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Automated Solar-Powered IoT-Based Blynk Clothesline Retriever with SMS Status Updates

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***Abstract* - The Philippines faces unpredictable weather changes that cause inconvenience for traditional hanging methods, impacting the time and effort required to retrieve clothes hung outdoors, especially when residents are away and unable to respond quickly. Thus, there is a need to innovate the traditional clothesline to fit the changing demands of climate problems. Moreover, this study aimed to design and develop an automated solar-powered IoT-based Blynk clothesline retriever with SMS status updates. Utilizing a Research and Development Design ensured a concise methodology for creating and evaluating the prototype. The researchers successfully developed a program logic and determined its mass-handling capability, with a maximum load of 22.4 kg and a threshold value of 20.3 kg. Furthermore, analysis showed no significant difference in retrieval speed (0.227 m/s) between no load and maximum load, and the reaction time remained constant at 1 second across all trials. Additionally, the prototype received high acceptability (M = 4.40) and adaptability (M = 4.25) ratings from evaluators. In conclusion, the researchers successfully developed an automated clothesline retriever with SMS status updates and a program logic, demonstrating high durability, fast retrieval speed, and consistent reaction time, with high acceptability and adaptability. This presents a viable solution to weather-related disruptions in traditional hanging methods. Ultimately, utilizing the automated clothesline retriever in the daily lives of Filipinos addresses the needs of residents facing challenges with retrieving hung clothes outdoors due to unpredictable weather conditions.**

Keywords: Arduino Uno, Light dependent resistor, temperature and humidity sensor, rain sensor, SDG.

I. INTRODUCTION

Characterized by its tropical climate, the Philippines is known for its high temperatures and abundant rainfall (Boquet, 2017) [1]. Surprisingly, there is a city in the Philippines that is vulnerable to climate change which leads to an increase in precipitation, temperature, and tropical storms (Bagtasa, 2019) [2]. With that, Bagtasa (2019) added that weather can be bothersome to people drying their clothes outdoors because of unexpected rain (Rajalakshmi et al., 2020) [3]. The unexpected rainfall is inconvenient for residents, especially those who are working away from home and are unable to respond quickly to sudden weather changes (Baruti et al., 2019) [4].

Several studies and projects were done to innovate the traditional outdoor method of drying clothes. In 2020, Rajalakshmi et al. developed a smart outdoor clothes-hanging system, equipped with sensors to autonomously detect atmospheric conditions, rain, and sunlight. The system efficiently provides shelter for clothes when raining and automatically extends them when it is sunny, ensuring optimal protection and convenience. In another study, Ahmmad et al. (2020) [5] presented an automated retractable roof system with humidity, UV, rain, and temperature sensors, accessible through a smartphone application. This innovative system enables users to control the retractable roof automatically or manually, ensuring effective protection for laundry from rain based on real-time weather parameter monitoring. Furthermore, Latif et al. (2021) [6] conducted a study on the S.M.A.R.T Automated Clothesline (SAC) prototype system, featuring an innovative rain sensor module. The SAC system automatically retrieves or releases clotheslines based on real-time weather conditions, retrieving them during rain and releasing them when the weather turns sunny. Similarly, Atsiq et al. (2022) [7] developed an automated clothes-drying system integrated with both a rain sensor and a light-dependent resistor (LDR) that uses these sensors to detect weather conditions. When the light sensor registers brightness, the clothesline will extend outward. Conversely, if the rain sensor detects moisture, the clothesline will retract inward. In yet another study, Wijaya et al. (2022) [8] developed a mobile app-monitored automatic clothes retriever (ACR) using the ESP32 as the central controller, complemented by sensors such as LDR, rain sensor, limit switch, motor, fan, and heating lamp. The ACR system autonomously adjusts the position of the hanger stand based on real-time weather conditions,

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retrieving the clothes during rainy weather, and protracting it during sunny weather.

In the Philippines, Arimado et al. (2022) [9] successfully developed a solar-powered automatic clothesline retriever, enhancing the conventional galvanized iron system with improved functionality and convenience, all powered by renewable energy. The system, driven by an Arduino Uno, autonomously retrieves clothes when specific conditions align, including reaching a programmed darkness level in the light-dependent resistor (LDR), rain sensor detecting moisture, and sensitivity of the smoke sensor to detect gas and smoke. Furthermore, in the context of innovative clothesline retrieval systems, utilizing artificial UV light poses a promising feature. Artificial UV light as an insect repellent is supported by the study of Marasini et al. (2021) [10], which highlights the effectiveness of artificial UV light in sterilizing clothes as they dry, effectively killing germs, bacteria, and other pathogens. Additionally, Brown et al. (2020) [11] found that clothes exposed to UV radiation remain safe from fabric damage if exposed for only 10 minutes. Therefore, utilizing artificial UV light within a specified range is effective as a disinfectant and will not result in fabric discoloration.

