Implementation of an Automatic Drying Roof Design Using an Arduino Microcontroller

Jokando Malau, Solly Aryza Lubis, Beni Satria

Abstract

Drying crops, especially rice, is still mostly done manually using direct sunlight. This method has disadvantages because it is highly dependent on unpredictable weather conditions, which can reduce crop quality due to rain or excessive humidity. This study aims to design and implement an automatic drying roof system based on the Arduino UNO R3 microcontroller with the support of rain sensors, light sensors (LDR), and temperature and humidity sensors (DHT22). The method used is experimentation through hardware and software design, followed by testing each sensor and simulating the system as a whole. The results show that the rain sensor can detect water droplets through changes in ADC values, the light sensor can accurately respond to light intensity, and the DHT22 sensor produces temperature and humidity data that is close to the reference values from a digital thermometer. The servo motor works stably at a voltage of 4.92 V to open and close the roof, while the fan turns on automatically when the temperature and humidity exceed the threshold. Overall, this system has been proven to work automatically and in real-time in response to weather changes, thereby increasing drying efficiency, maintaining crop quality, and minimizing farmers' losses due to environmental factors.

Keywords: Automatic Roof, Arduino UNO, Rain Sensor, Light Sensor, DHT22 Sensor, Smart Drying, IoT.

Jokando Malau[1]
[1]Bachelor of Electrical Engineering, Universitas Pembangunan Panca Budi, Indonesia
e-mail: jokandomalau523@gmail.com[1]

Solly Aryza Lubis[2], Beni Satria[3]
[2,3]Master of Electrical Engineering, Universitas Pembangunan Panca Budi, Indonesia
e-mail: sollyaryzalubis@pancabudi.ac.id[2], bsatria6@gmail.com[3]
2nd International Conference on Islamic Community Studies (ICICS)
Theme: History of Malay Civilisation and Islamic Human Capacity and Halal Hub in the Globalization Era
https://proceeding.pancabudi.ac.id/index.php/ICIE/index

Introduction

With the rapid development of technology, humans continue to innovate to create various tools that can simplify daily tasks (Alam and Hamida, 2019). Technology has now become a necessity and a support in various fields of life. These innovations were born as solutions to problems that arise in society, including in the field of agriculture.

Indonesia is a tropical country with two main seasons, namely the rainy season and the dry season (Susandi et al., 2018). However, due to global warming, weather conditions have become difficult to predict accurately (Yongshuo et al., 2019). This uncertainty causes concern for farmers when drying their crops, especially rice, in open areas. Conventional drying methods are still widely used, even though they have various disadvantages, such as the need to guard the harvest at all times, the requirement to remove the rice in the afternoon, and dependence on the intensity of sunlight, which is not always stable (Kurnia et al., 2019). These conditions can result in suboptimal rice drying, leading to decay and reduced rice quality (Nusyirwan, 2019).

To overcome these problems, a microcontroller-based automatic roof system was developed. This system utilizes light sensors and rain sensors as inputs that are processed by a microcontroller to automatically regulate the opening and closing of the roof. The advantages of microcontrollers lie in their compactness, speed, ease of modification, and support from relatively affordable software (Nuryanto et al., 2021). Previous studies have shown the application of microcontrollers in various automated systems, such as smart home systems (Mowad et al., 2021), face recognition-based automatic doors (Lwin et al., 2018), and automatic street lights (Saad et al., 2019). Additionally, multi-sensor node prototypes have been used to monitor weather parameters (Mosey, 2019).

Recent research shows significant developments in the application of automatic clothes drying roofs. Mastiyanto et al. (2024) designed a prototype of a smart clothes drying roof based on Arduino with rain sensors and LDRs that can close the roof when it rains and adjust the opening according to the intensity of sunlight. Furthermore, Fitri et al. (2025) developed an ESP32-based automatic drying system equipped with solar panels, batteries, blower fans, and Internet of Things (IoT) connectivity via a Telegram bot. This system allows remote control and continues to function even during power outages. In the context of drying crops, previous studies have also proven that automatic roofs can reduce farmers' anxiety when it rains suddenly (Damastuti and Syafi'i, 2019). Several researchers have proposed automatic roof technology based on solar radiation or a combination of humidity, temperature, light, and rain sensors (Jochem et al., 2018; Alausa dele and Kolawole, 2019). However, most of these studies have not optimally integrated all environmental sensors into a single control node.

