Design and Implementation of Clothesline And Air Dryer Prototype Base on Internet of Things

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***Abstract*—Drying clothes is an activity that takes a lot of time if you have to wait and keep them dry. Not infrequently, clothes that have been dried in the sun get wet again because of the rain, and no one picks them up for various reasons. In addition, clothes that have been left on the clothesline for a long time have the potential to get moldy, especially when the humidity level is high. An IoT-based prototype automatic clothesline and air dryer were designed. The working system of this tool is briefly the Arduino Nano microcontroller processes input from 3 sensors (light sensor, rain sensor, and humidity sensor), then gives an instruction signal to the actuator (motor and fan) to respond to various input combinations. In addition, this tool is also integrated with the Internet of Things system (using the Node-Red application) for remote monitoring and control processes. This tool has been tested to respond to all conditions appropriately according to the desired specifications. Namely, the motor pulls the clothesline into the storage room when the system detects night (lighting 400 lux) or detects rain (water > 0.1 mL). Then the dryer fan will turn on when the system detects a high humidity level (> 65%), and the clothesline is in the storage room. The average delay of the motor in responding to input/instructions in manual mode is 1.42 seconds and in automatic mode is 0.66 seconds. The average fan delay in responding to input/instructions in manual mode is 1.20 seconds and in automatic mode is 0.91 seconds. Then, the average time it takes the dryer fan to reduce 1% humidity is 59.68 seconds.**

Keywords*—*clothesline, internet of things, arduino nano, node-red.

I. Introduction

Human life in this modern era is so dynamic and competitive. The majority of people today, both men and women make a career a priority in their lives, so small things like domestic affairs are often overlooked, for example, in terms of drying clothes that tend to take a lot of time if it has to wait for all the process to be completed. Especially when the rainy season has come, the process of drying clothes can be troublesome. Thus, from every problem that arises in human life, technology continues to develop and present as a solution, including the examples of issues that have been mentioned.

Several previous studies have resolved this issue. In 2012, a study was designed for a prototype automatic clothes dryer using the ATmega8535 microcontroller. The working principle of the design is made briefly. When the rain sensor does not detect the presence of rain, the motor will rotate and pull the mine out so that the position of the clothesline is outside. If the sensor detects the presence of rain, then the engine will pull the clothesline mine to enter so that the place of the clothes that are dried is inside [1].

Furthermore, in 2013, a simulation of the drying roof cover system was developed that has been equipped with light sensors (LDR) and rain sensors. In short, the way the system works is when the light sensor detects the presence of light. Then the fin roof will open or shift and if the raindrop sensor detects rainwater falling, then the roof will move and close the room [2].

Furthermore, in 2015, a similar tool was also designed using the ATmega328p (on Arduino Uno) as a microcontroller, which incidentally is superior and more complete than the ATmega8535 and ATmega16, both in terms of features, capacity, and programming functions. The way this tool works is briefly almost the same as the way the tool works in previous studies, namely when the rain sensor does not detect rain and the light sensor does not detect night. The motor will rotate and pull the rope out so that the clothesline is outside, and if the sensor detects it, In the presence of rain or night, the motor will pull the clothesline to enter so that the position of the clothes to be dried is inside [3].

Then in 2017, a similar design was also made using the ATmega328p microcontroller (on Arduino Nano) as a microcontroller and equipped with a remote control system [4]. For the design and how it works, the designs made are the same as in the first and third studies, namely the part of the moving rope. In this study, the design has been integrated with a remote control system, namely using Bluetooth and an application on Android [5].

This research combines concepts from previous research and provides some modifications to create more innovative and solutive tools. In this study, the idea of design taken is from the first, third, and fourth research, namely by making the rope/mine clothesline a moving part, because this kind of design is more economical and simple.

II. Research Mehodology

Research has important stages, including literature study, problem identification, needs analysis, design, implementation, testing, and analysis. These stages are prepared to support the research process to be systematic. The steps are then arranged into the form of flowcharts. Flowchart of research methodology can be seen in Fig 1.

