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# An Automated Rain-Responsive Clothes Protection System

In Partial Fulfillment of the Requirements for the Science,
Technology, Engineering, and Mathematics'
Capstone Project

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## INTRODUCTION

This section presents a brief overview of the study which includes the background of the study, the problem of the study, the theoretical framework, the hypothesis, and who will benefit from this study.

### Background of the Study

In regions with unpredictable weather patterns, protecting clothing from unexpected rain is a common challenge faced by many individuals. This issue is particularly relevant for those who hang their clothes outside to dry, as sudden rain showers can quickly ruin them. The need for a practical and efficient solution to this problem has led to the development of automated systems that can detect rain and take immediate action to protect garments. This research aims to design and implement such a system using modern automation technologies.

Manual intervention is often required to protect clothes from rain, which can be time-consuming and inconvenient. In areas with frequent and unpredictable rainfall, this becomes a significant issue. The lack of automated systems to address this problem results in wasted time and resources, as well as potential damage to clothing. Moreover, the traditional method of manually covering or moving clothes during rain is not only labor-intensive but also unreliable, as it depends on human vigilance and prompt action.

Recent advancements in automation technology have led to the development of innovative solutions for rain detection and clothes protection. For instance, projects like the "Automatic RainShield" utilize Arduino Uno, a servo motor, and a rain sensor to create a hands-free rain protection system for clothing (Circuitsbazaar, 2024). Similarly, research by Dr. Dinesh Kumar D S and his team has demonstrated an automatic rain detection and clothing protection system that uses an Arduino Uno, a servo motor, and a rain sensor to move clothes to a protected area when rain is detected (S et al., 2024). Another project, "Automatic Cloths moves in Shed as Rain Detected," employs an Arduino Uno, a rain sensor, and a servo motor to efficiently move clothes from an open area to a sheltered location during rain (*Automatic Cloths Moves in Shed as Rain Detected – Arduino Project*, n.d.).

In the Philippines, a study by Cababan (2024) developed a Battery-Powered Automatic Clothesline Rain Protector to prevent clothes from getting wet during unexpected rainfall. The system utilizes a rain sensor to detect precipitation and automatically deploy a plastic sheet over the clothesline, retracting once the sensor dries. The device is powered by a rechargeable 12-volt battery, ensuring efficiency and reliability. Testing demonstrated the system's capability to promptly cover and uncover clothes based on real-time weather conditions, reducing the need for constant human intervention (Cababan, 2024).

Internationally, similar advancements have been made to enhance the convenience and efficiency of laundry drying systems. A study conducted by (Nopika et al., 2024) introduced an Automatic Clothing Tool Using Rain Sensor and Internet of Things (IoT). This system integrates a rain sensor with IoT technology, allowing real-time monitoring and automated protection of clothes during rainfall. The system features a mechanism that automatically covers or retracts clothes based on weather conditions and sends notifications to users through a mobile application. The study highlights the importance of smart home automation in reducing manual effort and ensuring convenience (Nopika et al., 2024).

These systems highlight the potential of integrating simple electronic components to create practical and efficient solutions for everyday problems. They reduce manual intervention, offer convenience, and provide effective management of outdoor clothing in inclement weather conditions. However, there is still room for improvement, particularly in terms of energy efficiency, user notification systems, and integration with weather forecasting technologies.

This capstone project seeks to contribute to the existing body of work by designing an automated rain-responsive clothes protection system that is not only effective but also energy-efficient and user-friendly. The system will utilize an Arduino microcontroller, a rain sensor, and a servo motor to detect rain and automatically protect clothing. By automating the process of shielding clothes from rain, this project aims to reduce human effort, save time, and prevent damage to garments. Additionally, the project will explore potential enhancements such as integrating solar power for energy efficiency and developing a user notification system to inform users when clothes are moved to a protected area.

**Statement of the Problem**

An Automated Rain-Responsive Clothes Protection System" aims to address the following research problems:

1. How effective is the automated rain-responsive clothes protection system in preventing clothes from getting wet?

a. Clothes are dry

b. Clothes are slightly wet

c. Clothes are soaked

2. How fast can the tarpaulin expand or retract to shelter?

a.15 seconds to 30 seconds

b.30 seconds to 1 minute

c. 1 minute+

3. How does the effectiveness and response time of Automated Rain Responsive Clothes Protection System Compare to traditional clothes drying rack?

a.Effectiveness in keeping the clothes dry.

b.Response on sudden rain fall.

**Hypotheses**

1. How effective is the automated rain-responsive clothes protection system in preventing clothes from getting wet?

a. Clothes are dry

b. Clothes are slightly wet

c. Clothes are soaked

$H_0$: There is no significant difference in the likelihood of clothes remaining dry when using the automated system compared to no protection.