Therefore, this study developed an automatic drying roof design based on an Arduino microcontroller with multiple sensors (humidity, temperature, light, and rain). These sensor nodes are not only capable of automatically opening and closing the roof, but also turning on fans to control air circulation in the drying area. Thus, it is hoped that this system will improve the effectiveness and quality of the crop drying process and support the sustainability of smart agriculture technology in Indonesia (Fitri et al., 2025; Mastiyanto et al., 2024).

Literature Review

1. Arduino UNO R3 Microcontroller

The Arduino UNO R3 is an ATMega328-based microcontroller board widely used in automation research because it is easy to program, open-source, and has a wide range of supporting modules available. This board is equipped with 14 digital input/output pins (6 of which can be used as PWM), 6 analog inputs, a 16 MHz crystal oscillator, a USB port, a power jack, an ICSP header, and a reset button. Arduino can be connected to a computer via USB or powered using an adapter and battery. The use of Arduino has proven effective in various

automated system applications such as lighting control in smart homes, temperature sensor-based cooling systems, and home security control (Mowad et al., 2014).

Figure 1. Arduino UNO R3 Board

2. Rain Sensor

Rain sensors detect water droplets using the principles of conductivity or capacitance. When water falls on the sensor surface, the resistance changes, producing an electrical signal that is read by the microcontroller. Previous research shows that rain sensors are effective in automatic drying roofs to detect rain conditions and trigger the roof closure system in real-time (Damastuti & Syafi'i, 2016). Similar technology is also used in other automation systems such as smart street lights (Saad et al., 2013).

Figure 2. Rain sensor

3. Light Sensor (LDR – Light Dependent Resistor)

A light sensor or LDR is a resistor whose resistance value changes according to light intensity. When the light is bright, the LDR resistance decreases, while in dark conditions the resistance increases. This sensor is widely used in automation systems such as automatic street lights and sunroof systems to detect sunlight intensity. Jochem et al. (2009) utilized sunlight radiation analysis to develop an automatic roof system for heating, lighting, and humidity control applications.

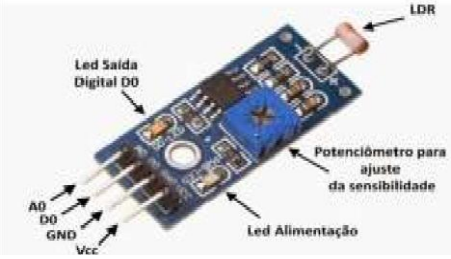

Figure 3. Physical form of the light sensor

4). Temperature and Humidity Sensor (DHT22)

The DHT22 is a digital sensor capable of accurately and stably measuring air temperature and humidity over the long term. This sensor uses capacitive humidity sensing and a thermistor to detect environmental conditions, then generates a digital signal that can be directly read by a microcontroller. In previous research, the DHT22 has been used for smart agriculture and smart home systems, such as controlling room cooling based on temperature, and supporting multi-sensor weather monitoring node systems (Mosey, 2017).

Figure 4. Physical form of the DHT22 sensor

Research Methodology

This research uses an experimental method with a research and development approach, namely through the stages of software design and hardware design. The developed system is designed to support the drying process of agricultural products with Arduino microcontroller-based automation, thereby reducing dependence on weather and increasing drying efficiency.

1. Software Design

The software was developed using the Arduino IDE programming language, which functions as the main controller for all sensors and actuators. Programming was carried out to regulate the logical conditions of:

a) Rain sensor and light sensor → function as triggers for opening or closing the drying roof.
b) Temperature and humidity sensors (DHT22) → function as triggers to activate or deactivate the air circulation fan in the drying room.

