IOT IMPLEMENTATION IN SMART BUILDING USING THE FUZZY METHOD

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ABSTRACT

With the advancement of internet technology, it is very easy for humans in the field of information, one implementation that utilizes this technology is the internet of things, where this technology connects electronic devices with internet technology, so that the equipment can be monitored and controlled remotely, one of the advantages of technology In this case, all electronic devices can be modified to make it easier for us to monitor and control according to our needs. By combining the fuzzy logic method, electronic devices that are connected to the internet will become smarter, because the electronic equipment can automatically adjust its condition according to the needs of its owner. In this research, the combination of internet of things and fuzzy logic technology will be implemented in smart buildings, with the hope that the condition of the building will run automatically, depending on the natural conditions that occur.

Keywords: *Smart Building, Internet of Things, Fuzzy Logic*

1. INTRODUCTION

Humans' desire to make life easier and more comfortable is currently supported by highly developed information technology, one of which is internet technology, apart from the higher speed, the price is also cheaper, so many people are developing this information technology for various fields, one One implementation is the internet of things, where in this technology electronic devices are connected to the internet so they can be monitored and controlled remotely.

Smart building is a technology that applies artificial intelligence, with the aim that the building can automatically respond to certain conditions, for example when the light is dim or dark, the lights will turn on automatically, if the air conditions are hot, the fan or AC will automatically turn on. will come to life, one of which is artificial intelligence by applying the Fuzzy logic method.

In general, other IoT research only applies On and OFF to light or fan devices, so that only knowing that the light or fan only has an on or off condition, in this research the Fuzzy method is applied so that the resulting output is not only on or off. , but the conditions vary depending on the temperature and light input, so the intensity of the lights can be dim, quite bright, bright and off, as is the case with the fan, it can spin slowly, rather quickly, quickly and off. So it can be concluded that the novelty of applying fuzzy logic is that when the lights and fans are turned on, they don't just turn on and off, but the brightness of the lights and the fan speed can be adjusted using several steps.

2. LITERATURE REVIEW

2.1. State ofTheArt

*Smart*Building is a system of a combination of technology and buildings. Buildings that previously still used manual operations can now be made completely automatic and sophisticated by being equipped with various sensors and toolscontroller [1][2][3].

Internet of Things (IoT)is a technology that allows objects and devices around us to be connected via the internet network, making human life easier, such as smart homes [4], smart buildings [5], health care systems, monitoring systems [6]. It can be said that IoT connects things that are not operated directly by humans. IoT can be used in everyday life, such as making lights turn on automatically with the help of light sensors or timers [7], doors that open automatically [8], fans that turn on when the room temperature starts to get hot [9] and many other human activities. which can be helped by the Internet of Things.

*Fuzzy*linguistically it is defined as vague or vague, which means that a value can be true or false at the same time. In fuzzy, there is a degree of membership that has a value range of 0 (zero) to 1 (one). Fuzzy logic is a logic that has a value of vagueness or vagueness between true or false. Intheoryfuzzy logic a value can be true or false simultaneously. But how much truth and error depends onweightmembership it has [10].

Fuzzy logic has a degree of membership in the range 0 to 1 and fuzzy logic shows the extentwherea value is true and the extent to which a value is false. Fuzzy logic is an appropriate way to map an input space into an output space and has continuous values [11]. Fuzzy is expressed in degrees of membership and degrees of truth. Therefore, something can be said to be partly true and partly false at the same time. In fuzzy logic, several methods are known, such as Tsukamoto, Mamdani, and Sugeno. To design Smart Buildings based on the Internet of Things, the Mamdani method [12] is used. The Mamdani method is also often called the Max-min

method with several stages such as fuzzyfication, inference and defuzzyfication [13].

2.2. Smart Buildings

*Smart*Building is a system of a combination of technology and buildings. Buildings that previously used manual operations can now be made fully automated and sophisticated by being equipped with various sensors and control devices.(Farid, 2017)

2.3. IoT (Internet of Things)

Internet of Things (IoT) is a technology that enables objects and devicesaroundWeconnectedvia the internet network making it easierhuman life, such as smart homes, smart buildings, health care systems, monitoring systems. It can be said that IoT connects things that are not operated directly by humans. IoT can be used in everyday life, such as making lights turn on automatically with the help of light sensors or timers, doors that open automatically, fans that turn on when the room temperature starts to get hot and many more human activities that can be helped by the Internet of Things. (Raharjo and Sabur, 2020)

2.4. Fuzzy

*Fuzzy*linguistically it is defined as vague or vague, which means that a value can be true or false at the same time. In fuzzy there are degreesmembershipwhich has a value range of 0 (zero) to 1 (one). Fuzzy logic is a logic that has a value of vagueness or vagueness between true or false. In fuzzy logic theory, a value can be true or false simultaneously. However, how much truth and error depends on the weight of the membership it has.

