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Design and Construction of an Automatic Clothes Drying System with Remote Control Using Arduino and WIFI

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Abstract — This research aims to address the problem of clothes drying, which is often hampered by unpredictable weather conditions in Indonesia, a tropical country with two main seasons: dry and rainy. To solve this problem, we developed an automatic clothes drying system that can be controlled remotely using Arduino and Wi-Fi technology. This system is equipped with temperature sensors, light sensors, and rain sensors that function to detect weather conditions in real-time. This automatic clothes drying system works by closing the clothes drying system when rain is detected and reopening it when the weather is clear. Users can also control the clothes drying system manually through an Android application connected to Wi-Fi. The results of the study indicate that this system functions well according to the planned design. Field testing demonstrated a fast and accurate response from the sensors to weather changes, as well as the ease of use of the Android application for manual control. The conclusion of this study is that this automatic clothes drying system is able to provide a practical and efficient solution for drying clothes, especially in the face of unpredictable weather. This system not only saves time and energy, but also provides extra protection for the clothes being dried.

Keywords – Automatic clothesline, Arduino, Wi-Fi, weather sensor

I. INTRODUCTION

Indonesia has a tropical climate, with both dry and rainy seasons. Rainfall is also high, so many people need technology to avoid getting wet from the rain, including drying clothes, as clothing is a basic necessity for everyone.

Nowadays, many people have opened laundry businesses, but doing it too often can be quite expensive. Therefore, to save money, people prefer to wash their clothes themselves. Washing clothes is a chore that is done almost every day, but that doesn't mean it's free of potential problems. When people are of productive age and have busy work schedules, they sometimes forget to monitor the clothes that are being dried. This happens in places where many people are active outside and leave their clothes exposed to the sun all day. However, because rainfall in Indonesia is quite high and unpredictable, people also worry that when drying their clothes outdoors, it will suddenly rain and they haven't had time to secure the clothes, which will cause the clothes to get wet again. A device that can automatically control the clothesline to avoid rain is needed. Rain, light, temperature, and humidity sensors will be used to determine the weather.

The Internet of Things (IoT) is a computing concept about everyday objects being connected to the internet and being able to identify themselves to other devices. Internet connection is a wonderful thing, it can give us all kinds of benefits that might have been difficult to obtain before. [1]Internet of Things technology makes it possible to connect devices to other objects, such as the roof of a house, to build a clothesline control system that can be controlled via an Android smartphone.

II. METHODOLOGY

This research uses a hardware and software engineering approach. The hardware consists of :

1. NodeMCU ESP 8266

NodeMCU is an open source IoT development platform and kit that uses the Lua programming language to assist in prototyping [2].

2. DHT22 Sensor

The DHT22 sensor is a digital sensor used to measure temperature and humidity. It uses an NTC-based temperature sensor and a resistive humidity sensor, connected to an 8-bit microcontroller. The DHT22 sensor is of excellent quality, very stable, and very reliable over the long term. [3].

3. LDR Sensor

The LDR sensor is a type of resistor that can change its resistance when the light received changes, namely the LDR (Light Dependent Resistor). [4]

4. Rain Sensor

A rain sensor is a device that detects whether it is raining or not. When rainwater hits the sensor panel, electrolysis of the rainwater occurs. [5]

5. Stepper Motor 28BYJ-48

Stepper motors are excellent for position control. They are a special type of brushless motor, where a full rotation is divided into equal steps . These motors are commonly found in desktop printers, 3D printers, CNC machines, and any machine that requires precise position control [6]. Stepper motors have the following specifications:

- Voltage: 5VDC
- Phase : 4
- Step Angle 5.625º (1/64)
- Reduction ratio: 1/64

And the software consists of:

1. Arduino IDE

Arduino IDE consists of:

- Program Editor, a window that allows users to write and edit programs in the Processing language.
- Compiler, a module that converts program code (Processing language) into binary code. However, a microcontroller only understands binary code.
- Uploader, a module that loads binary code from a computer into memory on the Arduino board.

The Arduino Integrated Development Environment (IDE) is a complete application that can be used for all series of Arduino family modules, except Arduino boards that use microcontrollers other than the AVR series [7].

2. *MIT App Inventor*

MIT App Inventor is an open-source web application currently maintained by the Massachusetts Institute of Technology (MIT) and originally developed by Google. New users can program computers and create software applications for the Android operating system using App Inventor, which has a graphical interface similar to the user interfaces of Stratch and StarLogo TNG [8]. To create applications that can run on Android devices , this graphical interface allows users to drag and drop visual objects. To achieve this goal, Google created App Inventor, which is based on computational computational research.