The software workflow is shown in the Flowchart in Figure 5. This diagram explains the process from sensor initialization, data reading, logic processing, to command execution on the actuator.

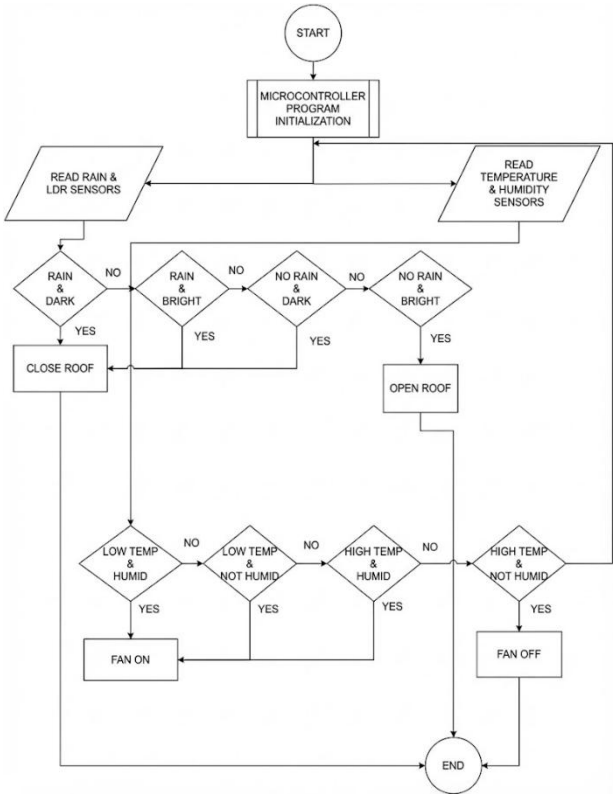

Figure 5. Software Design Flowchart

Program execution rules, which are the logical conditions that form the basis for the system's decision-making, for example:

a) If the rain sensor is active → the roof closes automatically.
b) If light intensity is high → the roof opens.
c) If humidity is high and temperature is rising → the fan is activated to improve air circulation.

The program code on the microcontroller is optimized so that the system can respond to changes in environmental conditions in real time with a high degree of reliability.

2. Hardware Design

The hardware is designed by integrating various components into a single automated system. The design process includes:

1) Sensor Layout

Rain sensors are installed on the roof to directly detect rainwater, light sensors (LDR) are placed in open areas that receive sunlight, while temperature and humidity sensors (DHT22) are positioned in the drying room to monitor internal conditions.

2) Module Integration

All sensors are connected to an Arduino UNO R3 microcontroller. The microcontroller functions as a data processing center that then provides output signals to drive the servo motor (roof opener/closer) and DC fan (air circulation).

3) Actuator Mechanism

The servo motor is connected to the sliding/folding roof mechanism so that it can open and close according to logic commands. The fan is installed on the side of the drying room to regulate air circulation, maintain temperature, and reduce excess humidity.

4) Hardware Block Diagram

The relationship between components is illustrated in the Hardware Block Diagram (Figure 6), which shows the data flow from the sensor → microcontroller → actuator (servo motor & fan).

