Design of Automatic Gate Rolling Door Control System Using Rain Drop Sensor

Afan Taufiqurrohman
Faculty of Engineering
Electrical Engineering Study Program
Mercu Buana University
affantaufiq97@gmail.com

Imelda Uli Vistalina Simanjuntak
Faculty of Engineering
Electrical Engineering Study Program
Mercu Buana University
imelda.simanjuntak@mercubuana.ac.id

Abstract - Rolling doors used by small-scale industrial companies are still operated manually with conventional up, down, and stop button panels. This is the cause of the problem of inefficient transportation mobility that operates and causes product losses due to rainwater splashing that enters the warehouse. Therefore, this study aims to implement an automatic rolling door with a DC motor drive assisted by a raindrop sensor. The research method used is a literature study approach: identifying problems, determining the focus and research objectives, designing and implementing prototype solutions, testing, discussing, and drawing conclusions. Based on system testing, it was found that the response time for reading the rain sensor took 1.19 seconds, and the response time for reading the rain sensor to detect light again was 0.92 seconds. The delay time for the DC motor to rotate to close the gate when it receives a sensor signal in rainy conditions is 1.34 seconds, and the delay time for opening the gate when it receives a sensor signal that is bright again or the sensor is dry is 0.98 seconds. Based on the results of system testing, it was found that the delay time buzzer sounded as a warning sign if someone crossed it for 0.86 seconds. Overall, the test results show that the system is running well according to the functions, and system algorithms are active at the same time.

Keywords : Arduino Uno, Raindrop Sensor, Infrared Sensor, response time, delay

I. INTRODUCTION

An industrial rolling door is a security gate from a building on all sides of the company building to facilitate entry and exit of vehicles from various receiving blocks and delivery of goods or products produced. [1]. Rolling doors, usually used by industrial companies, are usually made of aluminum, mild steel with a coating or plating coating, or a mixture of iron, such as plates coated with paint. The model often used is the model that opens and closes by rolling upwards where there is a storage roll, opening and closing like a curtain, and shifting towards one side of the gate. [2].

Almost every industrial company has a gate rolling door, which functions as the main door for employees to enter and leave, for delivery trucks to enter and leave, and as a barrier to rainwater when there is heavy rain. Several types of rolling gates can be operated automatically or manually. However, in reality, many industrial companies still operate gate rolling doors manually with panels placed on each gate rolling door, which are operated by pressing the Up, Down, and Stop buttons. [3].

Here are some references to support this research: Reference [1] uses a QR code connected to an Android via Bluetooth. If the QR Code is wrong, it will notify the user of danger, and an alarm will sound. Reference [4] uses a rain detection sensor on the Arduino Uno control. Reference [2] uses a motor driver and a 5V DC motor as a drive for a fence or an automatic door. Reference [5] uses an Arduino Atmega328 and a 5V DC motor as a sliding automatic door drive motor, also controlled by Bluetooth HC-05..

Reference [6] proposes an automatic clothesline design that is equipped with a light sensor and a water sensor and is also equipped with a humidity sensor to measure the dryness level of clothes. Reference [7] uses a DC motor to slide a door or railing while operating. The scope of this research is the design of automatic fences and doors on a residential scale. Reference [8] uses a rain sensor to detect weather and rainfall and a servo motor as the driving force of an automatic clothes drying system. The concept is straightforward, but with maximum results and functions from the design in this study, Reference [9] uses a fuzzy system to move the sensor, which moves based on the PH value, and this prototype uses the same system using sensors to detect weather and rainfall.

Based on the explanation above, the authors did this research aimed at designing an automatic system by monitoring the main gate area, the supervisor area, and the security post. Arduino Uno controls the system by using a rain sensor to read weather conditions and automatically close when it rains, anticipating rainwater splashing on the product. This tool makes it easier for supervisors to control and operate rolling gates within the scope of one company. This tool is called "Design of an Automatic Gate Rolling Door Control System Using a Rain Drop Sensor. With this prototype tool, it is hoped that it will be easier for supervisors and those in charge to operate the gate in the company's industry.