Fuzzy logic has a degree of membership in the range 0 to 1 and fuzzy logic shows to what extent a value is true and to what extent amarkThat is wrong. Fuzzy logic is an appropriate way to map an input space into an output space and has continuous values. Fuzzy is expressed in degrees of membership and degrees of truth. Therefore, something can be said to be partly true and partly false at the same time. In fuzzy logic, several methods are known, such as Tsukamoto, Mamdani, and Sugeno. For designing Smart Buildings based on the Internet of ThingsuseMamdani method.

The Mamdani method is also often called the Max-min method with several stages such as fuzzyfication,inferenceand defuzzification.(Wirawan and Azhari, 2014)

2.5. LDR Sensor Module

The LDR Sensor Module is a sensor with a resistor type that functions to measureintensitylight by experiencing a change in resistance when there is a change in light. The LDR Sensor Module can be seen in Figure 1(Mirza and Firdaus, 2016)

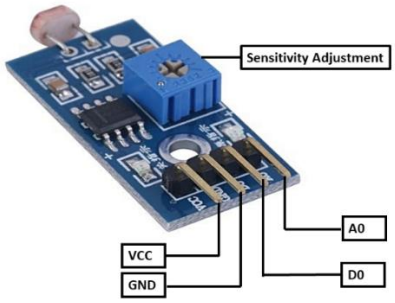

Figure 1. LDR Sensor Module

2.6. DHT11 sensor

The DHT11 sensor is a sensor that functions formeasuresugar and humidity with an analog voltage output which will then be processed using a microcontroller. This sensor generally has a fairly accurate calibration feature for temperature and humidity readings. The DHT11 sensor and its specifications can be seen in Figure 2.(Rangan et al., 2020)

Figure 2. DHT11 sensor

2.7. PIR sensors

The PIR sensor is a sensor that functions to detect the presence of infrared raysnaturepassive. This means that this sensor only receives infrared radiation from outside without emitting infrared rays by only responding to energy from passive infrared rays. The PIR sensor and its specifications can be seen in Figure 3.(Aribowo et al., 2020)

Figure 3. PIR sensor

2.8. ESP32 module

The ESP32 module is a microcontroller first made by Espressif Systems and is the successor ofmicrocontrollerESP8266. The ESP32 is equipped with a WiFi module on the chip so it is very supportive for use in creating Internet of Things application systems and their specifications.(Imran and Rasul, 2020)

2.9. Buzzers

*Buzzers*is an electronic component module that works by converting electrical signals into sound waves. Its easy use and only requiring an input voltage means that buzzers are often used for alarms, electricity meters that use house bell pulses, and even danger warnings. Buzzers are divided into two types based on their sound, namely Active Buzzer and Passive Buzzer.Active Buzzer has its own sound when an electric voltage is applied, or is called a Stand Alone Buzzer, while Passive Buzzer does not have its own sound and requires prior programming to determine the high and low tone. So it is very suitable when combined with the ESP32. The buzzer and its specifications can be seen in Figure 4.(Devira Ramady et al., 2020)

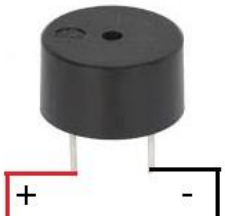

Figure 4. Buzzer

2.10. Dimmers

A dimmer is an electronic circuit whose function is to modify the form of a pure AC signal into a signaltruncated-cut. So the output power can be adjusted. Dimmers and their specifications can be seen in Figure 2.6 and Table 5(Sangian et al., 2019)

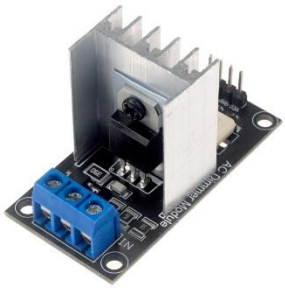

Figure 5. Dimmer

2.11. SW-420 sensors

The SW-420 sensor is a sensor that functions to detect vibrations, the way this sensor works is by using 1 metal float thatwillThe tube containing 2 electrodes vibrates when the sensor module receives vibration/shock. There are 2 outputs, namely digital output (0 and 1) and analog output (voltage). The SW-420 sensor and its specifications can be seen in Figure 6.(Saputra et al., 2018)