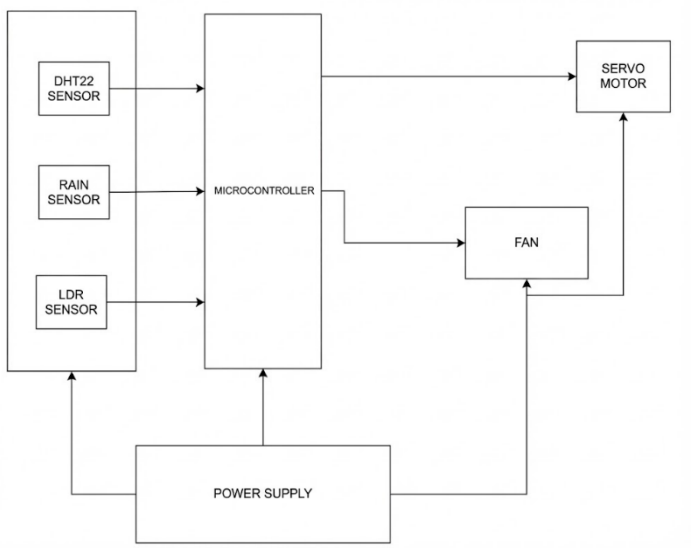

Figure 6. Hardware Design Flow

Results

1). Communication between Arduino and Sensor Module Components

The Arduino UNO R3 is used as the main controller that connects and processes data from various sensors and controls actuators (servo motors and fans). Arduino is equipped with digital and analog input/output pins that facilitate integration with sensor modules. The communication process is carried out in the form of analog/digital signal reading or through a digital protocol (I2C/One-Wire), depending on the type of sensor used. The Arduino UNO R3 functions as a control center that connects various sensors and actuators. The rain sensor and LDR communicate via analog pins to detect wet conditions and light intensity, while the DHT22 sensor transmits temperature and humidity data digitally using a single-wire protocol. Data from the sensors is processed by the Arduino, then transmitted to the servo motor via PWM ( ) signals to open or close the roof, as well as to the fan to regulate air circulation. With this communication, the system can respond to weather changes in real-time and automatically.

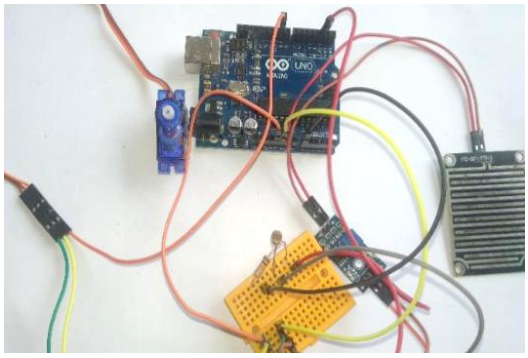

Figure 7. Arduino and Component Communication

2) LDR Sensor Test Results

Table 1 shows the test results of the Light Dependent Resistor (LDR) under different weather conditions, namely sunny and cloudy.

Table 1. LDR Sensor Test Results

No	Weather Conditions	LDR Sensor Value	Resistance Value	Voltage (V)
1	Bright	234	31.4 Ω	3.39 V
2	Bright	233	30.3 Ω	3.27 V
3	Bright	236	32.5 Ω	3.53 V
4	Cloudy	72	110.0 Ω	4.55 V
5	Cloudy	77	125.9 Ω	4.65 V
6	Cloudy	74	111.1 Ω	4.56 V

Based on the test results, the following findings were obtained:

1) Bright conditions
    a) The ADC value of the LDR sensor is quite high, ranging from 233 to 236.
    b) The LDR resistance is in the range of 30–32 Ω, indicating low resistance due to high light intensity.
    c) The output voltage is relatively low, around 3.3–3.5 V.
2) Cloudy conditions
    a) The ADC value of the sensor drops sharply to 72–77.
    b) The LDR resistance increases sharply to 110–126 Ω, indicating a decrease in light intensity.
    c) The output voltage increases to 4.5–4.6 V.

These results are consistent with the working principle of the LDR, namely that resistance decreases when light intensity increases, and conversely, resistance increases when light intensity decreases.

Therefore:

a) Higher light intensity → lower resistance → decreased output voltage.
b) Lower light intensity (dark/cloudy) → higher resistance → increased output voltage.

This finding is in line with the research by Subagio et al. (DIGIT Journal, ISSN: 2088-589X), which states that LDR sensors are very responsive to changes in light intensity, making them suitable as the main trigger for automatic clothesline roof systems in determining light/dark conditions as the basis for controlling the opening/closing of the roof.