$H_1$: There is a significant difference in the likelihood of clothes remaining dry when using the automated system compared to no protection.

2. How fast can the tarpaulin expand or retract to shelter?

a.15 seconds to 30 seconds

b.30 seconds to 1 minute

c. 1 minute+

$H_0$: There is no significant difference in the response time of the automated system compared to traditional manual methods of protecting clothes.

$H_1$: There is a significant difference in the response time of the automated system compared to traditional manual methods of protecting clothes.

3. How does the effectiveness and response time of Automated Rain Responsive Clothes Protection System Compare to traditional clothes drying rack?

a.Effectiveness in keeping the clothes dry

b.Response on sudden rain fall.

$H_0$: There is no significant difference in effectiveness and response time in protecting clothes between the automated system and traditional clothes drying racks.

$H_1$: There is a significant difference in effectiveness and response time in protecting clothes between the automated system and traditional clothes drying racks.

**Significance of the Study**

This research aims to develop a protection system to address the common issue of sudden rainfall affecting laundry drying. The success of this research can benefit the following:

**Homeowners and Families.** Homeowners will benefit by gaining a reliable solution for protecting their laundry from unexpected rain. This system will enhance convenience, allowing families to dry their clothes outdoors without the constant worry of sudden weather changes, thus promoting efficient use of time and resources.

**Senior Citizens.** Senior citizens can benefit significantly from this system as it reduces the physical effort required to manage laundry during rain. This is particularly important for those who may have mobility issues or find it difficult to respond quickly to changing weather conditions. The automated system ensures that their clothes are protected without needing manual intervention.

**Persons with Disabilities (PWDs).** PWDs can also benefit from the convenience and independence offered by this system. It allows them to manage their laundry more easily, reducing reliance on others for assistance during unexpected rain showers. This enhances their autonomy and quality of life by automating tasks that might otherwise be challenging.

Overall, this study not only addresses a practical problem faced by many but also aligns with global sustainability goals, making it relevant across various sectors and communities.

**Environmental Advocates.** The findings will support environmental advocates in their efforts to promote sustainable practices. By minimizing the need for re-washing clothes due to rain damage, the system contributes to water conservation and reduces energy consumption associated with laundry processes.

**Technology Developers.** Developers and engineers can leverage insights from this study to innovate further in automation technologies. The research provides a foundation for exploring advanced applications in smart home systems, potentially leading to improved designs that integrate seamlessly with existing home automation frameworks.

**Policy Makers.** Policymakers can utilize the results to inform regulations and incentives that encourage the adoption of smart home technologies focused on sustainability. By promoting innovations like the automated rain-responsive system, they can contribute to broader environmental goals and support initiatives aimed at reducing household energy consumption.

**Local Communities.** The implementation of such a system can stimulate local economies by creating demand for related products and services, such as installation and maintenance of automated systems. This can lead to job creation and foster community engagement in sustainability efforts.

**Researchers and Academics.** This study will serve as a valuable resource for researchers interested in automation and environmental sustainability. It opens avenues for further research into the integration of renewable energy sources, such as solar power, into automated systems, fostering advancements in eco-friendly technology.

Overall, this study not only addresses a practical problem faced by many but also aligns with global sustainability goals, making it relevant across various sectors and communities.

## REVIEW OF RELATED LITERATURE AND STUDIES

This chapter aims to discuss the review of related literature and review of related studies for, “An Automated Rain-Responsive Clothes Protection System”. The conceptual framework is also utilized to demonstrate the relationship between these ideas and how they relate to the research topic.

### Related Literature

The development of automatic clothes protective and drying system to react to weather factor has been addressed in some recent works. A striking case in point is provided by the investigation of S et al. (2024), “Rain detection and protection system for cloths.” This paper presents a solution that uses Arduino UNO, servo motor and rain sensors in detecting rainfall and automatically moving clothes to an area cover against the rain. The process is reversed when the rain stops and the clothes are delivered back to their original position. The low cost, energy efficient and ease of operation of the system are highlighted in the study.

On the basis of a like setting, Atsiq et al. (2022) entitled “Automated Drying of Clothes Using Rain Sensors and LDR Sensors”. Their device couples rain and light sensors to a motorized clothesline. It pulls the garment indoors when it starts to rain, and deploys it again once the sun emerges. The automation is accomplished using an H-Bridge circuit for both motor control and Arduino code, for smooth and efficient operation.