Previous studies have shown significant strides in addressing challenges related to automatic retrieval clothesline systems. The existing gaps include the absence of an IoT-based monitoring system using Blynk for real-time information on humidity, temperature, date, time, and rainfall status; the lack of Short Message Service (SMS) for configuration status; the lack of insect or bug repellents in their drying system; and the need for improved retrieval speed. Thus, this research fills the existing gaps by designing and developing an automated solar-powered IoT-based Blynk clothesline retriever with SMS status updates. To put it simply, the proposed system was innovated into a solar-powered setup, integrating artificial UV light, Internet of Things (IoT), and Blynk to provide real-time weather updates, as well as configuration status using SMS.

Specifically, it aimed to: (1) design an automated solar-powered IoT-based Blynk clothesline retriever with SMS status update; (2) develop a program logic for the prototype; (3) test the functionality of the automated clothesline in terms of mass, speed of retrieval, reaction time; (4) determine the different speed of retrieval and reaction time when there is no load and maximum load; and (5) evaluate the level of acceptability and adaptability of the automated clothesline. In today’s increasingly busy world, where tasks constantly vie for our attention due to high demands on our presence and focus, even simple chores like retrieving clothes can become inconvenient, especially with the increasingly unpredictable weather patterns caused by climate change. The automated solar-powered IoT-based Blynk clothesline retriever with SMS status updates addresses this inconvenience by saving time, effort, and the need to be physically present, which is particularly beneficial given the unpredictable weather conditions affecting traditional clothesline hanging methods in the Philippines. Aligned with Sustainable Development Goal (SDG) 9, the system utilizes IoT technology and solar power to provide a reliable and automated solution. This not only minimizes disruptions to daily routines but also promotes sustainable practices by harnessing the nation's abundant solar resources. By fostering innovation and contributing to economic growth, the project aligns with SDG 9's goal of building resilient and inclusive infrastructure, ultimately paving the way for a more sustainable future in the

II. MATERIALS AND METHODS

This section thoroughly summarizes the resources utilized in the study and the approaches that the researchers carefully selected to ensure the study's success. The materials included a variety of objects, including tools, resources, and equipment, that are essential for carrying out different parts of the research. Moreover, the methodologies also described the researchers' methodical strategy for guaranteeing the accuracy and consistency of the study's conclusions. These procedures, methodologies, and protocols were customized to meet the goals of the study and guarantee a methodical and rigorous approach to doing research.

2.1 Materials

The development of the Automated Solar- Powered IoT-Based Blynk Clothesline Retriever with SMS Status Updates necessitated a varied array of components, including the Arduino Uno microcontroller, rain sensor, Light-Dependent Resistor (LDR), Temperature and Humidity sensor (DHT11), relay, buck converter, DC motor, dual H-bridge motor driver, solar panel, artificial UV light, and 12V battery. These elements were integrated into a framework constructed from square steel tubing, fastened securely with heavy-duty screws, drywall anchors, and washers. Complementary structural elements include pulleys, a switch, aluminum rods, PVC end caps, and a steel base plate. This combination of materials and hardware facilitated the automation of the clothesline retriever, offering a unique and environmentally friendly solution with SMS status updates.

2.2 Research Design

The Research and Development (R&D) design was used for this research as it provided a concise yet comprehensive methodology for creating and evaluating a program (Kenton, 2024) [12]. The process started with planning and designing the program, followed by development. Then, construction

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happened, where the program was put into action according to the designed specifications. Pilot testing was conducted afterward to check if the program worked well and was effective in a controlled setting. After making necessary adjustments, the program was finalized, ensuring it was ready for broader use. Finally, an evaluation phase was carried out to assess the program's results and impact, providing useful insights for potential improvements or future versions.

2.3 Procedure

This study encompassed four (4) crucial stages: Designing, Developing, Testing, and Evaluating. In the Designing phase, it laid focus on assembling the materials required. Following this, in the Developing stage, the program logic for the prototype was crafted to ensure seamless operation and integration with the IoT platform Blynk enabling remote weather monitoring and SMS configuration status. Subsequently, the Testing phase involved thorough examination and validation of the prototype's functionality. Lastly, in the Evaluation phase, the prototype's performance was critically assessed against predetermined criteria, identifying any areas for improvement.

2.3.1 Designing the Automated Solar-powered IoT-based Blynk Clothesline Retriever with SMS Status Updates

The researchers constructed a sturdy frame for the automated solar-powered clothesline system, prioritizing dimensions, and structural integrity, using square steel tubing, heavy-duty screws, drywall anchors, washers, aluminum rods, PVC end caps, and a steel base plate. Following this, the researchers strategically positioned the solar panel in an area with direct sunlight, securing it with optimal angling for maximum energy absorption. The assembly process involved connecting the solar charge controller to the dual H-bridge motor driver and incorporating various hardware components onto the frame, including the rain sensor, raindrop sensor module, LDR, DHT11, relay, DC motor, artificial UV light, and other elements, adhering to the updated circuit diagram provided with the design.

