empowering proactive decision-making for clothes and hanger management.

Overall, the survey highlighted user preferences and habits, while the performance tests unveiled the hanger's capabilities and limitations, indicating areas for refinement. The motor's consistent performance and the sensors' accuracy affirmed their reliability, albeit with slight variations under load conditions. The notification system emerged as a valuable feature, promptly updating users about weather changes, allowing for informed decisions regarding clothes and hanger adjustments. The chapter serves as a comprehensive evaluation of the Smart Automated Foldable Clothes Hanger, offering insights into its functionality, strengths, and areas for potential enhancements.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Unpredictable weather patterns and increasingly busy lifestyles have made the clothes drying and collection process more challenging. However, technological advancements offer promising solutions to alleviate these challenges. Innovations aim to shield clothes from rain while permitting sunlight exposure on sunny days, ensuring efficient drying and protection from adverse weather conditions. This integration of technology endeavors to streamline and simplify the clothes maintenance process, catering to modern lifestyles.

By extensively studying individuals' experiences in managing home laundry processes and evaluating existing laundry hanging systems, we've introduced the innovative Smart Automated Foldable Clothes Hanger integrated with an Internet of Things (IoT) system. This new system aims to streamline and simplify the laundry drying process by automating it. The selection of specially curated, reliable, and cost-effective sensors has significantly reduced development costs by over 50%. This substantial cost reduction has made the entire system accessible and affordable for the general public, aligning with our goal of enhancing convenience and efficiency in household chores.

The accomplished objectives are as follows:

a) Able to develop an automated foldable clothes hanger with Internet of Thing (IoT). This is achieved through the utilization of simple, cost-effective, and dependable tools and development materials.

b) Able to employ a suitable microcontroller and IoT monitoring system for data collection. We implemented the ESP32 as the microcontroller and employed Blynk, ThingSpeak, and Telegram bot as the IoT monitoring system for effective data collection.

c) Analyzing and assessing the system's performance. The achieved objectives include obtaining real-time results through the utilization of Blynk apps. This platform enables immediate access to data. Conversely, with ThingSpeak, the achieved objective involves updates occurring at intervals of 15 seconds. While this platform provides valuable data, its update frequency operates on a slight delay compared to real-time data acquisition.

5.2 Future Works

One promising avenue for future enhancement centers around refining the motor control system through the integration of a PID (Proportional-Integral-Derivative) controller. By implementing PID control mechanisms, the objective is to optimize the motor's performance, ensuring smoother and more precise movements during the foldable clothes hanger's operations. The PID controller's ability to continuously adjust parameters in response to variations in load or environmental conditions holds the potential to significantly enhance the motor's speed, accuracy, and adaptability. This integration aims to fine-tune the folding and unfolding actions, providing a more efficient and responsive system. Future endeavors could involve comprehensive testing and parameter tuning to maximize the benefits of PID control, ultimately advancing the overall functionality and reliability of the automated foldable clothes hanger.

5.3 Commercialization

One survey has been conducted regarding the Smart Automated Foldable Clothes Hanger in Kuala Lumpur. The total number of respondents is 178. The survey provides details about SAFCH and asks if they would like to have one.