3. *Thingspeak ™*

ThingSpeak™ is a cloud-based IoT data analytics platform, enabling the collection, visualization, and analysis of data streams. With ThingSpeak™, people can instantly see the data posted on their devices. [9]. This Automatic Clothesline System requires a server to monitor sensor data sent via the wifi module. This is solved by Thinkspeak™. Thinkspeak™ is a free cloud service that you can use at no cost. For this final project, Thinkspeak™ was used because of its many features, such as data collection in a private channel ; application integration; support for Restful and MQTT APIs; MATLAB®-based analysis and visualization; and global community support. Devices such as Photon and Elektron Particle devices, Raspberry Pi, Arduino, and ESP8266 WiFi modules can all work with Thingspeak™. Thingspeak™ applications can be integrated with phones and web applications.

A. Methodology Design

The methodology design for this system uses *Visio software*, namely *Use Case* Diagram, *Flowchart Diagram, and includes application interface design, IoT* Architecture design , and prototype sketch design.

1. *Use Case* Diagram

The description of the system function in the form of symbols as documentation and a collection of actors in the existing system is known as a *use case* [10]. The expected functionality of the system is depicted in a use case diagram. The communication process between actors and the system, both human and machine entities that interact with the system to complete a specific task, is called a use case. A use case is a specific job, such as entering data into the system or making a shopping list. The following is *a Use Case* Diagram of an automatic clothes drying system. Where actors can control the clothes drying manually or automatically with a smartphone and can monitor weather conditions.

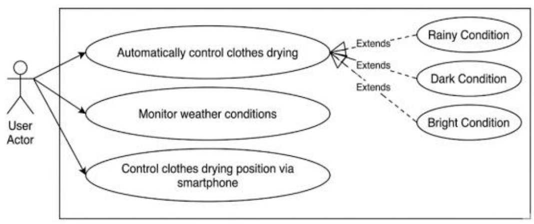

Figure 1. *Use Case* Diagram

2. *Flowchart* Diagram

The flowchart diagram of the automatic clothes drying system can be seen in Figure 2.

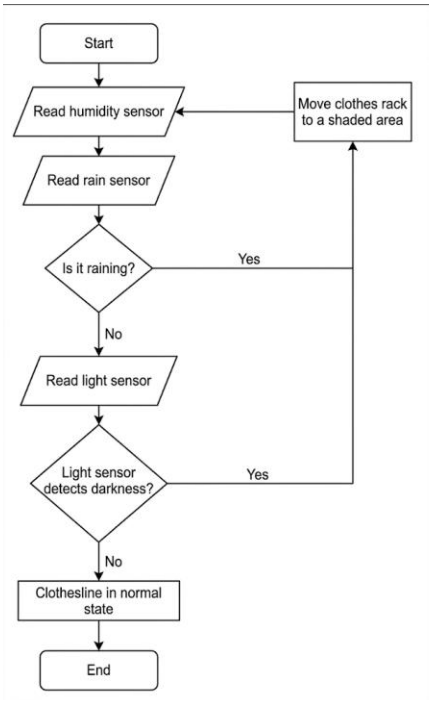

Figure 2. *Flowchart* Diagram

3. Application Interface Design

The application interface design for the automatic clothes drying system can be seen in Figure 3.

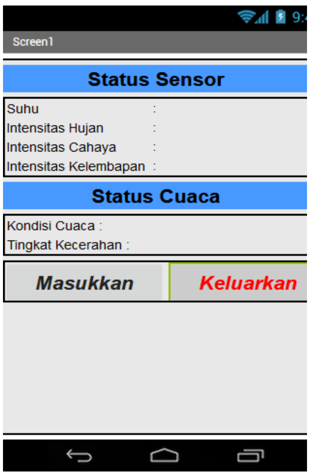

Figure 3. Application Interface Design

4. *IoT* Architecture Design

The Internet of Things architecture consists of four main parts: how IoT devices connect, communicate, and work together to achieve goals [11], namely:

a) *Device Layer* (*Things*)

The base layer in the IoT architecture that consists of all physical devices that collect, measure, and act on data from the physical environment. These devices include sensors, actuators, and *edge devices* that have computing capabilities. This layer is the foundation of the IoT architecture that enables the collection of data from the physical world and interaction with the physical environment through sensors and actuators [12].