3). Water Sensor Test Results

Table 2. Water/Rain Sensor Test Results

No	Sensor Condition	Sensor Value	Voltage (V)
1	Wet	0	2.89
2	Wet	0	2.87
3	Wet	0	2.90
4	Dry	1	4.57
5	Dry	1	4.34
6	Dry	1	4.58

Test results show that the water sensor is able to distinguish between wet and dry conditions well:

a) In wet conditions, the sensor reads 0, with an output voltage ranging from 2.87 to 2.90 V.
b) Under dry conditions, the sensor value changes to 1, with a higher output voltage of 4.34–4.58 V.

This difference in values is in accordance with the working principle of water sensors that use conductivity to detect the presence of water. This proves that the sensor works well as an indicator of environmental conditions (rainy or not), so it can be used as a trigger for logic commands on a microcontroller to close or open the roof.

4). Servo Motor Test Results

Table 3. Servo Motor Test Results

No	Weather Conditions	Voltage (V)	Roof Position
1	Cloudy, no rain	4.92	Cloudy
2	Cloudy, rain	4.92	Cloudy
3	Clear, rain	4.92	Cloudy
4	No rain, no clouds	4.92	Open

Servo motor testing shows that the supply voltage to the servo motor remains stable at **4.92 V** under all weather conditions. This means that the servo motor is always supplied with current even when it is not always performing the action of opening or closing the roof.

These results indicate that:

1) The servo motor responds to commands from the microcontroller, with the roof position changing according to sensor logic.
    a) Rainy conditions (both cloudy and sunny) → roof closed.
    b) Non-rainy and sunny conditions → roof open.

2) The output voltage is stable, so the servo motor's performance is not affected by changes in weather conditions.

Thus, the servo motor has proven capable of functioning as the main actuator in the automatic sunroof system, ensuring the roof moves as needed without voltage interference.

Discussion Analysis

The implementation of an Arduino microcontroller-based automatic sunroof system shows good performance in responding to changes in weather conditions. Rain sensor test results show that the ADC value decreases significantly when the sensor surface is exposed to water, allowing the system to quickly recognize rainy conditions. This provides the basis for the microcontroller to issue commands to close the roof automatically.

In the light sensor (LDR) test, it was found that the resistance value decreased when the light intensity was high and increased when it was cloudy or dark. These changes in value are directly proportional to the output voltage, making this sensor effective for controlling the roof position according to lighting conditions. The temperature and humidity sensor (DHT22) also showed good accuracy, with measurement results close to those of a digital thermometer. This proves that the DHT22 is suitable for use as an additional controller for fans to maintain air circulation in the drying room.

The servo motor actuator works stably at a voltage of 4.92 V and is responsive to microcontroller logic commands. The motor is capable of opening and closing the roof according to signals from the sensor, while the fan automatically activates when the temperature and humidity exceed the threshold. The integration between the sensor and actuator forms an adaptive and real-time system in response to weather changes.

The implementation of this automatic drying roof design can reduce dependence on human labor and lower the risk of crop damage due to sudden rain or excessive humidity. In addition, the use of an Arduino microcontroller makes the system compact, flexible, and easy to modify as needed. However, this research still has limitations, such as continuous power consumption in the servo motor even when it is not moving, as well as the need for long-term testing in extreme weather conditions.

Conclusion

Based on the results of the study, it can be concluded that the Arduino UNO R3 microcontroller-based automatic drying roof system can be implemented well through the integration of rain sensors, light sensors (LDR), temperature and humidity sensors (DHT22), servo motors, and fans as actuators. The rain sensor is capable of detecting water droplets by significantly lowering the ADC value, while the light sensor shows changes in resistance according to the intensity of light received. The DHT22 sensor has also been proven to be accurate with temperature and humidity measurements that are close to those of a digital thermometer, making it effective for use as a fan controller to maintain air circulation. The servo motor functions stably with a working voltage of around 4.92 V and is responsive in opening and closing the roof according to the logic processed by the microcontroller. Overall, the implementation of this system can help farmers in the drying process by reducing the risk of crop damage due to sudden rain or excessive humidity, as well as increasing efficiency and comfort. However, for further development, the system still needs to be optimized in terms of servo motor power consumption and tested further in extreme weather conditions on an ongoing basis.