II. BASIC OF THEORY

In simple terms, a system can be defined as a collection or assemblage of elements, components, or variables that are organized, interacting, interdependent, and integrated. The elements that make up a system are input, processing, and output [9]. Various kinds of research have been conducted to create a simulation or prototype of the operation of automatic gates and the design of automatic clotheslines. This research was done by combining the average of these studies to drive the automatic gate with the input signal from the rain sensor, which is based on the weather and then processed by Arduino and driven by a DC motor.

This study aims to design a prototype for operating a rolling door automatically based on the weather by using a rain sensor as a rain detector that can be used to make it easier for the user or person in charge to operate the rolling door when it rains, no longer needing to go around the entire building to press each button. Rolling Doors.

A. *Rain Drop Sensor*

The definition of a rain sensor is a rain detection signal that functions to provide signals in the form of ON and OFF logic. This rain sensor has two outputs, namely analog (AO) and digital (DO) [10]. The rain sensor (figure 1) is mounted directly on top of the prototype tool so that the simulation can read when it rains or is hit by water splashes..

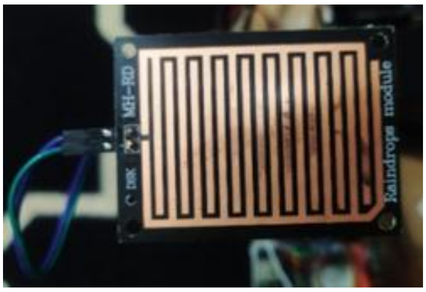

Figure 1. Rain Sensor

B. *Infrared Sensor*

In making a system, a safety system must be embedded when the system is actively operating automatically, namely by adding an input sensor. Infrared sensors, as shown in Figure 2, are used as security sensors in the system because they can detect an object blocking and passing in front of the sensor when the system is operating automatically. The infrared sensor works when the infrared sensor is directed at an object and is blocked. The sensor then receives the reflection and generates an electric current as a manifestation of the distance between the sensor and the object [11].

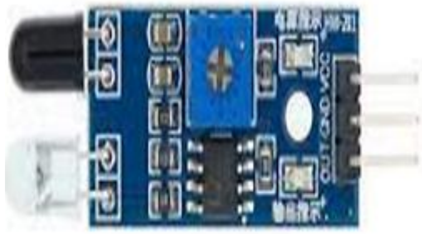

Figure 2. Infrared Sensors

C. The 5 Volt DC

The 5 Volt DC motor has two wires, namely the positive power supply and ground, which can be exchanged for rotation in different directions [12]. In controlling the DC motor (figure 3), it is assisted by the L298N motor driver. This DC motor is the prime mover to close or open the gate according to the signal received by the rain sensor and infrared sensor, which Arduino Uno processes as a microcontroller in making a prototype of this tool.

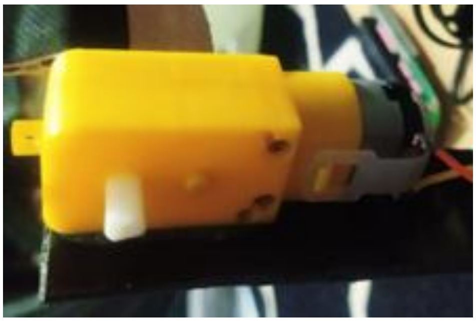

Figure 3. 5V DC Motor

D. Buzzer

The buzzer in Figure 4 is an electronic component that converts electrical vibrations into sound vibrations [13]. This buzzer is used as a security on the system, made in the form of a warning alarm marker that sounds automatically when the system is running.

Figure 4. Buzzers

E. LCD I2C

I2C LCD (figure 5) is a component used for display on the microcontroller. It can display information in text and numbers with a maximum of 16 characters on the top display and 16 characters on the bottom. I2C LCDs information on the condition of the system that is running.