b) *Communication Layer*

The Communication Layer is considered the backbone of an IoT system, and is the main channel between the application layer and the different operational activities in an IoT system [13].

c) *Platform Layer*

The platform layer consists of software and services that manage data collected by IoT devices and provide various services such as device management, data management, data analysis, and integration with cloud services [14].

d) *Application Layer*

The application layer is the user interface (UI) that provides a means for users to interact with IoT systems. These interfaces can take various forms, including web-based dashboards, mobile apps, voice assistants, or even augmented reality/virtual reality (AR/VR) experiences. The UI allows users to monitor, control, and access data generated by IoT devices [15].

5. Prototype Sketch Design

Figure 4 shows a sketch of a prototype of an automatic clothes drying system with remote control using Arduino and WiFi.

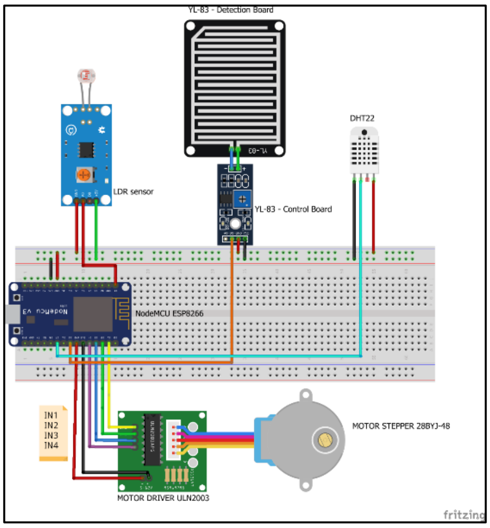

Figure 4. Prototype Sketch

Explanation of the structure connecting the sensors and actuators in the sketch above:

a) LDR sensor = Ground on the sensor is connected to Ground on the Nodemcu, VCC on the sensor is connected to 3v3 on the Nodemcu, A0 on the sensor is connected to Pin A0 on the Nodemcu.

b) Rain Sensor = Ground on the sensor is connected to Ground on the Nodemcu, VCC on the sensor is connected to 3v3 on the Nodemcu, D0 on the sensor is connected to Pin D5 on the Nodemcu.

c) DHT Sensor = the (-) symbol on the sensor is connected to Ground on the Nodemcu, the (+) symbol on the sensor is connected to 3v3 on the Nodemcu, Out on the sensor is connected to Pin D5 on the Nodemcu.

d) 28BYJ-48 Stepper Motor = the (-) symbol on the sensor is connected to Ground on Nodemcu, the (+) symbol on the sensor is connected to 3v3 on Nodemcu, Pin IN1 can be connected to Pin D1 on Nodemcu, Pin IN2 can be connected to Pin D2 on Nodemcu, Pin IN3 can be connected to pin D3 on Nodemcu, pin IN4 can be connected to pin D4 on Nodemcu.

III. RESULT DISCUSSION

This research will describe and illustrate the developed system and the findings obtained. The explanation begins with the specifications *of the hardware* and *software* used, the interface created, and *the database structure* implemented.

A. Hardware

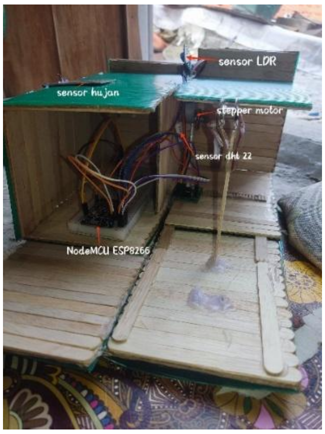

Figure 5. Hardware used

1) NodeMCU ESP8266 is used to control the entire system and communicate with sensors and platforms used in the automatic clothes drying system.
2) The DHT22 sensor is used to detect temperature and humidity which will send sensor signals to the NodeMCU.
3) The LDR sensor is used to detect light which will send a sensor signal to the NodeMCU.
4) Rain Sensor is used to detect the presence of rain/water which will send a sensor signal to the NodeMCU.
5) The 28BYJ-48 Stepper Motor is used to move the clothesline, where if it detects rain and dark light, it will put the clothesline in, and if it detects no rain and bright light, it will take the clothesline out.