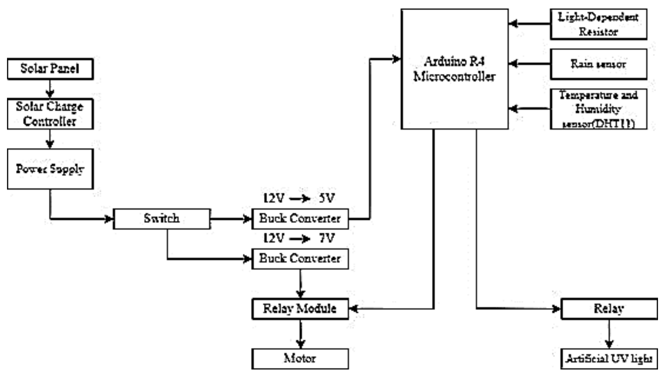

Figure 1: Block Diagram

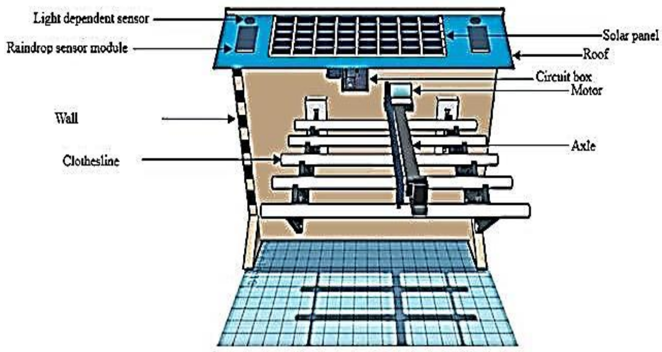

Figure 2: Prototype Design (Front view)

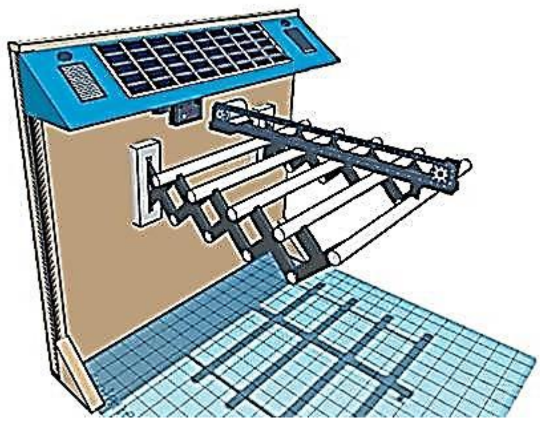

Figure 3: Prototype Design (Isometric view)

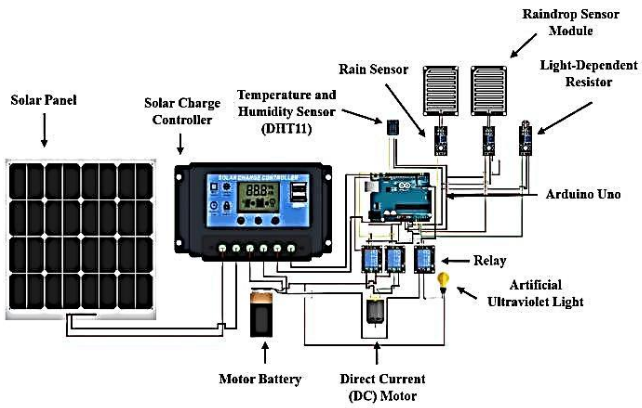

Figure 4: Circuit Diagram

2.3.2 Developing the Program Logic for the Prototype

The researchers developed a code for the automated clothesline retrieval system, utilizing the Arduino Uno microcontroller and implementing algorithms. The light sensor would determine the intensity of light in the environment, the rain sensor would determine the presence of the rain, and the humidity and temperature sensor would determine the intensity of humidity in the surroundings. As shown in Figure 4 below, the Arduino Uno microcontroller was programmed to satisfy the following conditions. If one of the conditions was satisfied, the Arduino Uno would send a command to the relay

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system, enabling the motor to retract or protract. This action enabled the IoT Blynk to send an update to the end-user.