Figure 5. LCD I2C

III. RESEARCH METHOD

This system includes two designs: hardware (hardware) and software (software). The discussion covers the steps that will be used in completing hardware in the form of supporting physical components such as Arduino Uno, raindrop sensors, LEDs, buzzers, DC motors and motor drivers, infrared sensors, and Arduino IDE software, which contains a program for tools. The implementation is done by determining general specifications, designing hardware, and realizing software..

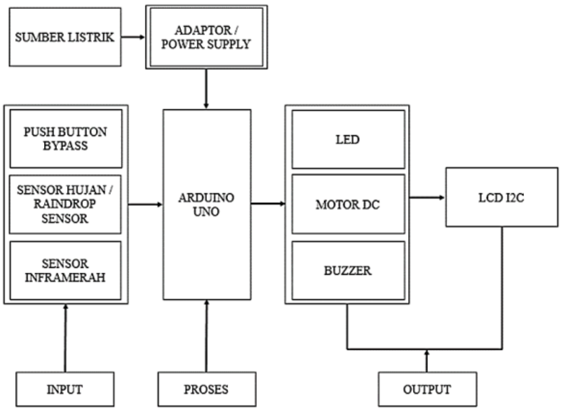

Figure 6. System Block Diagram

Based on Figure 6, a series of block diagrams consisting of input, process, and output is designed. The explanation of the block diagram function is as follows:

1. Rain sensors and infrared sensors are used as a system input. Rain sensors are used to read actual weather conditions, and infrared sensors as signal readings for obstacles when the system runs automatically.
2. Arduino Uno will process the reading results of the two sensors as a microcontroller in the created system.
3. Arduino controls the DC motor as a gate drive that automatically opens or closes according to sensor readings.
4. The results that the Arduino has processed will display the information on the I2C LCD.

The control system starts with system initialization. In the system initialization process, the system will initialize all devices connected to the Arduino Uno. Rain sensor readings are the primary input in the system. When the rain sensor is active, when the weather is rainy, when the infrared sensor is not active, or when there are no obstacles, the DC motor is active to close the gate, along with the red LED that lights up and the I2C LCD. If the weather is bright or the rain sensor is dry again, then the DC motor is active to open the gate, the green LED lights up, and the information is displayed on the I2C LCD. However, if the two sensors are active simultaneously, namely the rain sensor and the infrared sensor (there is an obstacle), the DC motor stops or does not move. The alarm will sound until the infrared sensor does not detect any obstacles. The system returns to reading the condition of the rain sensor.

Figure 1 is a schematic diagram assembled using software simulation to connect each component to the Arduino Uno by pulling the jumper wires connected based on the output of an analog or digital signal. The schematic circuit that has been made is made by the Arduino Uno IDE program with the Arduino C++ language, adjusted for the jumper cables that are connected, so that the program will be made according to the jumpers that have been arranged. Figure 7 is the hardware that used the microcontroller as the input provider to the rain sensor (Raindrop Sensor), figure 8 is the infrared sensor, and figure 9 is the push button bypass (figure 9)..

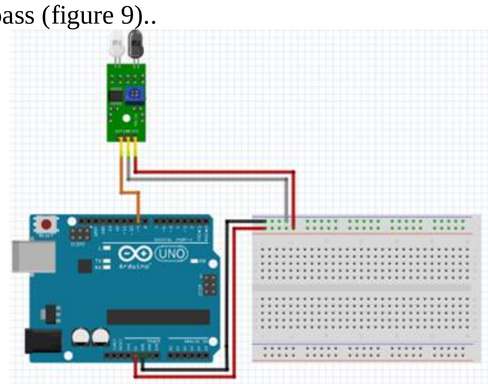

Figure 7. Rain Sensor Circuit

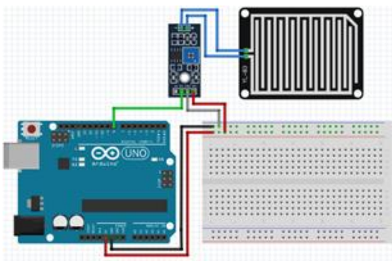

Figure 8. Infrared Sensor Circuit

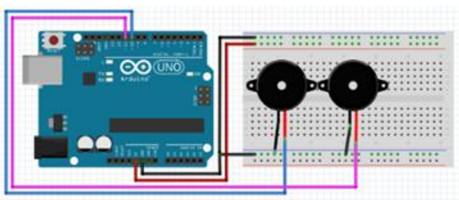

Figure 9. Buzzer circuit

Then it processes the received data according to the program that was made before and output it according to the program that has been made, namely to move the DC motor (figure 10) as the driving force for opening and closing the gate. Then calculate the digital and analog values obtained, then the information can be displayed on the I2C LCD (figure 11).