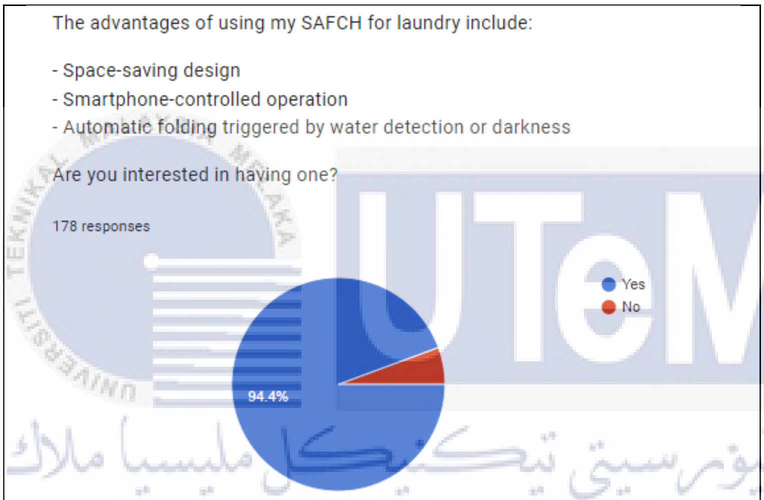


Figure 5.1 Survey about SAFCH

Based on Figure 5.1, the smart automated foldable clothes hanger demonstrates significant commercial potential within the consumer market. Its integration of advanced technologies, such as sensor-driven automation and real-time notifications, addresses the growing demand for smart home solutions focused on convenience and efficiency. Targeting urban households and individuals seeking space-efficient garment care, the hanger's value proposition lies in simplifying clothing organization, optimizing space, and providing proactive environmental alerts. To initiate commercialization, strategic steps would involve market analysis, partnerships with retailers or e-commerce platforms, and targeted marketing campaigns. Challenges may arise in market competition and pricing strategies, necessitating a balance between affordability and quality. Overall, the hanger presents an innovative solution poised to meet modern lifestyle demands and offers substantial commercialization opportunities in the evolving landscape of smart home appliances.