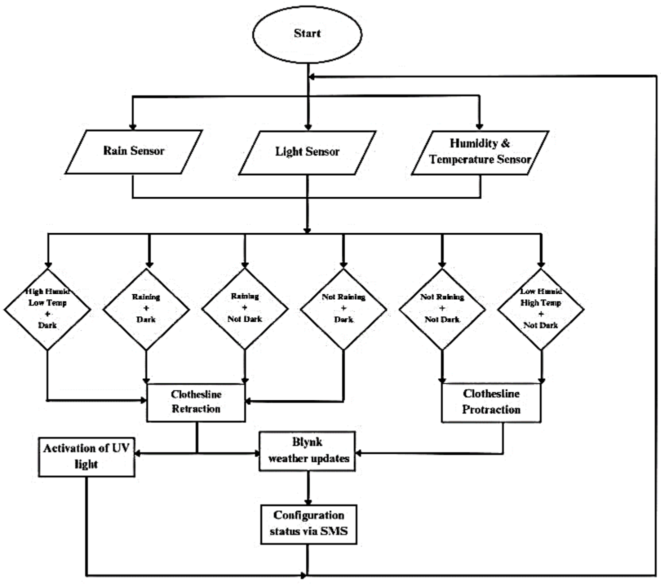

Figure 5: System Flow for the Prototype Function

2.3.3 Testing the Functionality

The researchers tested the functionality of the prototype in terms of its mass handling capability, speed of retrieval, and reaction time. The mass handling capability of the prototype was assessed using a weighing scale. The average speed of retrieval was measured by timing how long it takes to retrieve an item from the prototype. The average response time was assessed using the set codes in the program logic. This stage in the development process is crucial as it ensures that the prototype fulfills the requirements of the users and achieves success in practical application.

2.3.3.1 Mass Handling Capability Test

The researchers conducted ten (10) trials to evaluate the system's mass-handling capabilities and test its functionality in terms of mass. The prototype's threshold value on an artificial wall is set at 20.3kg. In these trials, different loads were applied to the system. Thus, the researchers gradually increased the weight of the load in every trial to assess the capacity of the clothesline to support different weights. Each load was first measured by a weighing scale and then placed on the prototype. If the system reaches its maximum weight capacity, signs such as difficulty to retract and protract indicate nearing the maximum capacity.

2.3.3.2 Retrieval Speed Test

The researchers installed the clothesline retriever outdoors with the clothes spread evenly across the line to test the average speed of retrieval. The system was then activated, and the time taken for the prototype to retract was recorded using a stopwatch/recorder. The test was repeated over the course of ten (10) trials both with the prototype having no load and maximum load.

2.3.3.3 Reaction Time Test

The researchers conducted a series of trials to evaluate the prototype's functionality in terms of reaction time. The prototype's reaction time was measured by utilizing the features provided by the Blynk application, as the system automatically notified the user of its reaction time upon detecting the signals. Furthermore, to confirm the accuracy of the Blynk application, the researchers checked the set codes in the program logic. This process was repeated ten (10) times with the prototype under no load and maximum load to ensure reliability.

2.3.4 Evaluation of Acceptability and Adaptability

The evaluation of acceptability and adaptability was a critical aspect of this research process as it helped the researchers identify weaknesses that are beneficial in improving the prototype. This evaluation would be helpful in understanding the level of viability and impact of such innovation on society.

2.3.4.1 Respondents and Sampling Technique

The prototype was evaluated by experts selected through purposive sampling. The respondents were: (a) degree holders in engineering (preferably electronics and communications engineering); (b) employed and practicing the engineering profession for at least three years; and (c) residing in Region XII, Philippines.

2.3.4.2 Research Instrument

The researchers utilized a 5-point Likert scale self-made questionnaire consisting of 2 sections with 17 questions in total. The first section contains the level of acceptability of the prototype which rates the overall user experience towards the prototype as well as its design. The second section assesses the level of adaptability of the prototype given that there are changes in the environment as well as its ease of use and navigation. The instrument was validated through pilot testing by experts to ensure its reliability and validity.

2.4 Data Analysis

The researchers used a weighted mean interpretation adapted from Vagias (2006) [13], as demonstrated in Table 1, in analyzing the acceptability and adaptability of the automated clothesline system prototype. Microsoft Excel was used for analysis, allowing easy data entry and calculation of

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weighted means. Data collected included ratings from the evaluators, on a Likert scale, regarding the system's acceptability and adaptability. Lastly, a paired t-test was utilized as the study's statistical inference to determine if there is a significant difference between the retrieval speed and reaction time of the prototype with no load and maximum load.

Table 1: Table of Interpretation

Range	Description	Interpretation
4.50-5.00	Extremely Likely	Very High Level of Acceptability
3.50 - 4.49	Likely	High Level of Acceptability
2.50 - 3.49	Neither	Moderate Level of Acceptability
1.50 - 2.49	Unlikely	Low Level of Acceptability
1.00 - 1.49	Extremely Unlikely	Very Low Level of Acceptability

2.5 Ethical Consideration

The researchers adhered strictly to established research protocols throughout this study. A permission letter was written to the principal to request approval for conducting the study. Additionally, the researchers prepared a consent letter for the evaluators and professionals, seeking their explicit approval and ensuring they understand the voluntary, private, and confidential nature of their participation. The evaluators were also informed that the data collected would be used solely for academic purposes and treated with the highest level of confidentiality. Moreover, the research was conducted with integrity and free from any plagiarism.