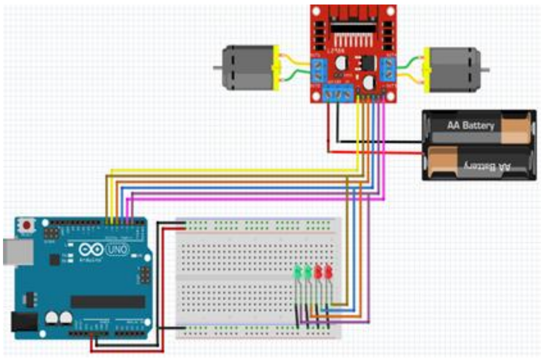

Figure 10. DC Motor Circuit and Motor Driver L298N

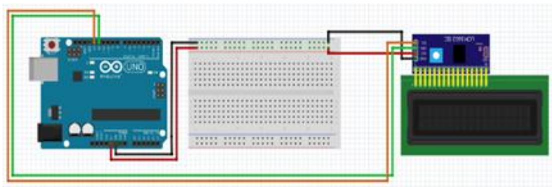

Figure 11. I2C LCD series

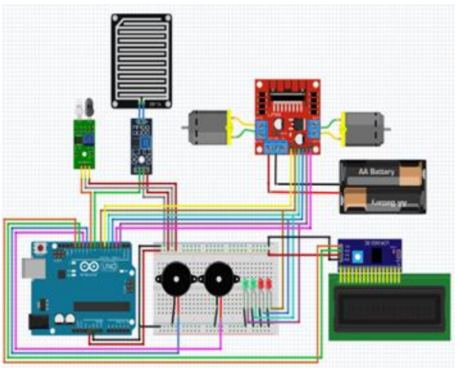

Figure 12. Control System Schematic Diagram

IV. RESULTS AND DISCUSSION

Testing is one of the steps that must be carried out to know the advantages and disadvantages of the system that has been made. The test results will be analyzed to find out the causes of deficiencies and errors in the gate rolling door system (Figure 14) that have been made.

Figure 13. Design of Automatic Gate Rolling Door Control System

A. Response Time Testing of Rain Sensor

This test was carried out on the system to ensure the speed response when the rain sensor detects rain or when the weather returns to sunny. The sensor works when it gets water droplets or the sensor surface is wet, and when the sensor is dry again..

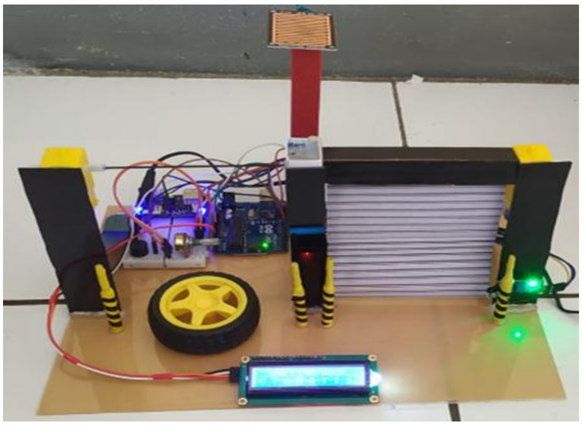

Figure 14. Water droplets on the rain sensor

Table 1. Response time of the rain sensor to detect rain

No.	Rain Sensor Status	Number of Water Drops	Detected Response Time (seconds)
1	Active (Rain)	3 x	1.54
2	Active (Rain)	3 x	1.65
3	Active (Rain)	3 x	1.47
4	Active (Rain)	4 x	1.25
5	Active (Rain)	4 x	1.11
6	Active (Rain)	4 x	1.19
7	Active (Rain)	5 x	0.97
8	Active (Rain)	5 x	0.90
9	Active (Rain)	5 x	0.95
10	Active (Rain)	6 x	0.87

