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Intelligent IoT-Enabled Roof Control System Using Mamdani Fuzzy Logic With Telegram-Based Remote Monitoring

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ABSTRACT

Automatic clothesline system is one of the solutions to the problem of clotheslines that are not due to sudden changes in weather, by using the esp8266 microcontroller it can be done to facilitate the community. This automatic clothesline system consists of esp8266 as a microcontroller, then a raindrop sensor as a rain detector and an ldr sensor as a sunlight detector. All components are assembled into a system to open and close the roof automatically, and users will also get notifications via telegram if the roof is open or closed. The results of this research show that the sensors work as expected, namely the roof can open and close automatically in rainy and dark conditions.

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1. INTRODUCTION

The development of software and hardware technology covers many areas of everyday life. Not only continuing to look for new innovations, but also optimizing existing technological developments, humans are required to think creatively and maximize technological performance to help human work [1]. The erratic changes in seasons in Indonesia often cause problems for some people who are drying something. The essence of the problem is that if it suddenly rains, the person must immediately lift the clothesline so as not to get hit by the rain. This process is very ineffective, because it wastes time and energy [2].

Drying is a method used to dry wet clothes using the sun's heat. Clothespins are almost often found in every home. The difficulty of lifting the clothesline while outside will cause you to worry about leaving the clothesline outside the house because if the clothes are exposed to rain while drying, the clothes will get wet and will cause an unpleasant odor [3].

Home roof automation may be very necessary for millennial society like today, apart from being needed to increase the comfort of the residence, automation is one of the additional devices that allows the system to work more simply, efficiently and practically, thereby shortening the process and providing a high level of accuracy. So, with microcontroller technology, all sensor modules can certainly be a good solution to be developed to overcome automatic control system problems [4].

Several studies related to the design of automatic roof systems are explained as follows. In the research, we made a roof prototype that can set water and temperature sensors so that the roof will move automatically if there is a temperature difference and it is exposed to water, using electrical power sourced from solar panels [5].

This research designs an automatic drying system based on Arduino Uno R3 using a light sensor and rain sensor, with light intensity values of 84 Lux when bright and 184 Lux when cloudy [6]. Another study built a smart roof prototype with IoT-based multisensors using fuzzy logic to determine weather conditions [7]. In another research, an Android-based roof control system was created using the Arduino Uno microcontroller, adding an IoT system to enable user control via the Blynk Android app [8]. Further, a safety system prototype for roof opening and closing was built using two water sensors and an LDR, controlled by an Atmega328 microcontroller [9], [10].

In contrast to these previous studies, this research presents an automatic roof system using the Fuzzy Mamdani method, which is known for its ability to model human-like reasoning by transforming sensor inputs into linguistic variables [11]. This approach is considered suitable for environmental conditions that are uncertain or imprecise, such as weather changes, because Fuzzy Mamdani enables more adaptive, intuitive decision-making. The system is expected to respond accurately to changes in light intensity and rain conditions.

Furthermore, this research is realized in the form of a miniature or prototype system at a small scale, which serves as a model to simulate the actual implementation. This prototype facilitates design validation, functional testing, and evaluation of system behavior in a controlled environment before real-world deployment.

Based on the problems above, the main problem that can help with this issue can be identified, namely the control and management of automatic drying roofs by adjusting environmental conditions or weather changes. This is expected to provide solutions to existing problems and is outlined in this research with the title "Development of an Automatic Closing Roof System Using the Fuzzy Logic Mamdani Method Integrated with Telegram.".

2. METHODOLOGY

This research uses a method, namely the Mamdani fuzzy logic method. This method can estimate rainfall conditions because fuzzy logic can be useful for drawing the best decisions or conclusions from an uncertain problem. It is hoped that this system will help and make things easier for people when drying clothes and it will rain.

2.1. Analysis of Tool and Material Needs

Hardware design aims to design equipment or supporting circuits for the system to be created. There are tools and materials used in designing the automatic drying roof prototype that are used, consisting of:

2.1.1 Fuzzy Mamdani

Mamdani is a well-known fuzzy logic method, Fuzzy Mamdani is frequently used to create systems with reasoning that resembles human intuition or feelings. As a result, the Mamdani model can be used to represent human guesses.