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APPENDICES

Appendix A Coding for ESP32 WROOM

```
/*
   PROJECT   : SMART AUTOMATED FOLDABLE CLOTHES HANGER
   AUTHOR    : AHMAD IRFAN BIN ANAS
*/

// Define blynk and ThingSpeak
// Unique ID for this project
#define BLYNK_TEMPLATE_ID "TMPL6kbsdW4mH"
#define BLYNK_TEMPLATE_NAME "IOT Automated Ampaian"
#define BLYNK_AUTH_TOKEN "ZiQv3zsqSyRqveaM6X34QYBWz8SHnnTt"
#define BLYNK_PRINT Serial

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include "ThingSpeak.h"
#include "CTBot.h"

BlynkTimer timer;

// Your WiFi credentials.
// Set password to "" for open networks.
char auth[]  = BLYNK_AUTH_TOKEN;
char ssid[]  = "Irfansem";
char pass[]  = "1234567890";
int keyIndex = 0;          // your network key Index number (needed only for WEP)
WiFiClient  client;

#define SECRET_CH_ID 2382642
#define SECRET_WRITE_APIKEY "Q14OYD7MDWPIPQOI"

unsigned long myChannelNumber = SECRET_CH_ID;
const char * myWriteAPIKey = SECRET_WRITE_APIKEY;

// Declare virtual pin for blynk
#define vP_statusData V0
#define vP_Mode       V1
#define vP_button     V2
#define vP_motorSpeed V3

int statusMode;
int modeButton;
```

```
int buttonVirtual;
int manual_button = 0;

bool AUTO = true;
bool MANUAL = false;

CTBot myBot;
String token = "6314099154:AAEPkdz9_HNWopae3m209D4NgmxFzr_wAvE"; // token
bot telegram

// Define for notification
String ALERT1 = "alert_ldr";
String ALERT2 = "alert_water_drop";
String StatusData;

void initWiFi() {
  WiFi.begin(ssid, pass);
  Serial.println("Connecting");
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }

  Blynk.begin(auth, ssid, pass);

  //status for success connect
  Serial.println("WiFi CONNECTED");

  Serial.println("");
  Serial.print("Connected to WiFi network with IP Address: ");
  Serial.println(WiFi.localIP());
  WiFi.mode(WIFI_STA);
  ThingSpeak.begin(client);  // Initialize ThingSpeak
}
//==========================================================

// Define push button with limit switch
#define limitSwitch1_pin 25
#define limitSwitch2_pin 26
#define limitSwitch3_pin 27

int limitSwitch1;
int limitSwitch2;
int limitSwitch3;
int sttsRunAuto = 0;
int sttsRunManual = 0;
bool pressed = false;
bool touchedLimit1 = false;
bool touchedLimit2 = false;
```

```
bool touchedLimit3 = false;
byte buttonState;
byte lastButtonState = LOW;
byte motorState = LOW;

// Define relay motor
#define relayMotor1_pin  13
#define relayMotor2_pin  12
#define relayMotor3_pin  14

// motor power supply & Direction
#define relayPower1_pin  18
#define relayPower2_pin  19

// read sensor pin
#define waterSensor_pin  35
#define ldrSensor_pin    34

int waterValue;
int ldrValue;
int waterPercentage;
int brightnessValue;

void initPinMode() {
  pinMode(limitSwitch1_pin, INPUT_PULLUP);
  pinMode(limitSwitch2_pin, INPUT_PULLUP);
  pinMode(limitSwitch3_pin, INPUT_PULLUP);

  pinMode(relayMotor1_pin, OUTPUT);
  pinMode(relayMotor2_pin, OUTPUT);
  pinMode(relayMotor3_pin, OUTPUT);
  pinMode(relayPower1_pin, OUTPUT);
  pinMode(relayPower2_pin, OUTPUT);

  pinMode(waterSensor_pin, INPUT);
  pinMode(ldrSensor_pin, INPUT);

  digitalWrite(relayMotor1_pin, LOW);
  digitalWrite(relayMotor2_pin, LOW);
  digitalWrite(relayMotor3_pin, LOW);

  digitalWrite(relayPower1_pin, HIGH);
  digitalWrite(relayPower2_pin, HIGH);
}
//==================================================================

void setup() {
  Serial.begin(9600);
  initWiFi();
```

```
  initPinMode();

  // timer to set function
  timer.setInterval(1000L, readAllSensor);
  timer.setInterval(100L, readLimitSwitch);
  timer.setInterval(10000L, sendDataToThingSpeak);

  myBot.wifiConnect(ssid, pass);

  myBot.setTelegramToken(token);

  // check if all things are ok
  if (myBot.testConnection()){
    Serial.println("\n Connected to Telegram");
}
  else
  {  Serial.println("\n Can't Connect to Telegram");
  }
}
//=============================================================

void loop() {
  Blynk.run();
  timer.run();
}
//=============================================================

void readLimitSwitch() {
  limitSwitch1 = digitalRead(limitSwitch1_pin);
  limitSwitch2 = digitalRead(limitSwitch2_pin);
  limitSwitch3 = digitalRead(limitSwitch3_pin);

  if (statusMode == AUTO) {
    readMotorAuto();
    Serial.println("AUTO");
  } else {
    readMotorManual();
    Serial.println("MANUAL");
  }
}
//=============================================================

// Read Motor Direction Auto
void readMotorAuto() {
  // close
  if ((brightnessValue <= 5 || waterPercentage >= 50) && statusMode == AUTO /*&&
sttsRunAuto == 0*/) {
    if (sttsRunAuto == 0) {
      CCW_Rotation(); // change direction to ccw
```

```
      Blynk.virtualWrite(vP_motorSpeed, 5); // send data to app blynk
      digitalWrite(relayMotor1_pin, HIGH);
      digitalWrite(relayMotor2_pin, HIGH);
      digitalWrite(relayMotor3_pin, HIGH);
      sttsRunAuto = 1;
    }
  }

  // open
  // limit switch are press
  if ((brightnessValue >= 5 && waterPercentage <= 50) && statusMode == AUTO && limitSwitch1 == 0 && limitSwitch2 == 0 && limitSwitch3 == 0 /*&& sttsRunAuto == 1*/)