The results of the rain sensor response time test (table 1) aim to detect rain, which is done by calculating the response time for the active rain sensor when it gets water droplets and counting it using a stopwatch ten times. Testing Average time in testing = (total amount of time)/(number of tests) $= \frac{11{,}9}{10} =$ 1,19 seconds.

So the results of the tests carried out are the average sensor response time of 1.19 seconds with four times the water droplets on the surface of the rain sensor.

Table 2. Response time of the rain sensor to detect sunny weather

No	Rain Sensor Status	sensor condition	Detected Response Time (seconds)
1	not active	dry	0,96
2	not active	dry	0,89
3	not active	dry	0,92
4	not active	dry	1,01
5	not active	dry	0,83

Table 2 shows the rain sensor's response time to detect when the weather is sunny again. This test was carried out by wiping the wet sensor surface to dry again and performing five tests. Testing Average time in testing =(total amount of time)/(number of tests) = 4.61/5 = 0.92 seconds.

B. Testing Delay Time on DC Motors

This test is carried out to determine the function of the DC motor and to determine the delay time of the DC motor rotating or moving. How To rotate the DC motor, there are two methods by getting a signal from the rain sensor with two conditions: when it is raining and when it is bright.

Table 3. DC motor delay time when receiving a rain condition sensor signal

No.	DC Motor Condition (Rotating)	Delay Time (seconds)
1	ON (close)	1,17
2	ON (close)	1,38
3	ON (close)	1,24
4	ON (close)	1,56
5	ON (close)	1,29
6	ON (close)	1,08
7	ON (close)	1,62
8	ON (close)	1,59
9	ON (close)	1,42
10	ON (close)	1,73

Table 3 calculates the delay time using a stopwatch for ten times the test. Testing Average time in testing = (total time)/(number of tests) = 13.48/10 = 1.34 seconds.

The delay time is influenced by the amount of voltage and electric current received by the DC motor because it uses an additional power supply.

Table 4. Delay Time for DC motors when they get a sensor signal. The conditions are bright again

No.	DC Motor Condition (Rotating)	Delay Time (seconds)
1	ON (Open)	0,92
2	ON (Open)	0,77
3	ON (Open)	0,89
4	ON (Open)	1,04
5	ON (Open)	1,17
6	ON (Open)	0,91
7	ON (Open)	1,25
8	ON (Open)	0,85
9	ON (Open)	1,12
10	ON (Open)	0,94

For ten tests, calculate the delay time on a DC motor using a stopwatch. Testing Average time in testing =
(total time)/(number of tests) = 9.86/10 = 0.98 seconds
The delay time in Table 4 is influenced by the voltage and electric current received by the DC motor because it uses an additional power supply.

C. Infrared Sensor Accuracy Testing

Infrared sensor testing is carried out in 4 positions of the object's state as an obstacle or object in front of the sensor by calibrating according to the desired limit distance. The results of infrared sensor testing can be seen in Figure 15 as follows:

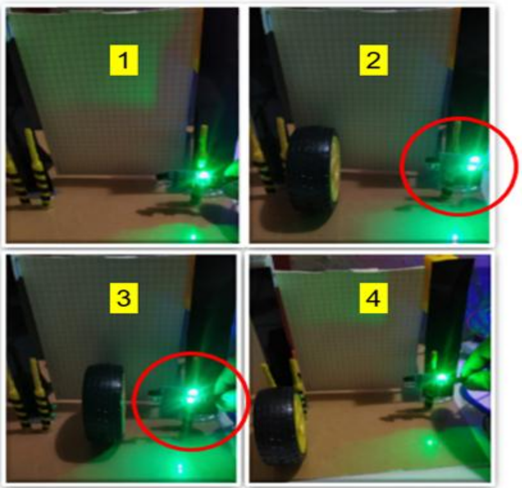

Figure 15. Infrared Sensor Testing

The sensor will activate and signal the system when an obstacle is in front of the infrared sensor at a predetermined distance.