Another example is given by 成岗 (2013) about an intelligent device for a rainproof cloth which covers outdoor drying racks with humidity and photometric sensors. Worked,Easy Install: The tub covers opened, retracted automatically according to weather factor, remote settings manually control, so you can use  it in all weathers.

Also, Tejass Publisheers (n.d.) describes a motor driven water sensing auto folding laundry hanger. This system is constantly checking for rain and will automatically pull your drying rack back when rain comes to save the hassle without having to remember as you  now can live your life and worry when it actually rains.

Finally, attentions the performing design, “Rain Water Detection and Automatic Clothes Retrieval Machine” (IJCRT, 215) is developed that the screen of a wet clothes from the outdoors extreme environment due to the mechanical activation to controlled by the electrical power supply. When the rain stops, the machine will autonomously redeploy the clothes outside. The mechanism also includes limit switches to avoid over-rotation for the sake of efficiency as well as safety.

Collectively, these studies demonstrate the growing use of sensor-based, automated systems for drying and protecting laundry. By utilizing microcontrollers, sensors, and motorized systems, these systems provide functional, energy-saving, and easy-to-use methods for handling laundry under different weather conditions.

**Related Studies**

A research of Sulaiman et al. (2023) entitled, "Automated Clothesline Retrieval System" presents the development of an Automated Clothesline Retrieval System aimed at addressing challenges associated with drying clothes outdoors in regions with unpredictable weather conditions. The system integrates rain monitoring capabilities and push notification features to enhance user convenience. Utilizing sensors to detect rainfall, the system automatically retracts the clothesline to a sheltered area, thereby protecting the laundry from getting wet. Additionally, it sends real-time notifications to users, informing them of the change in weather and the system's response. The prototype was constructed using an Arduino microcontroller, rain sensors, and a motorized mechanism for clothesline movement. Testing demonstrated the system's reliability in detecting rain and executing the retrieval process promptly. The authors suggest that this automated solution can significantly improve the efficiency of laundry management, particularly in equatorial regions where sudden weather changes are common.

Additionally, the study, "Design and Development of SMART Automated Clothesline" (Latif et al. 2021) introduces the SMART Automated Clothesline, an innovation equipped with a rain sensor module designed to automatically retract and extend clotheslines in response to changing weather conditions. The primary aim is to assist individuals in managing their laundry during unpredictable weather, preventing clothes from becoming damp due to rain. The system utilizes a microcontroller that processes input from the rain sensor to control the movement of the clothesline. Upon detecting rain, the sensor signals the microcontroller, which then activates a motor to retract the clothesline under a sheltered area. Conversely, when favorable weather conditions are detected, the system extends the clothesline for optimal drying. The research encompasses the design, development, and testing of a prototype, demonstrating the system's effectiveness in automating the protection of laundry from adverse weather. The authors conclude that the SMART Automated Clothesline offers a practical solution to enhance daily household chores, particularly in regions with unpredictable weather patterns.

Moreover, “Automatic Clothing Drying Using Rain Sensors and Ldr Sensors Based on Arduino UNO” (Astiq et al. 2022) is proposed to use an Arduino Uno microcontroller, a rain sensor, and an LDR (Light Dependent Resistor) sensor to detect weather conditions and retract a clothesline when rain or low light levels are detected. The use of an Arduino Uno in their system demonstrates its suitability for controlling automated mechanisms, supporting our decision to use a similar microcontroller in our project. Their implementation of a rain sensor aligns with the "rain-responsive" aspect of our system, confirming its effectiveness in detecting rainfall and triggering protective actions.

Finally, the study “Automated Solar-Powered IoT-Based Blynk Clothesline Retriever with SMS Status Updates” (Basan et al. 2024) contains a solar-powered setup, which utilizes solar panels to provide energy for the system's operation. This sustainable design reduces reliance on external electricity sources and aligns with global efforts toward energy efficiency and environmental sustainability. While our project focuses on rain-responsive protection mechanisms, adopting solar power could be a valuable addition for future iterations to improve energy efficiency.

**Conceptual Framework**

The "An Automated Rain-Responsive Clothes Protection System" is designed to address the issue of sudden rainfall affecting clothes hung outdoors for drying. The system operates through an automated mechanism that detects rain using sensors and triggers a motorized cover to protect the clothes. The researcher employed the input-process-output (IPO) method. The conceptual Paradigm showed that at the input stage, the researchers thought of what statements of the problem are in order to determine how effectively the Automated Rain-Responsive Clothes Protection System device prevents clothes from getting wet. Then at the process stage, the researchers will proceed with the data gathering done through survey questionnaires.And the final stage Output, the researchers are to sum up the gathered data and come up with a conclusion.