2.1.2 Prototype

A prototype is an example of system implementation that shows the limitations and main functional capabilities of the proposed system. After the prototype is built, it is delivered to consumers for evaluation. Prototypes help consumers determine how features function in the final software. Consumers provide suggestions and improvements to the prototype.

2.1.2 Arduino IDE

Arduino IDE is a software that plays a very important role in writing programs, compiling them into binary code and uploading them to the microcontroller's memory. Arduino can be run on computers with various platforms because it is based on Java. The source program that we create for microcontroller applications is C/C++ language and can be combined with assembly.

2.1.3 Telegram

Telegram messenger is a chat application, can share messages, videos, location tagging between fellow users. The bot feature that has artificial intelligence is a feature that can be integrated with various services via the internet. With this bot feature, the author will create a system that can be integrated into a home security system [12].

2.1.4 Servo Motor

A servo motor is an electric motor with a closed feedback system (close loop) where the position of the motor will be informed back to the control circuit. The electronic component is a motor with limited movement whose movement angle can be adjusted to 90 degrees or 180 degrees. Servo motors are different from DC motors and stepper motors which can rotate or rotate up to 360 degrees [13].

2.1.5 Jumper Cables

Jumper cables are electrical cables to connect components on a breadboard without requiring soldering. Jumper cables generally have connectors or pins at each end. There are three types of jumper cables, namely male to male, male to female, and female to female [14].

2.1.6 ESP 8266

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ESP 8266 is a complete chip which includes processor, memory and access. This causes the ESP8266 to be able to directly replace the Arduino and add to its ability to support WiFi connections directly[15].

2.1.7 Raindrop Sensor

RainDrop sensor or rain sensor is a sensor that can function as a detector for the presence or absence of raindrops. The working principle of this sensor is that when rainwater falls and hits the sensor panel, an electrolysis process will occur with the rainwater. In this sensor there is a comparator IC where the output from this sensor can be logic high, low and on or off [16]].

2.1.8 Light Dependent Resistor Sensor

Light Dependent Resistor is a type of resistor component with a resistance value that changes, according to the intensity of light hitting the sensor. The more light that hits the LDR sensor, the more its resistance value will decrease. Well, the less light that hits the sensor (dark), the greater the resistance value will be, so the electric current flowing will be hampered[17].

2.2. System planning

At this stage, an automatic drying roof system will be designed, with previously identified needs. This step is an important part of the in-depth research process, through the prepared design system, we aim to ensure effectiveness and successful implementation of the system we created.

2.2.1 Design System

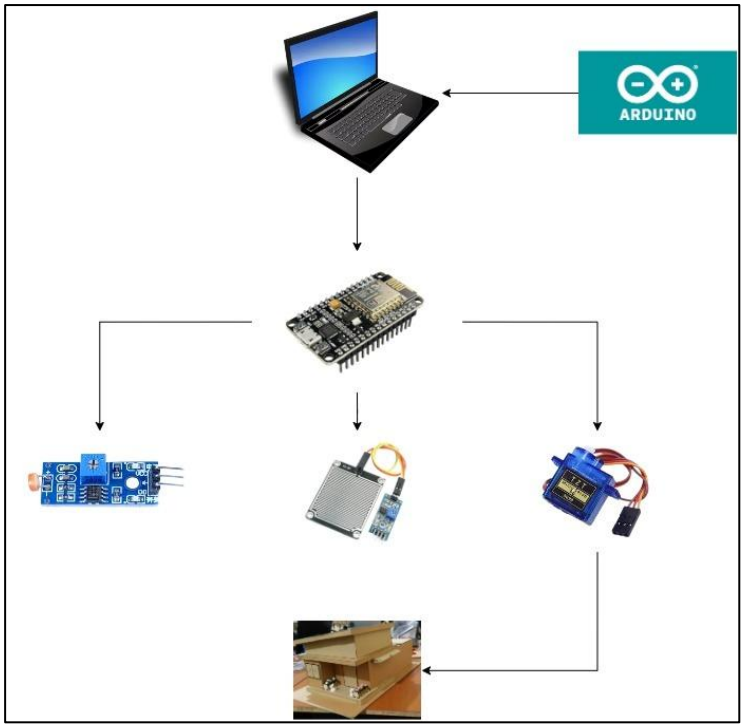

Figure 1. Design System

The automatic roof system design utilizes an ESP microcontroller, LDR sensor, raindrop sensor, servo motor, and Telegram communication module. This system measures light intensity and humidity using LDR and raindrop sensors, then uses a servo motor to automatically regulate the opening or closing of the roof based on the resulting data. Integration with Telegram allows the system to send roof status notifications to users