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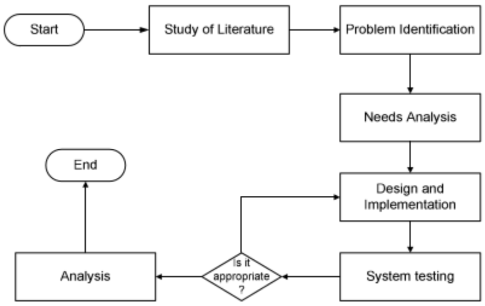


Fig. 1. Research Flow

Figure 1 shows that this research begins with a literature study, problem identification, and needs analysis, followed by designing a system, where this system has several inputs for light sensors including brightness levels measured by a luxmeter, rain sensors including the presence of detected rainwater, and the humidity sensor includes the level of humidity in the air in the clothesline. So that the sensors are combined in the form of a prototype so that it becomes easy to implement. System automation can be enabled as well as disabled. If the automatic mode is activated, the system will work based on the input data received by the sensor. When the automatic mode is deactivated, the system will work according to the user's command via his smartphone.

III. Design and Implementation

A. Design

The design is made as shown below:

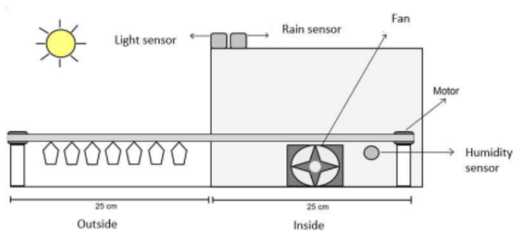
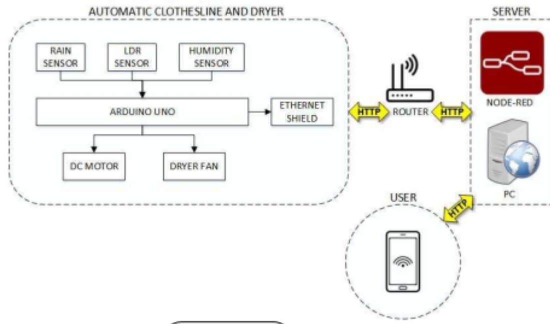


Fig. 2. Project Design

The design is created use case created on the application that has been prepared. A Use case diagram is a diagram used to briefly describe who is using the system and what can be done on the system. The use case diagram doesn't explain in detail about using use case, but it only gives a brief overview of the relationship between use case, actors, and systems. A use case diagram for prototype automatic clothesline and air dryer based on IoT shown in Fig 3.



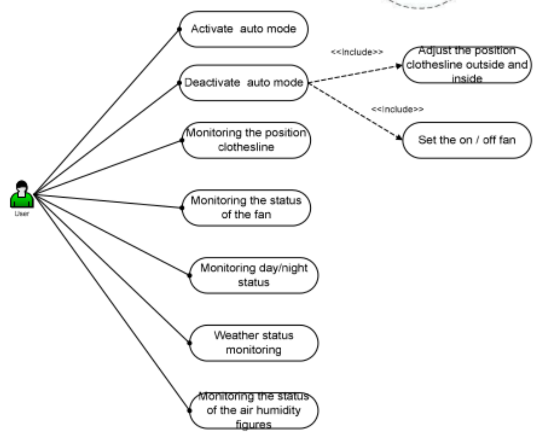


Fig. 3. Use case diagram

Tools require a working system design in order to work according to the desired function. This work system design contains a workflow of tools ranging from the first input to the last output. The system/workflow design of the internet-based automatic clothesline and dryer prototype of things is demonstrated by Figure 4

Fig. 4. System Design

Based on Figure 4, the design of the prototype automatic clothesline and air dryer system based on IoT is divided into three parts, namely the tool parts (clothesline and dryer), server, and user. The sensor de-texts the parameters/stimulus in the tool section and sends it to the microcontroller (Arduino Nano) as input. The light sensor detects the level of exposure. The rain sensor de-texts the presence of rain, and the humidity sensor detects the humidity figure in the storage space (the inside of the clothesline). Furthermore, the microcontroller will process the inputs, and then the microcontroller will send a command signal to the driver and relay according to the input received. The driver will control the rotation of the motor, while the relay will control the active and the absence of the dryer fan by the orders received from the microcontroller. The response of the motor and dryer fan is the final output of the tool [6].

Furthermore, Arduino Nano that has been connected with an ethernet shield, will send information data from the device to the server through the internet or local network (LAN) with HTTP protocol as a connecting "bridge". On the server side,

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ethernet sends sensor input data to Node-RED. Then Node-RED will process and visualize the data on the server computer after that, Node-RED will display the user interface on the user's smartphone bridged by the HTTP protocol [7].