III. RESULTS AND DISCUSSIONS

The data collected were analyzed and interpreted after the functionality testing and evaluation of the prototype. Thus, this section presents the graphical, tabular, and narrative forms of the results of the study and their corresponding implications. Additionally, this section also presents the discussions of the results supported by different research studies.

3.1 Design of the Prototype

The researchers successfully designed an automated solar-powered IoT-based Blynk clothesline retriever with SMS status updates. Firstly, the construction began with building the clothesline using square steel tubing, aluminum rods, and PVC end caps to provide support and rigidity to the frame of the clothesline. Secondly, a sturdy foundation-like wall was constructed to support the attachment of the clothesline. Thirdly, a steel base plate was mounted at the bottom of the foundation-like wall to provide support to the overall prototype. Fourthly, pulleys were mounted near the DC motor and at the other end of the clothesline to guide the clothesline, facilitating retraction and protraction. Lastly, a roof was attached to the upper part of the foundation like-wall to provide coverage.

Figure 6: Prototype Design (Front view)

Figure 7: Prototype Design (Isometric view)

3.2 Program Logic

As the sensors reach a set threshold value upon detection of external stimuli such as rain, light, temperature, and humidity, they will send a signal to the Arduino Uno R4 WiFi, which then communicates the update to the Blynk application. The system processes this information to determine the appropriate action for the prototype, whether to retract or protract. The Blynk application will then provide real-time information on the changes in data sensed by the rain sensor, light-dependent resistor, temperature sensor, and humidity sensor as presented in figure 7. Moreover, when the clothesline retracts, the code programmed in the Arduino Uno microcontroller commands the UV light to turn on within a ten (10) minute timeframe and turns off when the clothesline retracts. Additionally, the user receives an SMS notification depending on the received stimuli and action taken by the prototype.

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```
void loop()
{
  Blynk.run();
  sendSensor();
  light();
  rain();
  check();
}