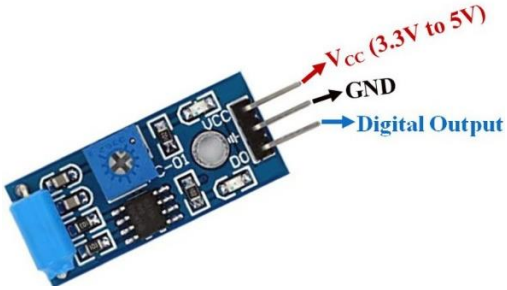

Figure 6. SW-420 sensor

2.12. MQ135 sensor

The MQ135 sensor is a chemical sensor or gas sensor which has a resistance value of Rs which will change when exposed to gas and has a heater which functions to clean the sensor chamber from air contamination. The MQ135 sensor and its specifications can be seen in Figure 7.(Harpad et al., 2022)

Figure 7. MQ135 sensor

2.13. VSCode

Visual Studio Code is a text editor created by Microsoft which is available on Linux, Mac and Windows by supporting the Javascript, Typescript and Node.js programming languages, etc. with the help of plugins that can be installed via the Visual Studio Code marketplace.(Permana and Romadlon, 2019)

3. RESEARCH METHODS

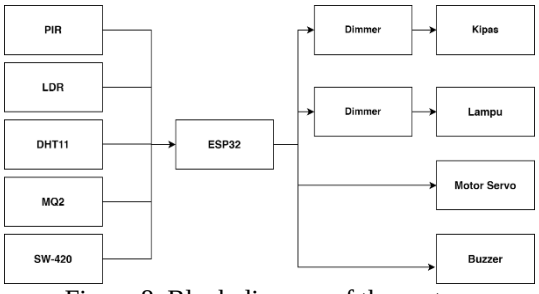

Figure 8. Block diagram of the system

The explanation is as follows:

a. ESP32 functions to provide instructions and control all data processes from the input and output of all components.
b. PIR functions as a detector when someone approaches.

c. The LDR Sensor Module functions to detect the presence of light.
d. DHT11 functions to read indoor temperature.
e. MQ135 functions to detect smoke in the room.
f. SW-420 functions to detect earthquake vibrations.
g. The dimmer functions to regulate the intensity of light emitted by the lamp and the fan rotation speed.
h. Servo motors, lights, fans and buzzers function as output from each sensor.

3.1. *Flow chart*Fuzzy Fan Method

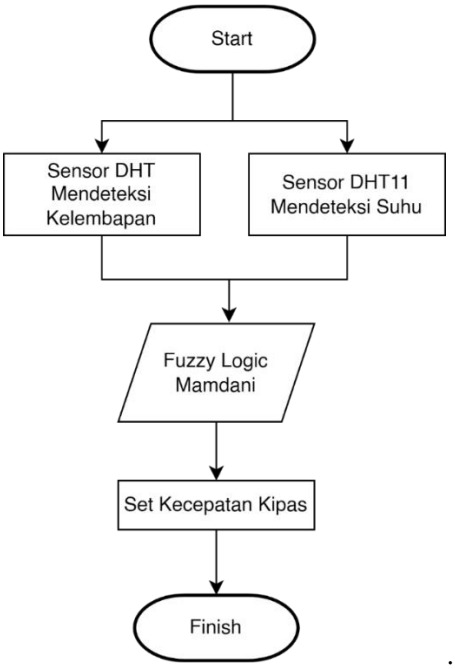

Figure 9. Flowchart of the Fuzzy Fan Method

Based on the method flowchart in Figure 9, it starts with the DHT11 sensor which detects the presence of temperature and humidity in the room, after which it is processed using Mamdani fuzzy logic so that it can produce a set of fan speeds.

3.2. *Use*case Admin Diagram

Figure 10 explains the use casediagramin the Admin view. Admin cannot enter any menu before logging in. If you have logged in, the user can open the monitoring menu to monitor the status of ultrasonic sensors, temperature sensors, light sensors, smoke sensors for fires, lights, doors and fans and can control them manually, Add Account to add employee accounts and log out. to exit the application.