In the user section, smartphones connected to the same internet connection or network as the server can access the tool through the user interface on the Node-RED dashboard. With the user interface, the user can monitor and control the tool remotely, anywhere, and anytime (as long as it is connected to the same internet network/network as the server) [8].

In this research using Arduino because this module is equipped with various things needed to support the microcontroller to work, the rain sensor detects the presence of rain, and the humidity sensor detects the humidity in the storage room (the inside of the clothesline).

B. Implementation

The design of the program is applied to the smartphone user as a user interface display, with which the user can monitor and control the tool (in this case, clothesline and automatic dryer) [9]. The user interface view on the smartphone can be seen in Figure 5

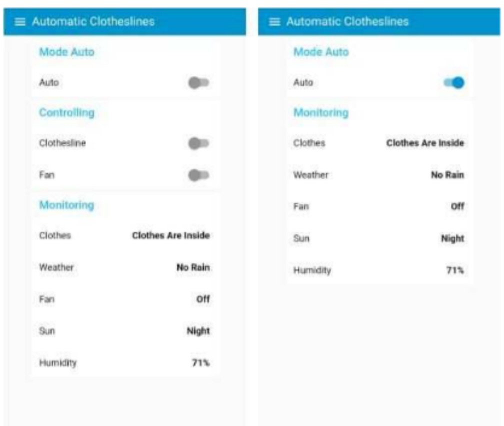

Fig. 5. User interface on smartphone

Implementation/realization of The Internet of Things-based Automatic Clothesline and Dryer Prototype system can be seen in Figure 6

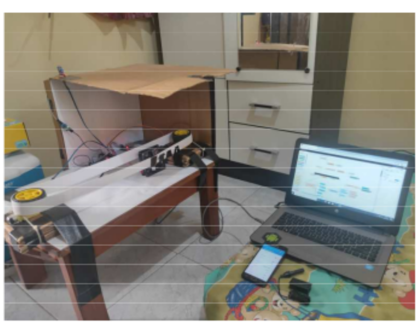

Fig. 6. Prototype system automatic clothesline and dryer

IV. TESTING AND ANALYSIS

A. Rain sensor (FC-37) Testing and Analysis

Rain sensor testing is performed by dripping water on the sensor using a dropping pipette to represent rain. The experiment was conducted by varying the number of water droplets (it is known that the volume of every one drop of water from the pipette is 0.05 mL). The sensor is accurate and worth using if the indicator light is lit in the presence of water on the sensor and turns off when dry. The results of this rain sensor test can be seen in Table I below

TABLE I. RAIN SENSOR TEST RESULT

Test	Water (ml)	Indicator Light	Information
1	0	Off	dry
2	0,05	Off	1 drop pippete
3	0	Off	be dried
4	0,10	On	2 drop pippete
5	0	Off	be dried
6	0,15	On	3 drop pippete
7	0	Off	be dried
8	0,20	On	4 drop pippete
9	0	Off	be dried
10	0,25	On	5 drop pippete

From the test result data in Table I, it can be known that the indicator light lights up when given input two drops of water or more because the sensitivity of the sensor is deliberately set in such a way as to be inactive when the input received < 0.1 mL (less than two drops of the pipette) to distinguish between rain inputs and inputs from other water sources, such as dew, water vapor and so on.

B. Light Sensor Testing and Analysis

Light sensor testing is performed by lighting the light sensor using a flashlight. In this experiment, lux meters were used as a measure of exposure levels. The flashlight is brought near or away so that various levels of exposure are obtained. The sensor is declared accurate and worth using if the indicator light is lit when given a lighting level above 400 lux and turns off when given a lighting level below 400 lux. The test results of light sensors with a lighting level of ≤ 400 lux can be seen in Table II below.

TABLE II. TEST RESULT < 400 LUX

Test	Lux Meter (Lux)	Indicator Light
1	0	Off
2	1	Off
3	20	Off
4	25	Off
5	40	Off
6	50	Off
7	60	Off
8	75	Off

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Test	Lux Meter (Lux)	Indicator Light
9	100	Off
10	125	Off

From the test result data in Table 5.2, it can be known that the indicator light on the light sensor is off for all input samples ⩽ 400 lux. With these test results, the light sensor used meets 1 of 2 eligibility requirements for use. Furthermore, the test results of light sensors with a > 400 lux exposure level can be seen in Table III.