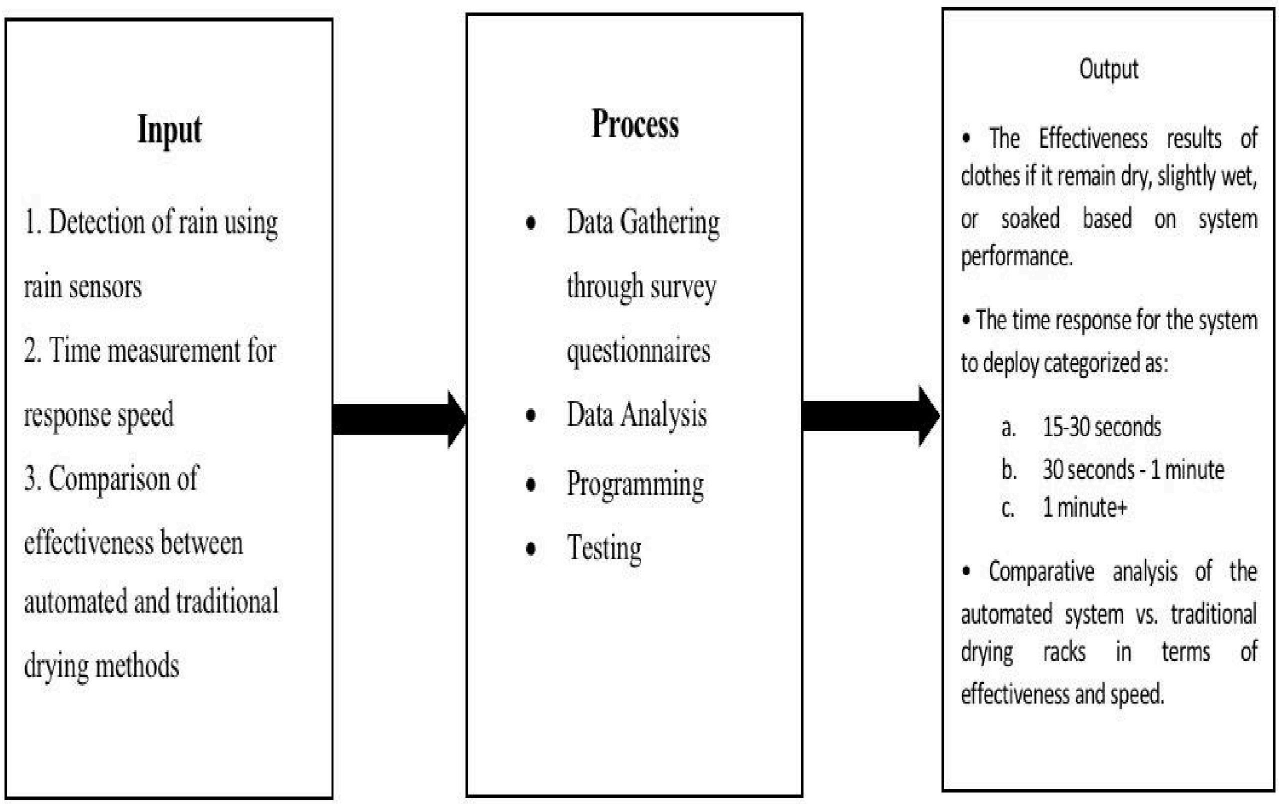


**Figure 1.** *Conceptual Paradigm*

## RESEARCH DESIGN AND METHODOLOGY

### Research Design

This study will involve a mixed-methods approach, combining qualitative and quantitative elements. Quantitatively, the performance of the automated rain-sensitive clothes protector system is measured by quantifiable outcomes, such as the amount of clothes that are dry, half-wet, or wet in instances of rain events, and the reaction time of the system (categorized in terms of seconds). Qualitatively, participant experience and observation will be received in the form of detailed feedback on satisfaction with the device, how easy it is to use, and overall performance as compared to traditional methods. The mixed-method approach enables extensive testing of the system's performance, supplementing the quantitative data with individual users' comments to inform future upgrades and user interface.

### Setting and Respondents of the Study

This study will be conducted at Tektone Village, Legazpi City, focusing on homeowners. A purposive sampling method will be used to select 10 respondents. These respondents will provide insights into the effectiveness of the automated rain responsive clothes protection system.

### Sampling Method

In this study, the researchers will use purposive sampling to select participants. This method was chosen to ensure that data will be collected from individuals who would directly benefit from a system designed to protect clothing from rain when the owner is unavailable or unable to attend to their laundry immediately. To simplify the selection process, the researchers will focus on participants who met specific criteria, such as homeowners, families, senior citizens, and persons with disabilities (PWDs). By targeting these groups, the study will aim to gather relevant insights into the practicality, usability, and overall effectiveness of the system.