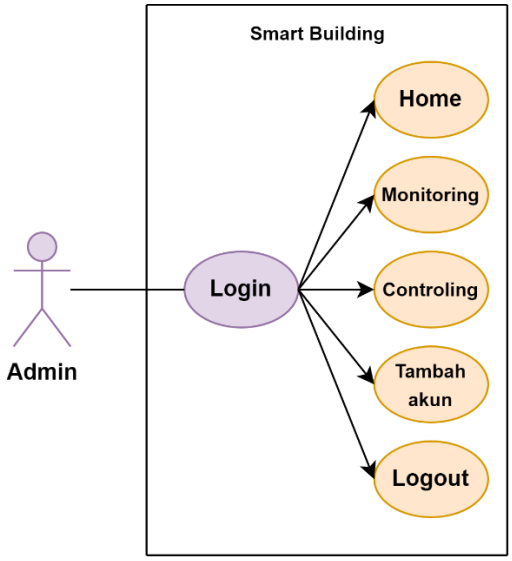

Figure 10. Admin use case diagram

3.3. *Use case User Diagram*

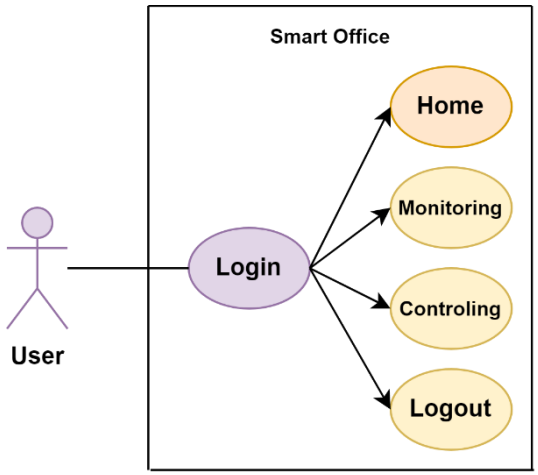

Figure 11. Use case User Diagram

Figure 11 explains the use case diagram in the User view. Users cannot enter any menu before logging in. If you have logged in, the user can open the monitoring menu to monitor the status of the ultrasonic sensor, temperature sensor, sensorslights, smoke sensors for fires, lights, doors and fans and can control manually and log out to exit the application. Users cannot add new accounts like admin

In Figure 12 is a design view of monitoring with the turning on and off featuredeviceManually.

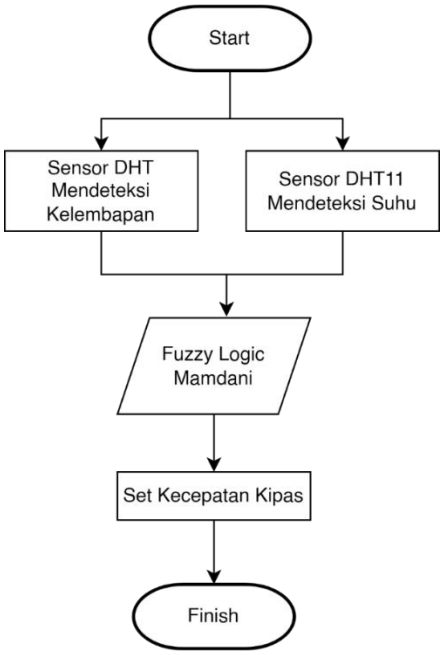

Figure 12. Flowchart of the Fuzzy Fan Method

Based on the method flowchart in Figure 12, it starts with the DHT11 sensor which detects itexistsAfter that, the temperature and humidity in the room are processed using Mamdani fuzzy logic so that it can be generated in the form of a fan speed set.

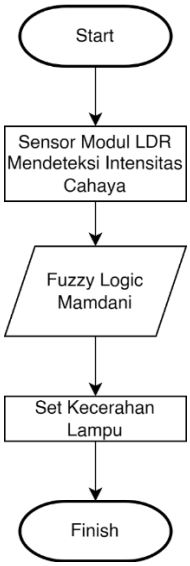

Figure 13. Flowchart of the Fuzzy Light Method

Based on the method flowchart in Figure 13. starting with the LDR module sensor which detects andtakethe value of the light intensity, then processed using Mamdani fuzzy logic so that various sets of lamp brightness can be produced.

4. RESULTS AND DISCUSSION

4.1. Fuzzy Mamdani Set

a. Temperature

Temperatures are grouped into three fuzzy sets, namely cold, normal and hot. The membership function for the temperature parameter can be formulated as follows:

$$\mu(x)Dingin = \begin{cases} 1, Untuk\ x \leq 23 \\ \frac{28-x}{28-23}\ Untuk\ 23 \leq x \leq 28 \\ 0, Untuk\ x \geq 28 \end{cases}$$

$$\mu(x)Normal = \begin{cases} \frac{x-23}{28-23}\ Untuk\ 23 \leq x \leq 28 \\ \frac{33-x}{33-28}\ Untuk\ 28 \leq x \leq 33 \\ 0, Untuk\ x \geq 33 \end{cases}$$