2.2.2 Diagram Block

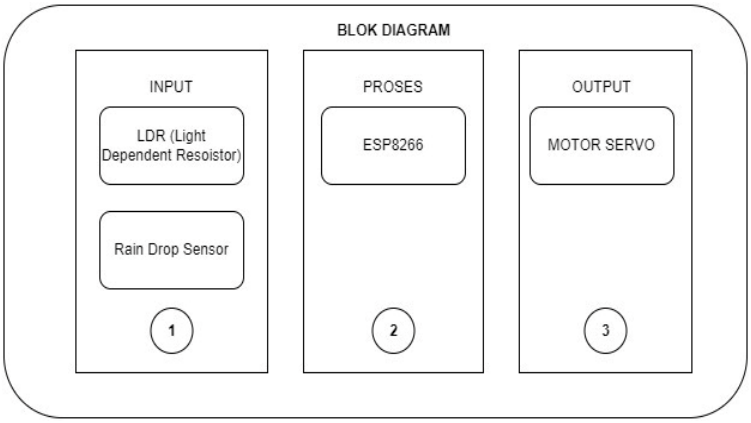

Figure 2. Diagram Block

The workings of this system generally consists of 3 main parts:
1. Input (LDR and Rain Drop Sensor): this section is the initial step for data or information to be entered into a system or microcontroller.
2. Process (ESP8266): This section is the steps or operations carried out by the ESP8266 to process input data into output results.
3. Output (Servo Motor): The result of the process, namely information or data produced by the system or program after processing the input.