{
    if (sttsRunAuto == 1) {
      CW_Rotation();
      Blynk.virtualWrite(vP_motorSpeed, 5);
      digitalWrite(relayMotor1_pin, HIGH);
      digitalWrite(relayMotor2_pin, HIGH);
      digitalWrite(relayMotor3_pin, HIGH);
      delay(3500);
      digitalWrite(relayMotor1_pin, LOW);
      delay(3200);
      digitalWrite(relayMotor2_pin, LOW);
      digitalWrite(relayMotor3_pin, LOW);
      Blynk.virtualWrite(vP_motorSpeed, 0);
      STOP_Rotation();
      sttsRunAuto = 0;
    }
  }
  readLimitSwitchStatus();
}
//============================================================

// Read Motor Direction Manual
void readMotorManual() {
  if (motorState == LOW && statusMode == MANUAL) {
    if (sttsRunManual == 0) {
      CCW_Rotation();
      Blynk.virtualWrite(vP_motorSpeed, 5);
      digitalWrite(relayMotor1_pin, HIGH);
      digitalWrite(relayMotor2_pin, HIGH);
      digitalWrite(relayMotor3_pin, HIGH);
      sttsRunManual = 1;
    }
  }
  if (motorState == HIGH && statusMode == MANUAL) {
    if (sttsRunManual == 1) {
      CW_Rotation();
      Blynk.virtualWrite(vP_motorSpeed, 5);
```

```
      digitalWrite(relayMotor1_pin, HIGH);
      digitalWrite(relayMotor2_pin, HIGH);
      digitalWrite(relayMotor3_pin, HIGH);
      delay(3500);
      digitalWrite(relayMotor1_pin, LOW);
      delay(3200);
      digitalWrite(relayMotor2_pin, LOW);
      digitalWrite(relayMotor3_pin, LOW);
      Blynk.virtualWrite(vP_motorSpeed, 0);
      STOP_Rotation();
      sttsRunManual = 0;
    }
  }
  readLimitSwitchStatus();
}
//==========================================================================

// Read limit Switch
void readLimitSwitchStatus() {
  // if limit switch are press and
  if (limitSwitch1 == 0 && (sttsRunAuto == 1 || sttsRunManual == 1)) {
    digitalWrite(relayMotor1_pin, LOW); // off motor
    Blynk.virtualWrite(vP_motorSpeed, 0); // send data motor
  } else {
    // Do nothing here
  }
  ////////////////////////////////////////
  if (limitSwitch2 == 0 && (sttsRunAuto == 1 || sttsRunManual == 1)) {
    digitalWrite(relayMotor2_pin, LOW);
    Blynk.virtualWrite(vP_motorSpeed, 0);
  } else {
    // Do nothing here
  }
  ////////////////////////////////////////
  if (limitSwitch3 == 0 && (sttsRunAuto == 1 || sttsRunManual == 1)) {
    digitalWrite(relayMotor3_pin, LOW);
    Blynk.virtualWrite(vP_motorSpeed, 0);
  } else {
    // Do nothing here
  }
}
//==========================================================================

void readAllSensor() {
  // read analog value
  waterValue = analogRead(waterSensor_pin);

  // mapping to convert analog to percentage
  waterPercentage = map(waterValue, 0, 1700, 0, 100);
```

```
  // correction factor
  if (waterPercentage >= 100) {
    waterPercentage = 100;
    String message;
    message ="ALERT ❗ ❗ ❗ ❗ ITS RAINING ❗ ❗ ❗ ❗ ";
    myBot.sendMessage(1257968817, message);
    delay(500);
  }
  else if (waterPercentage <= 0) {
    waterPercentage = 0;

  } else {
    waterPercentage = waterPercentage;
  }

  // read analog value
  ldrValue = analogRead(ldrSensor_pin);

  brightnessValue = map(ldrValue, 4095, 1600, 0, 100);

  if (brightnessValue >= 100) {
    brightnessValue = 100;
  }
  else if (brightnessValue <= 0) {
    brightnessValue = 0;
    String message;
    message ="ALERT ❗ ❗ ❗ ❗ ITS DARK ❗ ❗ ❗ ❗ ";
    myBot.sendMessage(1257968817, message);
    delay(500);

  } else {
    brightnessValue = brightnessValue;
  }

  StatusData = "Brightness : " + String(brightnessValue) + "%, Water : " + String(waterPercentage) + "%";

  Blynk.virtualWrite(vP_statusData, StatusData);
}
//==================================================================

void sendDataToThingSpeak() {
  // set the fields with the values
  ThingSpeak.setField(1, brightnessValue);
  ThingSpeak.setField(2, waterPercentage);
  //ThingSpeak.setField(3, motorSpeedRPM);
  // write to the ThingSpeak channel
```

```
  int x = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
  if (x == 200) {
    Serial.println("Channel update successful.");
  }
  else {
    Serial.println("Problem updating channel. HTTP error code " + String(x));
  }
}
//==============================================================

BLYNK_WRITE(vP_Mode) {
  modeButton = param.asInt();
  if (modeButton == pressed) {
    statusMode = AUTO;
  } else {
    statusMode = MANUAL;
  }
}
//==============================================================

BLYNK_WRITE(vP_button) {
  buttonState = param.asInt();

  if (buttonState != lastButtonState) {
    lastButtonState = buttonState;
    if (buttonState == HIGH) {
      motorState = (motorState == HIGH) ? LOW : HIGH;
    }
  }
}
//==============================================================

void CCW_Rotation() {
  digitalWrite(relayPower1_pin, LOW);
  digitalWrite(relayPower2_pin, HIGH);
}
/*****************************************/
void CW_Rotation() {
  digitalWrite(relayPower1_pin, HIGH);
  digitalWrite(relayPower2_pin, LOW);
}
/*****************************************/
void STOP_Rotation() {
  digitalWrite(relayPower1_pin, HIGH);
  digitalWrite(relayPower2_pin, HIGH);
}
```