TABLE III. TEST RESULT > 400 LUX

Test	Lux Meter (Lux)	Indicator Light
1	401	On
2	1007	On
3	1230	On
4	2072	On
5	2967	On
6	3194	On
7	5377	On
8	10465	On
9	15475	On
10	20007	On

From the test result data in Table III, the indicator light on the light sensor is on for all exposure input samples > 400 lux. With these test results, it can be ensured that the light sensor used is accurate and feasible to use.

C. Humidity Sensor Testing and Analysis

This experiment used a hygrometer as a measure of humidity level. Moisture variations are obtained by placing sensors and hygrometer probes in rooms with different humidity. It can also be by using a damp or slightly wet cloth. This moisture sensor test uses the fan to indicate whether or not the sensor works because of the humidity sensor, and there are no indicator lights such as light sensors and rain sensors. The sensor is accurate if the fan (as an indicator) turns on when it detects a humidity figure above 65% and turns off when it detects a humidity figure of ⩽ 65%. In addition, the percentage of errors will also be calculated by comparing the humidity figure detected by the hygrometer with the humidity figure detected by the sensor (visualized on Node-Red). The results of moisture sensor testing with a humidity level of ⩽ 65 % can be seen in Table IV below.

TABLE IV. HUMIDITY SENSOR TEST RESULT <65%

Test	Hygro meter (%)	DHT (%)	Fan	Deviation	Error (%)
1	51	57	Off	6	11,76
2	53	59	Off	6	11,32
3	52	58	Off	6	11,53
4	52	57	Off	5	9,62
5	54	59	Off	5	9,26
6	53	58	Off	5	9,43
7	53	57	Off	4	7,55
8	53	58	Off	5	9,43
9	57	60	Off	3	5,26
10	56	59	Off	3	5,36
Average				4,8	9,05

The test data in Table IV shows that the indicator fan is off for all moisture samples detected by the sensor 65%. This indicates that the humidity sensor used has met 1 of 2 eligibility requirements for use. Furthermore, testing the humidity sensor with a humidity level of > 65% can be seen in Table V.

TABLE V. HUMIDITY SENSOR TEST RESULT > 65%

Test	Hygro meter (%)	DHT (%)	Fan	Deviation	Error (%)
1	64	67	On	3	4,69
2	68	71	On	3	4,41
3	68	72	On	4	5,88
4	67	71	On	4	5,97
5	66	69	On	3	4,55
6	64	67	On	3	4,69
7	62	66	On	4	6,45
8	74	77	On	3	4,05
9	67	70	Off	3	4,48
10	68	73	On	5	7,35
Average				3,5	6,15

From the test result data in Table V, it can be known that the indicator fan is on for all moisture samples detected by the sensor > 65%. With this, it can be ensured that the moisture sensor used is worth using. It is also known that the average difference in the value of the hygrometer measurement with the sensor for the humidity figure > 65 % is 3.5. Furthermore, it is known that the average error is 6,15 % so that the sensor accuracy value is intercepted to detect humidity > 65 % by 94.92 %. From the results of this test can be ascertained that the moisture sensor used is entirely accurate.

Through the measurement data in Table IV and Table V, the results show that the average measurement error produced by DHT is 9.05% and 6.35, this shows that the level of accuracy in measuring air humidity is quite good because it is still below 10%. If the measurement error is above 10%, it needs to be recalibrated, because the level of accuracy is low.

D. Manual Mode Testing and Analysis

The tool can be operated in 2 modes, manual and automatic modes. When manual mode is enabled, the tool

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will work according to the user's instructions and ignore the input of all sensors. This test aims to know the delay required by the tool in responding to user instructions. In addition, the delay time is also calculated using a stopwatch ranging from inputs inserted up to actuators (motors and fans) moving. Manual mode is declared successful on the average delay of no more than 5 seconds. The results of manual mode testing with the motor actuator can be seen in Table VI.