2.2.3 Flowchart

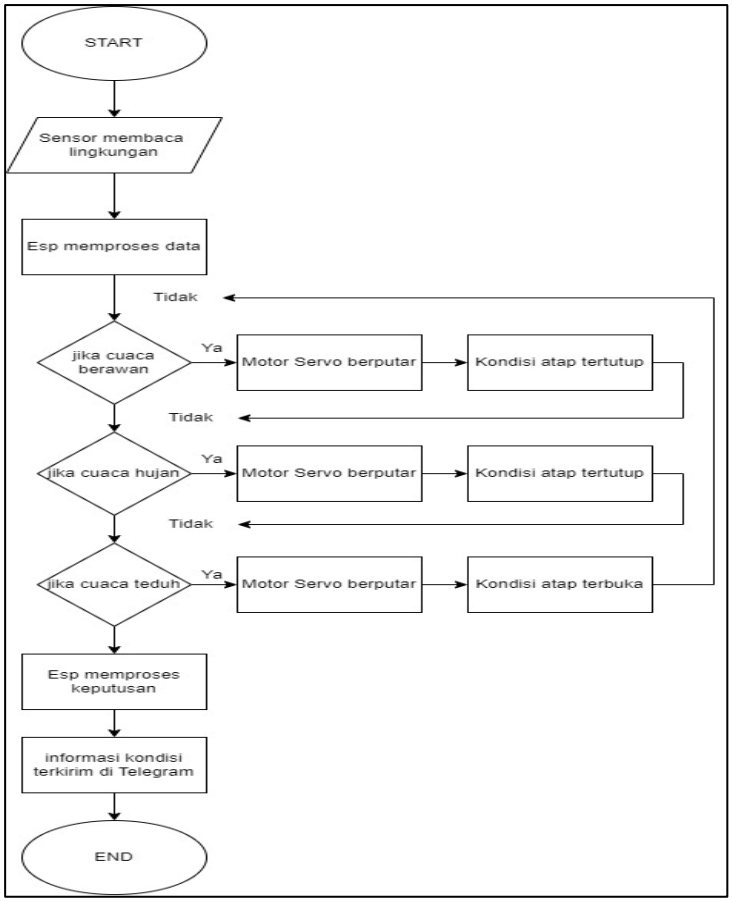

Figure 3. Flowchart

The automatic roof system uses an ESP8266 microcontroller, LDR sensor, raindrop sensor, servo motor and Telegram communication module. The program starts with initializing components, such as microcontrollers and sensors. Next, the light intensity value from the LDR sensor and the humidity status from the raindrop sensor are read, and weather conditions are evaluated. The servo motor is activated to close the roof, and the roof status is sent via a Telegram bot. This process repeats with a time delay for continuous sensor readings,

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ensuring system adaptation to changing weather conditions. The entire program creates a responsive, automated roofing system, utilizing microcontroller and sensor technology to make decisions and provide notifications via Telegram.

2.3. Method

2.3.1 Sensor Condition

Testing on the smart roof prototype with the aim of finding out whether the prototype works as desired and knowing the results of measuring the voltage or current acting on the circuit when it is operating and determining the test point of the circuit. The measurement results can later be used as a reference in analyzing the circuit.

Table 1. Sensor Condition

No	P. LDR	P. Rain Drop	Kondisi
1	Dark	Rain	Close Roof
2	Dark	Not Rain	Close Roof
3	Light	Not Rain	Open Roof
4	Light	Rain	Close Roof

2.3.2 Fuzzy Logic Mamdani

Table 2. Rule Base

Rule 1	If (keadaan hujan) and (cahaya is gelap) then (atap is tertutup and notifikasi)
Rule 2	If (Rain drop sensor is Not Rain) and (LDR Sensor is Dark) then (Roof is close and notifikasi Atap Tertutup)
Rule 3	If (Rain drop sensor is Not Rain) and (LDR Sensor is Light) then (Roof is open and notifikasi Atap Terbuka)
Rule 4	If (Rain drop sensor is Rain) and (LDR Sensor is Light) then (Roof is close and notifikasi Atap Tertutup)

3. RESULT AND ANALYSIS

3.1. 3D Design

The 3D design is made first so that during implementation there are no errors and there is a reference that can be imitated. In the 3D design that we made, we took the form of a simple house model like most people's houses.

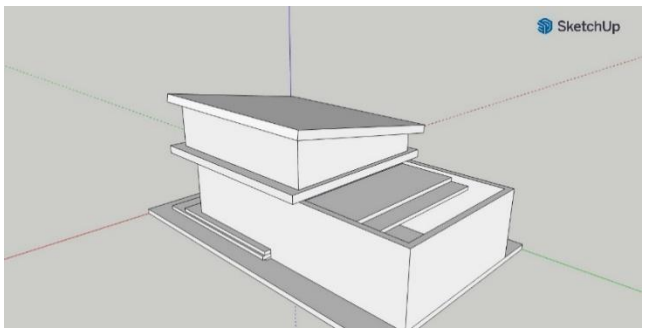

Figure 4. Design 3D

3.2. Design Implementation

The following is the result of a miniature simple house complete with an automatic roof system that has been integrated with Telegram. If the system detects that it will rain or rain, the roof will close, and if the system detects that it will not rain or the sky is clear, the roof will open.

Figure 5. Implementation Design

3.3. Telegram Notification

If the system is running as it should, then if there is a change in conditioning from the roof being closed to the roof being opened, and vice versa, then the esp8266 will send data to Telegram, and Telegram will display a notification on the user's cellphone.

Figure 6. Telegram Notification

4. CONCLUSION

Based on the results that have been obtained and the tests that have been carried out, it can be concluded as follows:

From the results of the research that has been carried out, it can be concluded that the telegram integrated automatic roof system has been successfully realized. So you don't have to worry about your clothesline due to sudden changes in the weather when you leave the house because there is a roof opening and closing system that can work automatically to protect your clothesline from changes in the weather. With 2 Raindrop sensors and also LDR as variables, the level of accuracy of the roof system will be higher, if it rains the roof will close automatically, and vice versa if the system detects clear skies then the roof will open.

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