1. No sensor obstruction in a free state
2. The sensor is blocked by an object at the end of the gate or at the farthest distance from the sensor.
3. An object in the middle of the gate blocks the sensor.
4. Obstacle-free sensors cannot detect objects because they are outside the set distance range.

D. Testing the Delay Time on the Buzzer Sounding

Its function is to make a warning sound in the form of an alarm if someone crosses while the system is operating. Testing the delay time on the buzzer sounds was carried out 10 times, and the time was calculated using a stopwatch

Table 5. Delay Time buzzer sounds

No.	Buzzer's status	Delay Time (seconds)
1	ON (Beep)	0,78
2	ON (Beep)	0,88
3	ON (Beep)	0,91
4	ON (Beep)	0,93
5	ON (Beep)	0,84
6	ON (Beep)	0,73
7	ON (Beep)	0,99
8	ON (Beep)	0,76
9	ON (Beep)	0,89
10	ON (Beep)	0,95

Test results in Table 5 average time in testing =

(total time)/(number of tests) = 8.66/10 = 0.86 seconds

So the results of the tests show the delay time buzzer sounds as a warning sign of an alarm if someone crosses while the system operates with an average of 0.86 seconds.

E. I2C LCD Display Testing

In the display test, the I2C LCD will display information regarding the actual conditions of the running system. The information display adapts to weather conditions and gates simultaneously.

Figure 16. Testing the I2C LCD Display

F. Overall System Testing

This test is carried out with a tool made and installed on an automatic rolling door system. Tests are carried out to determine whether each component's function works appropriately, following the algorithm that has been made. Retrieval of data by testing some of the logic of the system, then testing it as a whole according to the plan made as the main requirement for the system to work correctly.

Table 6. Overall System Testing

INPUT		OUTPUT		Rolling Door Condition	Status
Rain Drop Sensor	Infra red Sensor	Motor DC	Buzzer		
ON (Rain)	OFF	ON (Down)	OFF	close	OK
ON (sunny / dry)	OFF	ON (Up)	OFF	open	OK
ON (Rain)	ON	OFF	ON Alarm	stop	OK
ON (sunny / dry)	ON	ON (Up)	OFF	open	OK
OFF	OFF	OFF	OFF	stop	OK

From Table 6, it can be seen that the system can work according to the algorithm that has been made. The system works when the weather outside is rainy. Then the rain sensor or raindrop sensor detects rain and sends a signal to the system to be forwarded to the DC motor as the driving force to close the gate rolling door, and the gate closing indicator lights up.

When the rain is over and the weather is sunny again, the surface of the rain sensor or raindrop sensor is dry again, so it sends a signal to the system to be forwarded to the DC motor as the driving force to open the rolling door gate again, and the open gate indicator lights up. Then if it is raining and the active infrared sensor detects an obstacle and the DC motor is not active or silent, the alarm will sound until the infrared sensor is free..

V. CONCLUSION

Based on system testing, the average response time for rain sensor readings to detect rain is 1.19 seconds, and the average response time for rain sensor readings when it is sunny again or when the sensor is dry is 0.92 seconds. The average delay time for DC motors to close the gate when receiving sensor signals in rainy conditions is 1.34 seconds, and the average delay time for DC motors when receiving sensor signals in sunny conditions is 0.98 seconds. The DC motor delay time is greatly influenced by the voltage and current received by the DC motor because it uses an additional power supply. In testing, the actual system voltage given is 4.8 volts. Accuracy of readings on infrared sensors The sensor will activate and signal the system when there is an obstacle within a predetermined distance of the infrared sensor. The delay time for the buzzer to sound as a warning sign if someone is crossing while the system runs automatically is an average of 0.86 seconds. The I2C LCD can display information on weather conditions and gates according to the running system. Based on testing the entire system, it runs well according to the system functions and algorithms that have been made. The two input sensors (rain sensor and infrared sensor) that are active simultaneously can be adequately connected.