TABLE VI. TEST RESULT MANUAL MODE WITH MOTOR ACTUATOR

Test	Initial Status	Final Status	Delay Motor (s)
1	Out	In	1,24
2	In	Out	1,25
3	Out	In	1,96
4	In	Out	1,31
5	Out	In	1,11
6	In	Out	1,51
7	Out	In	1,77
8	In	Out	1,19
9	Out	In	1,70
10	In	Out	1,57
Average			1,46

From the test result data in Table VI, it can be known that the average delay in manual mode testing with a motor actuator is 1.46 seconds. For manual mode test results with the actuator can be seen in Table VII.

TABLE VII. MANUAL MODE TEST RESULTS WITH FAN ACTUATOR

Test	Initial Status	Final Status	Delay Fan (s)
1	Off	On	1,18
2	On	Off	1,31
3	Off	On	1,24
4	On	Off	0,85
5	Off	On	0,79
6	On	Off	1,37
7	Off	On	0,98
8	On	Off	1,11
9	Off	On	1,50
10	On	Off	1,50
Average			1,18

From the test result data in Table VII, it can be known that the average delay in manual mode testing with the fan actuator is 1.20 seconds. The test results can be ensured that the manual mode on the tool is successful and feasible to use.

E. Automated Mode Testing and Analysis

When automatic mode is activated, the tool will work according to the input received by the sensors. This test aims to ensure the accuracy of the tool system response to various input variations and to know the delay of the system response. The delay time is calculated using a stopwatch ranging from the auto mode button pressed until the actuator (motor and fan) move. The results of automatic mode testing with the initial position of the clothesline (motor) outside and the fan off can be seen in Table VIII.

TABLE VIII. AUTO MODE TEST RESULTS

No	Input			Output			
	LDR	*FC-37*	*DHT*	*Motor*		*Fan*	
				Status	Time (s)	Status	Time (s)
1	Night	Rain	Moist	in	1,2	on	3,1
2	Night	Rain	Moist	in	1,32	on	3,29
3	Night	Rain	Dry	in	1,12	off	0
4	Night	Rain	Dry	in	1,18	off	0
5	Night	No Rain	Moist	in	1,58	on	2,24
6	Night	No Rain	Moist	in	1,53	on	2,84
7	Night	No Rain	Dry	in	1,25	off	0
8	Night	No Rain	Dry	in	1,05	off	0
9	Day	Rain	Moist	in	1,51	on	2,96
10	Day	Rain	Moist	in	1,07	on	2,19
Average					0,96	Avrg	1,04

From the test result data in Table VII, it can be known that the system response is suitable for all conditions and obtained an average motor delay of 0.96 seconds and an average fan delay of 1.04 seconds. For delays worth 0 seconds, there is no change in the position/status of the actuator.

F. Testing and Analysis of Air Dryer Fans

This test aims to determine the effectiveness and time it takes for the air dryer fan to reduce the amount of air humidity in the clothesline storage space. Testing was conducted by making the humidity figure in the storage room above 65% first (putting a damp cloth/spraying water with spray). Then when the air humidity figure detected by the sensor stops moving up/stable, then the dryer fan starts to turn on until the humidity figure drops to 65% and the time is recorded. The air dryer fan is considered effective if it can reduce the humidity rate in the room up to a ⩽65%. The data of dryer fan test results can be found in Table IX.

TABLE IX. AIR DRYER FAN TEST RESULTS

Test	Initial Humidity (%)	Final Humidity (%)	Time (s)
1	68	65	187
2	73	65	453
3	80	65	886
4	86	65	1,238
5	93	65	1,720

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V. CONCLUSION

This study concludes that the design of the Prototype Automatic Clothesline and Air Dryer tool based on the Internet of Things is, in automatic mode can respond to all conditions appropriately according to the desired function. The motor pulls clothesline into the storage room when the system detects night (lighting $\leqslant$ 400 lux) or detects rain (water > 0.1 mL). Then the dryer fan will turn on when the system detects a high gluing rate (> 65 %) and the clothesline is in storage.

The average delay of the motor in responding to input/instruction in manual mode is 1.42 seconds and in auto mode is 0.66 seconds. Then the average delay of the fan in responding to inputs/instructions in manual mode is 1.20 seconds and in automatic mode of 0.91 seconds.

The air dryer system is able to lower the amount of air humidity in the clothesline storage room to the figure of $\leqslant$ 65%, with the average time it takes to decrease 1% of the gluing rate is 59.68 seconds (the higher the humidity figure in the room, the more time it takes).

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