References

[1] Anisah, S., Tharo, Z., Hamdani, H., & Butar, A. K. B. (2023). Optimization Analysis Of Solar And Wind Power Hybrid Power Plant Systems. Prosiding Universitas Dharmawangsa, 3(1), 614-624.

[2] Hamdani, H., Sastra, A., & Firmansyah, D. (2023). Study of the Development of a 50 Kg Capacity Smart Goods Lift with Solar Power Generation (PLTS). INTECOMS: Journal of Information Technology and Computer Science, 6(1), 429-433.

[3] Hamdani, H., Tharo, Z., Anisah, S., & Lubis, S. A. (2020, September). Design of a Modified Sine Wave Inverter in Solar Power Plants for Residential Use. In Proceedings of the UISU National Engineering Seminar (SEMNASTEK) (Vol. 3, No. 1, pp. 156-162).

[4] Tharo, Z., Hamdani, H., & Andriana, M. (2019, May). Hybrid solar and wind power plants as an alternative source to address the fossil fuel crisis in Sumatra. In Proceedings of the UISU National Engineering Seminar (SEMNASTEK) (Vol. 2, No. 1, pp. 141-144).

[5] Tharo, Z., Hamdani, H., Andriana, M., & Yusar, J. H. (2022). Implementation of environmentally friendly generator sets based on solar panels in Tomuan Holbung Village. Journal of Higher Education Lecturer Service (Jurnal Deputi), 2(2), 98-101.

[6] Tharo, Z., Syahputra, M. R., Hamdani, H., & Sugino, B. (2020). Analysis of Medium Voltage Network Protection System Using Etap Application at Kualanamu International Airport. Journal of Electrical and System Control Engineering, 4(1), 33-42.

[7] Wibowo, P., Lubis, S. A., & Hamdani, Z. T. (2017). Smart home security system design sensor based on pir and microcontroller. International Journal of Global Sustainability, 1(1), 67-73.

[8] Yusup, M. (2022). Radio Frequency Identification (RFID) technology as a tool for automatic door opening systems in smart houses. Jurnal Media Infotama, 18(2), 367-373.

[9] Atsiq, A., Gunawan, A., & Nugraha, A. A. D. (2022). Automatic Clothing Drying Using Rain Sensors and Ldr Sensors Based on Arduino UNO. Spectrum, 1(02).

[10] Fhaizal, M. A., Rivaldi, S., Wijaya, W., Kristianti, L., Sani, W., & Lukman, A. (2023, October). Automatic Drying Roof with Short Messages (SMS) using a Microcontroller Module. In 2023 17th International Conference on Telecommunication Systems, Services, and Applications (TSSA) (pp. 1-5). IEEE.

[11] Putri, D. P. E., & Yudhana, A. (2020). Prototype of Automatic Cover Roof Control system for Grain Drying Based on Internet of Things (IoT). Signal and Image Processing Letters, 2(1), 27-35.

[12] Mauludin, M. S., Khairudin, M., Asnawi, R., Prasetyo, S. D., Alfaiz, N. F., & Arifin, Z. (2024). Modeling and Application of Rain-Light Sensor in Automatic Clothes Drying Design. Journal Européen des Systèmes Automatisés, 57(4), 1215.

[13] Gorakh, J., Khandezod, S., Tarwatkar, P., Gopewar, S., & Patle, R. (2025). Rain Detection Based Automatic Clothes Collector. International Journal on Advanced Electrical and Computer Engineering, 14(1), 141-145.

[14] Swaraj, P. P., Shivuni, D., Chatragadda, L., Ettom, S., Srivastava, V. K., & Bindu, K. H. (2023). Motorized Smart Roofing System using IoT for Sustainable development. In E3S Web of Conferences (Vol. 430, p. 01098). EDP Sciences.