void setup()
{
  //THIS FUNCTION RUN ONLY ONCE
  // Debug console
  Serial.begin(9600);
  pinMode(relay,OUTPUT);
  pinMode(relay1, OUTPUT);// set pin as output for relay 1
  pinMode(relay2, OUTPUT);// set pin as output for relay 2
  // keep the motor off by keeping both HIGH
  digitalWrite(relay1, HIGH);
  digitalWrite(relay2, HIGH);
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
  //UPON TURNING ON THE SWITCH THIS CODE WILL FIRST SCAN IF ITS RAINING,CLOUDY,DARK,AND IF ITS SUNNY.
  //IT WILL SCAN FOR TEN SECONDS THEN IT WILL DO ITS TASK WITH THE GATHERED DATA
  digitalWrite(relay, HIGH);
  dht.begin();
  light();
  rain();
  sendSensor();
  check();
  //TEN SECONDS DELAY FOR SCANNING
  delay(10000);
}
```

Figure 8: code

3.2.1 Blynk Application with SMS notification

When stimuli is detected by the sensors, the Blynk application automatically provides the user an SMS notification regarding on the action taken by the prototype, whether it retracted or protracted. Additionally, it also presents real-time data base on the stimuli detected by the sensor, when it is raining, there are changes in light levels, humidity, and temperature.

Figure 9: Function of the Application

3.3 Functionality Test of the Prototype

The researchers conducted a series of tests in assessing and evaluating the functionality of the prototype. These tests aimed to evaluate the prototype's capability to handle its different weights, its speed in retrieving clothes, and its reaction time under various conditions. Moreover, this section presents the results of the functionality testing of the prototype in both tabular and narrative form, along with its implications and discussions, supported by different research studies.

Table 2: Functionality Test for the Prototype

No.	Components	Functional	Not Functional
1	Arduino Uno R4	/	
2	Light-Dependent Resistor	/	
3	Rain Sensor (2 pcs)	/	
4	Raindrop Sensor Module (2 pcs)	/	
5	Temperature and Humidity Sensor (DHT11)	/	
6	Artificial UV light	/	
7	Motor	/	
8	Solar Charge Controller	/	
9	Solar Panel	/	
10	Buck converter (12V-5V)	/	
11	Buck Converter (12V-7V)	/	
12	Relay Module (2 pcs)	/	
13	Switch	/	

Table 2 presents the results of the functionality test conducted for the prototype of an automated solar- powered IoT-based clothesline retriever with SMS status updates. The test assessed the functionality of various components essential for the system's operation. Overall, all the components of the system listed in the table were found to be fully functional, as indicated by the absence of any "Not Functional" entries under the functional column. This denotes that all individual components of the prototype's system, including the Arduino Uno R4, Light-Dependent Resistor, rain sensors, raindrop sensor modules, temperature, and humidity sensor (DHT11), artificial UV light, motor, solar charge controller, solar panel, buck converters (12V-5V and 12V-7V), relay modules, and switch, were operational and capable of performing their intended functions. The absence of any non-functional components signifies that the functionality testing of the prototype was successful, indicating that the prototype is ready for further testing and deployment in the real world as a feasible innovation for the community. In conclusion, the functionality test results of the prototype demonstrate its preparedness for real- world adaptation, highlighting its promising potential to address the problem of unpredictable weather changes in the Philippines.

3.3.1 Mass Handling Capability Test Results

This section presents and discusses the results of the mass handling capability test of the prototype. The gathered data were from the conducted 10 trials with different numbers of loads and their corresponding weights for each trial.

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Table 3: Results of the Mass Handling Capability Test

Trial no.	Load (pcs of medium-sized clothes)	Mass (kg)
1	8	5.6
2	11	7.7
3	14	9.8
4	17	11.9
5	20	14.0
6	23	16.1
7	26	18.2
8	29	20.3
9	32	22.4
10	35	24.5

Table 3 presents the results of mass handling capability of the prototype. It was evident that the prototype underwent rigorous testing to determine its lifting capacity. Each load in the tests was standardized to a mass of 0.7 kg. Among the tests conducted, trial 9 exhibited the highest capacity handling of the prototype, successfully retracting and protracting 32 loads totaling 22.4 kg. This indicated the maximum load the prototype can handle effectively. However, trial 10 highlighted a limitation of the prototype. Despite handling a total mass of 22.4 kg, the prototype successfully retracted and protracted. However, when the load reached 32 pieces of clothes, it did not accommodate the additional loads, indicating its inability to manage higher loads beyond this amount. Therefore, the threshold value for load was 29 pcs of medium-sized clothes or 20.3 kg. Furthermore, these findings emphasized the importance of understanding the limitations of the prototype under different load conditions. While it demonstrated lifting capabilities, there was a clear threshold beyond which its functionality was compromised. Hence, careful consideration must be given to the intended application and load requirements when utilizing this prototype in practical scenarios.

These findings also emphasize the necessity of testing the mass handling capability to know the mass capacity of the prototype. According to Petersen et al. (2017) [14], testing the mass handling capability was necessary for a prototype to achieve large mass transfer coefficients. Additionally, as noted by Wang et al. (2019) [15], the performance of lifting prototypes can vary significantly depending on factors such as load distribution, structural integrity, and mechanical efficiency. Furthermore, the study of Arkadii et al. (2020) [16] stated that it was crucial to conduct testing under various conditions to verify the limits and capabilities of the prototypes. Finally, carefully evaluating the intended use and load requirements of the prototypes before deployment is important. Failure to account for these factors could result in poor performance or even pose safety hazards in practical scenarios.

3.3.2 Retrieval Speed Test Result

This section presents and discusses the results of the retrieval speed of the prototype under both no- load and maximum-load conditions. The data collected were from 10 trials each for no load and maximum load conditions.

Table 4: Results for the Retrieval Speed

Test no.	Speed (m/s) (No load)	Speed (m/s) (Max Load = 22.4 kg)
1	0.23	0.23
2	0.23	0.23
3	0.23	0.22
4	0.23	0.22
5	0.23	0.23
6	0.23	0.23
7	0.23	0.23
8	0.23	0.23
9	0.23	0.23
10	0.23	0.22
Mean	0.230	0.227
t-value	1.964	
p-value	0.081	