REFERENCES

[1] A. Putra and D. H. R. Saputra, "Otomasi Rolling Door Menggunakan Android dan QR Code," *Jurnal Simetri Rekayasa*, vol. 1, no. 2, pp. 36–38, 2019.

[2] A. P. Zanofa, R. Arrahman, M. Bakri, and A. Budiman, "Pintu Gerbang Otomatis Berbasis Mikrokontroler Arduino UNO R3," *Jurnal Teknik Dan Sistem Komputer*, vol. 1, no. 1, pp. 22–27, 2020.

[3] D. Ngani, K. J. Tute, and B. Y. Bhae, "RANCANG BANGUN AKSES KONTROL PINTU RUMAH DENGAN MENGGUNAKAN MIKROKONTROLER ARDUINO UNO," *Simtek: jurnal sistem informasi dan teknik komputer*, vol. 8, no. 1, pp. 154–158, 2023.

[4] D. Siswanto, "Jemuran pakaian otomatis menggunakan sensor hujan dan sensor ldr berbasis Arduino Uno," *e-NARODROID*, vol. 1, no. 2, 2015.

[5] F. Sihombing and N. J. Siburian, "Perancangan Gerbang Otomatis Menggunakan Frekuensi Berbasis Arduino," *Jurnal ELPOTECS*, vol. 4, no. 2, pp. 10–21, 2021.

[6] T. M. Banjarnahor, S. Sumarno, B. E. Damanik, I. Gunawan, and I. O. Kirana, "Jemuran Pintar Dengan Sensor Ldr, Sensor Hujan, Sensor Suhu Dan Sensor KecepatanAngin Berbasis Arduino," *Building of Informatics, Technology and Science (BITS)*, vol. 1, no. 2, pp. 75–81, 2019.

[7] A. Hasibuan, R. Rosdiana, and D. S. Tambunan, "Design and Development of An Automatic Door Gate Based on Internet of Things Using Arduino Uno," *Bulletin of Computer Science and Electrical Engineering*, vol. 2, no. 1, pp. 17–27, 2021.

[8] M. Berahim, S. N. A. A. Hei, E. N. Nazri, and N. F. M. Rafik, "Automatic Clothesline Retrieval Prototype with Humidity Alert System to Aid Clothesline Drawbacks for Reducing Laundry Worries," *Multidisciplinary Applied Research and Innovation*, vol. 2, no. 1, pp. 401–410, 2021.

[9] L. M. Silalahi, D. Jatikusumo, S. Budiyanto, F. A. Silaban, I. U. V. Simanjuntak, and A. D. Rochendi, "Internet of things implementation and analysis of fuzzy Tsukamoto in prototype irrigation of rice," *Int. J. Electr. Comput. Eng*, vol. 12, no. 6, pp. 6022–6033, 2022.

[10] J. Pakaian, M. Sensor, H. Berbasis, M. Dwi Payana, W. Mulia, and M. Iqbal, "Perancangan Prototipe Sistem Tutup Kanopi Otomatis Pada," *Journal of Informatics and Computer Science*, vol. 5, no. 1, pp. 1–9, 2019.

[11] Azmi Kurdianto and Wiendartun, "Rancang Bangun Pengisi Toren Air Otomatis Menggunakan Sensor Inframerah Berbasis Arduino Uno," *Prosiding Seminar Nasional Fisika*, vol. 0, pp. 317–322, 2019.

[12] S. Muliarni and I. Husnaini, "Aplikasi Pengontrolan Lampu Dan Motor DC Berbasis Arduino," *JTEV (Jurnal Teknik Elektro dan …*, vol. 06, no. 02, pp. 285–291, 2020.

[13] K. Fatmawati, E. Sabna, and Y. Irawan, "Rancang Bangun Tempat Sampah Pintar Menggunakan Sensor Jarak Berbasis Mikrokontroler Arduino," *Riau Journal Of Computer Science*, vol. 6, no. 2, pp. 124–134, 2020.