While purposive sampling allows for a focused and relevant participant group, the researchers acknowledge its limitations. Since the study only includes individuals who meet the predefined criteria, the findings may not fully represent all potential users. However, given the study's objective of assessing accessibility, convenience, and efficiency, purposive sampling remains the most suitable method for gathering meaningful data that can contribute to the development of a functional and user-friendly rain-responsive clothes protection system.

**Statistical Analysis**

The following statistical tools were used to compute, analyze, and interpret the data gathered in this study.

*Mean*. This was used to find the average rating of the respondents to the Automated Rain-Responsive Clothes Protection System and traditional drying rack.

This mean is computed using the formula:

$$\bar{x} = \frac{\Sigma x}{n}$$

Where:

x is the frequency of each score , and

n is the total number of respondents who answered the survey

*Wilcoxon Signed-rank test*. This test statistic is used to test the hypothesis of the result of the survey in each of the factors such as effectivity, retractability, and effectiveness.

## Materials and Methods

### *Materials*

To investigate the effectiveness, speed, and user experience of the automated rain-responsive clothes protection system, the following research instruments will be employed:

*Survey.* A structured survey questionnaire will be distributed to homeowners, senior citizens and persons with disabilities. The survey aims to collect data regarding:

- Perceived effectiveness of the system in preventing clothes from getting wet (compared to no protection).
- Perceived speed of the system's response (compared to manual methods).
- Overall satisfaction and user experience with the automated system.
- Comparison with traditional clothes drying racks in terms of effectiveness and response to sudden rainfall.

This comprehensive approach will help assess the practical benefits and user acceptance of the automated system. The survey will include both qualitative (open-ended questions) and quantitative (Likert scale, multiple choice) data.

*Experimental Materials.* The following tools and instruments will be used in the experiment:

| | |
|---|---|
| Arduino nano | 12v Servo Motor |
| Rainwater Sensor Module | Relay Module |
| Solar Panel | Battery |
| Charge Controller 10a | -18650 x 4 |

| | |
|---|---|
| -BMS 4S 12V for 18650 Battery | Misc: |
| LED | Breadboard |
| | Wire/Jumperwires |

***Methods***

The system will use an Arduino Nano as its master controller to receive sensor input and manage outputs through the servo motor and LED. The rainwater sensor module will alert the Arduino to detect precipitation via digital signals, while the relay module will enable the Arduino to control high-power devices by checking compatibility and managing current ratings. A 20W solar panel will power the battery under the control of a 10A charge controller, ensuring safe charging operations. A 4S 12V lithium-ion battery pack using 18650 cells will store energy, protected by its integrated BMS against overcharging, short circuits, or over-discharging conditions. The system will include a 12V servo motor for completing movement tasks and an LED for system status notifications.

The system-building process will involve placing the Arduino Nano board on a breadboard alongside the rain sensor, relay module, and LED. Simultaneously, the 4S battery pack will be configured to generate 12V power through the BMS. The output of the solar panels will connect to the charge controller for battery charging purposes and supply power to the servo motor using the relay module. Programs on Arduino will constantly check the rain sensor status to activate the relay module, supplying power to the motor during precipitation and triggering protective actions. The device will use the LED as a status indicator by either turning it on or making it blink depending on whether rain is detected or the system is at rest.

The system will rely on self-contained power, utilizing photovoltaic energy from solar panels to run indefinitely. The charge controller will ensure safe battery charging during sunlight hours, while the BMS will protect the batteries against dangerous charging and discharging events.

**Data Gathering Procedure**

The data gathering procedure for this research will take place at Tektone Village, Legazpi City with a maximum of 10 purposive sampling selected participants who regularly dry their clothes outdoors or indoors. Each participant will have schedules for using the device. We will give them each 2-3 days to use and all participants will be oriented on the objectives and procedures of the device, followed by the demonstration of the system's functionality to ensure participants understand its operation.

Researchers will monitor the device system’s performance during actual rainfall events, documenting its effectiveness in keeping clothes dry and if its response time in deploying the protective cover. Participants will also record their observations, noting whether their clothes remained dry, slightly wet, or soaked, and how quickly the system reacted (15-30 seconds, 30 seconds to 1 minute, or more than 1 minute).

After collecting the survey responses, The gathered data will then be analyzed to assess the system’s overall performance of the device, identifying its strengths and areas for improvement and analyzed to identify significant advantage over traditional drying methods. Based on the results.

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