Table 4 presents the results of retrieval speed of the prototype. Taking into consideration that the length of the clothesline is 0.965 m, without any load, the speed remains consistent at 0.23 m/s across 10 test trials. However, under a maximum load, variation in speed is observed at 0.23 m/s during the first, second, fifth, sixth, seventh, eight, and ninth trials, while the lowest speed of 0.22 m/s occurs during the third, fourth, and tenth trials. The mean speed without load remains at 0.23 m/s, while the maximum load is 0.227 m/s due to the slight differences in the speed of each trial. However, the calculated t-value is 0.081, and the p- value is 1.964, indicating no significant difference in retrieval speed between no load and maximum load conditions.

The calculated t-value and p-value also suggest that the presence or absence of a load does not significantly impact the speed of prototype retrieval. The retrieval speed testing is necessary, as highlighted by Ashiwini et al. (2016) [17], who emphasized that different loads could affect motor speed. With that, conducting tests on retrieval speed is essential to guarantee that the motor can effectively adapt to various load conditions. However, the outcomes of the tests confirm the stability of the design of the prototype and its ability to perform, especially in terms of retrieval speed, which remains unaffected by changes in load conditions. This suggests that the functionality of the prototype remains reliable across varying load scenarios.

3.3.3 Reaction Time Test Result

This section presents and discusses the results of the reaction time testing for the prototype under no load and maximum load conditions. The researcher used the data

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gathered from the 10 trials for no load and 10 trials for maximum load.

Table 5: Results for the Reaction Time

Test no.	Time (s) (No load)	Time (s) (Max Load = 22.4 kg)
1	1.0	1.0
2	1.0	1.0
3	1.0	1.0
4	1.0	1.0
5	1.0	1.0
6	1.0	1.0
7	1.0	1.0
8	1.0	1.0
9	1.0	1.0
10	1.0	1.0
Mean	1.0	1.0
t-value	0.000	
p-value	1.000	

Table 5 presents the results of the reaction time test conducted for the prototype, including the t- value and p-value. The results demonstrate a consistent reaction time of 1 second under both no-load and maximum-load conditions, with a calculated t-value of 0 and a p-value of 1. This p-value exceeding the significance level of 0.05 indicates a lack of statistically significant difference in the system's reaction time across varying loads.

This statistically non-significant difference in reaction time ($p > 0.05$) suggests that the system's performance was not adversely affected by varying load weights. Testing the reaction time of the system in different conditions was important to ensure its effectiveness and reliability (Hew et al., 2022) [18]. The system's 1-second reaction time, recorded and observable through the loop function of the code, further highlights its efficiency. In real-world scenarios, a fast reaction time would be beneficial to users by minimizing the time clothes are exposed to the elements. By demonstrating a fast and consistent response time, the research establishes a foundation for the usability of the clothesline retriever.

3.4 Levels of Acceptability and Adaptability

The results of the pilot tests show that the level of acceptability yielded a cronchbach's alpha of 0.94, while the level of adaptability yielded a cronchbach's alpha of 0.88 indicating that the questionnaire is indeed reliable. Moreover, the prototype's level of acceptability and adaptability were evaluated using the aforementioned questionnaire, by experts in the field of engineering under predetermined criteria to assess the prototype's viability as an innovation for the community. Furthermore, the results of the evaluation are presented in the tables below along with its discussion and implications.

Table 6: Results for the Acceptability of the Prototype

Item no.	Indicator	Mean	Standard Deviation	Interpretation
1	Understanding the functionality of the prototype was easy	4.40	0.55	High Level of Acceptability
2	I am satisfied with the performance of the prototype.	4.60	0.55	Very High Level of Acceptability
3	I am likely to recommend this prototype to others.	4.60	0.55	Very High Level of Acceptability
4	The prototype was intuitive and easy to use.	4.60	0.55	Very High Level of Acceptability
5	The prototype design/layout is intricate and well- thought-out.	4.20	0.45	High Level of Acceptability
6	The wire management of the prototype is satisfactory	4.40	0.55	High Level of Acceptability
7	The features of the prototype are relevant to its purpose.	4.40	0.55	High Level of Acceptability
8	The different parts of the prototype are easy to navigate.	4.20	0.45	High Level of Acceptability
9	Overall, I am satisfied with the prototype.	4.40	0.55	High Level of Acceptability
	Weighted Mean	**4.40**		**High Level of Acceptability**

Table 6 indicates the results of a high level of acceptability for the prototype among the evaluators. Overall, evaluators strongly agreed that they were satisfied with its performance (M= 4.60, SD= 0.55), and intuitiveness and ease of use (M= 4.60, SD= 0.55), indicating that the prototype was highly functional and user-friendly. Additionally, the evaluators indicated a strong likelihood of recommending the prototype to others (M= 4.60, SD= 0.55) denoting that the prototype was promising and commendable. Although the results for the design's intricacy and navigational ease were slightly lower (M= 4.20, SD= 0.45), the evaluators generally agreed that the prototype's design was well thought-out and its different parts were easy to navigate, implying the need for improvement in the prototype's design. Finally, the overall weighted mean of 4.40 implied a high level of acceptability, pointing to promising potential for its adoption.

The results for the overall performance of the prototype, its ease of use, and its likelihood of recommendation to others were high. This indicated that the prototype can be used effortlessly by anyone in the community and was viable for use in the real world. Moreover, prioritizing the prototype's overall performance and ease of use was crucial for any product or prototype, as stated in the study by Catenazzo and Paulssen (2020) [19], where prototype defects concerning performance and ease of use damage overall quality perceptions and its likelihood for recommendation. Furthermore, the studies of Yassine (2021) [20] and Zhang and Thomson (2019) [21] highlight the need for improvement in the prototype's design because a well-thought-out design decreases the complexity of the prototype, thereby making it easy to navigate its different parts. Lastly, as stated in the study of Meyer et al. (2020), it is crucial for emerging technologies such as this prototype to receive high acceptability because of the factor it plays in the perception of users towards the prototype and user experience.