B. Software

1) Arduino IDE is a platform used to write and upload code to NodeMCU.
2) Thingspeak™ is a cloud platform used to collect, visualize, and analyze sensor data in real-time.
3) MIT *App Inventor* was used to create a mobile application that allows users to control the clothesline and view the intensity of all sensors via an Android smartphone.

C. Testing Results

The following are the results of trials using various methods :

1) When it rains and the weather is daytime

When the rain sensor detects that it is raining and the LDR sensor detects light, it will send a signal to the nodemcu which will immediately activate the stepper motor and make the clothes being dried come inside and provide information in the form of weather conditions and the condition of the clothes that have been put inside via the mobile application.

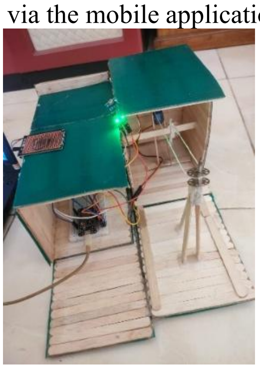
Figure 6 Conditions when it is raining and the weather is sunny during the day

2) When it is not raining and the weather is daytime

When the rain sensor detects that there is no rain and the LDR sensor detects the presence of light, it will send a signal to the nodemcu which will immediately activate the stepper motor and make the clothes come out and be ready to be dried and provide information in the form of weather conditions and the condition of the clothes that have been dried via a mobile application.

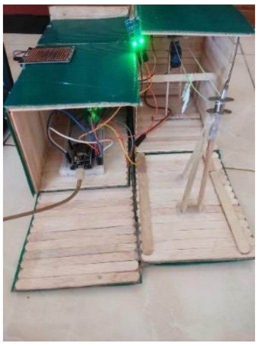
Figure 7 Conditions when it is not raining and the weather is daytime

3) When it rains and the weather is at night

When the rain sensor detects that it is raining and the LDR sensor detects that there is no light, it will send a signal to the nodemcu which will immediately activate the stepper motor and make the clothes being dried come inside and provide information in the form of weather conditions and the condition of the clothes that have been put inside via the mobile application.

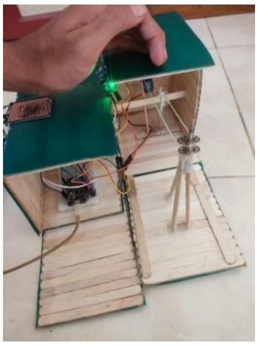

Figure 8 Conditions when it is raining and the weather is at night

4) When it is not raining and the weather is at night

When the rain sensor detects that there is no rain and the LDR sensor detects that there is no light, it will send a signal to the nodemcu which will immediately activate the stepper motor and make the clothes being dried come inside and provide information in the form of weather conditions and the condition of the clothes that have been put inside via the mobile application.

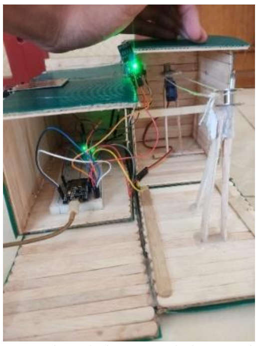

Figure 8 Conditions when it is not raining and the weather is at night

IV. CONCLUSION

From the results of research and development of an automatic clothes drying system with remote control using Arduino and WiFi, several conclusions can be drawn as follows:

1) Implementation of an Automatic Clothesline System **:** The developed automatic clothesline system is capable of moving the clothesline based on weather conditions detected by sensors (DHT22, LDR, and rain sensors). This system can close the clothesline when it detects rain or nighttime conditions with certain temperatures and humidity, and open the clothesline when the weather is sunny and supports drying clothes.
2) Using the ESP8266 and SG90 Servo Motor **:** The ESP8266 microcontroller allows the system to connect to a WiFi network and send sensor data to the ThingSpeak platform. The SG90 servo motor is used to physically move the clothesline based on conditions detected by the sensor.
3) Manual Control and Monitoring Dashboard: The MIT App Inventor application developed makes it easy for users to manually control the clothesline using the "Put Clothesline In" and "Take Clothesline Out" buttons. Furthermore, the monitoring dashboard provides real-time information on temperature, humidity, light intensity, and rainfall status, which helps users monitor the environmental conditions around the clothesline.

ThingSpeak Integration: Integration with the ThingSpeak platform enables real-time sensor data storage and analysis. This helps monitor and analyze changes in environmental conditions over time, improving the efficiency and reliability of the automated clothesline system.

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