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Table 7: Results for the Acceptability of the Prototype

Item no.	Indicator	Mean	Standard Deviation	Interpretation
1	The prototype can easily be adjusted to fit different user needs.	4.20	0.55	High Level of Adaptability
2	It is easy to add new features or functions to the prototype.	4.00	0.55	High Level of Adaptability
3	Users can change settings or how the prototype works without trouble.	4.00	0.55	High Level of Adaptability
4	The prototype can keep up with new trends or technology changes.	4.40	0.55	High Level of Adaptability
5	Users can make the prototype fit different places or conditions.	4.40	0.45	High Level of Adaptability
6	Putting together or taking apart the prototype is simple and doesn't need special tools.	4.20	0.55	High Level of Adaptability
7	The prototype's materials are strong and can handle different kinds of weather.	4.40	0.55	High Level of Adaptability
8	Storing, moving, and using the prototype in different places is easy.	4.40	0.45	High Level of Adaptability
	Weighted Mean	4.25		High Level of Adaptability

Table 7 indicates the results of a high level of adaptability for the prototype among the evaluators. They were particularly impressed with its capacity to keep pace with evolving trends and adapt to various locations and conditions (M= 4.40, SD= 0.55), suggesting a good fit with user needs and high versatility. Additionally, high scores for the use of strong materials that withstand weather conditions and the overall convenience for storage, transport, and use across settings (M= 4.40, SD= 0.55) denote the prototype's durability and portability. While the results for accommodating new features (M= 4.00, SD= 0.71), and allowing for easy changes to settings and functionality (M= 4.40, SD= 0.00) were slightly lower, the evaluators generally agreed that the assembly and disassembly of the prototype can be done with ease (M= 4.20, SD= 0.44), indicating a user-friendly design with modular construction. The overall weighted mean score of 4.25 indicates a high level of adaptability and suggests the prototype's overall flexibility and versatility, signifying that the prototype functions effectively and efficiently.

The results in the overall performance of the prototype provide a strong support for the prototype's adaptability in demonstrating compatibility with various user needs and changing weather conditions. By prioritizing flexibility, its dynamic features allow new integration and effortless modification in the prototype, ensuring versatility and practicality in various situations. Moreover, Asaram, (2023) [22] and Waheed, (2023) [23] emphasized the importance of systems to be able to adapt and understand user needs, without disrupting daily life and accommodate the changes in the environment and keep up with new technological changes, as it is critical for successful outcomes, leading to continuous improvement and innovation. Furthermore, Allioui and Mourdi (2023) [24] highlighted that the adaptability of systems ensures reliability and offers versatile solutions across diverse circumstances, thereby contributing to the system's efficacy and practicality.

IV. CONCLUSIONS

The researchers successfully designed and developed an automated solar-powered IoT-based Blynk clothesline retriever with SMS status updates along with its program logic. The prototype was fully functional with its features, showing promising results. The prototype showed promising results with a high maximum capacity of 22.4 kg, denoting the prototype's durability. Furthermore, the prototype exhibited fast retrieval speed which was concluded to not have any significant difference in its speed whether the prototype has no load (M=0.230 m/s) or when it is at maximum load (M=0.227 m/s), indicating that the retrieval speed of the prototype was not affected by the mass and number of loads. Additionally, no significant difference has also been observed throughout the ten (10) trials of the prototype's reaction time when the prototype has no load (M=1.0s) and when it was at its maximum load (M=1.0 s), also denoting that the prototype's reaction time was independent of the load's mass and quantity. Moreover, the results for the prototype's acceptability showed a high level of acceptability among evaluators (M=4.40), signifying that the prototype is highly functional, user-friendly, and viable to be introduced in the community. Lastly, the prototype's adaptability results also revealed a significantly high level of adaptability (M=4.25), designating the prototype's flexibility, durability, and versatility to changes in the environment. Overall, the results showed that the prototype was a viable solution to the country's problem of unpredictable weather changes affecting traditional clothesline hanging methods. The results also denote that the prototype can aid in enhancing productivity by minimizing disruptions caused by unpredictable weather conditions.

V. RECOMMENDATIONS

The conclusions of this study present promising results for the prototype, leading the researchers to recommend its design for future studies. Furthermore, the prototype's program logic was fully functional, which significantly contributed to its overall performance. As such, the researchers also recommend adopting the program logic for future studies and innovations in related fields. Moreover, the prototype demonstrated a high capacity on an artificial wall, leading the researchers to highly recommend constructing it on a sturdy wall to further increase its maximum capacity. Additionally, the prototype's retrieval speed was proven to be fast and independent of the mass and number of loads, prompting the researchers to recommend adopting the prototype's design to achieve similar results for retrieval speed. Furthermore, the researchers recommend adopting the program logic for reaction time to achieve no delay in sensor signal detection. The prototype's acceptability and adaptability show promising results, leading the researchers to recommend

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its introduction in the community as a viable innovation that is user-friendly and highly versatile for any environmental conditions. The researchers recommend adding a curtain or enclosure to the prototype's design to prevent the clothes from getting soaked in areas with strong winds. Additionally, the researchers also recommend extending the clothesline and pulley for the prototype to accommodate more loads. Lastly, the researchers highly recommend adding a manual override function in case the prototype malfunctions.

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