$$\mu(x)Panas = \begin{cases} 1, Untuk\ 33 \leq x \leq 36 \\ \frac{x-28}{33-28}\ Untuk\ 28 \leq x \leq 33 \\ 0\ Untuk\ x \leq 28 \end{cases}$$

b. Humidity

Humidity is grouped into three fuzzy sets, namely low, normal and high. The membership function for the humidity parameter can be formulated as follows:

$$\mu(x)Rendah = \begin{cases} 1, Untuk\ x \leq 50 \\ \frac{65-x}{65-50}\ Untuk\ 50 \leq x \leq 65 \\ 0, Untuk\ x \geq 65 \end{cases}$$

$$\mu(x)Normal = \begin{cases} \frac{x-50}{65-50}\ Untuk\ 50 \leq x \leq 65 \\ \frac{80-x}{80-65}\ Untuk\ 65 \leq x \leq 80 \\ 0, Untuk\ x \geq 80 \end{cases}$$

$$\mu(x)Panas = \begin{cases} 1, Untuk\ 80 \leq x \leq 100 \\ \frac{x-65}{80-65}\ Untuk\ 65 \leq x \leq 80 \\ 0\ Untuk\ x \leq 65 \end{cases}$$

c. Light intensity

The membership function for the light intensity parameter can be formulated as follows:

$$\mu(x)Gelap = \begin{cases} 1, Untuk\ x \leq 25 \\ \frac{50-x}{50-25}\ Untuk\ 25 \leq x \leq 50 \\ 0, Untuk\ x \geq 50 \end{cases}$$

$$\mu(x)Normal = \begin{cases} \frac{x-25}{50-25}\ Untuk\ 25 \leq x \leq 50 \\ \frac{75-x}{75-50}\ Untuk\ 50 \leq x \leq 75 \\ 0, Untuk\ x \geq 75 \end{cases}$$

$$\mu(x)Terang = \begin{cases} 1, Untuk\ 75 \leq x \leq 100 \\ \frac{x-50}{75-50}\ Untuk\ 50 \leq x \leq 75 \\ 0\ Untuk\ x \leq 50 \end{cases}$$

d. Fuzzyfication

The input input to the fan system will automatically be fuzzified into a fuzzy set and functioned as a fuzzy member so that a rule base will be formed. In Figure 14 and Figure 15 are fuzzyfication of the values obtained from the DHT11 sensor in the form of temperature and humidity values, while in Figure 16 is a

fuzzyfication of the values obtained by the LDR sensor.

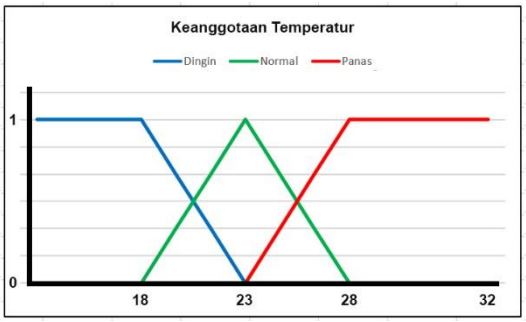

Figure 14. Temperature Membership Function

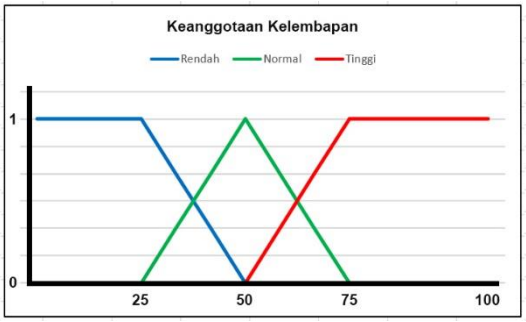

Figure 15. Humidity Membership Function

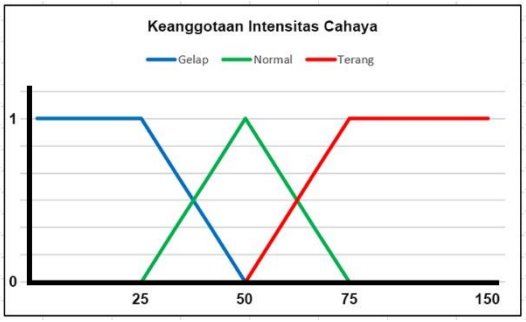

Figure 16. Light Intensity Membership

e. *Rule base*

This automatic fan and light system has a rule base which was formed with the aim of being a rule for making decisions on the program in order to determine the right output. The following is a table of the rule base that has been created:

Table 1. Fan Rule Base

		Temperature		
		Cold	**Normal**	**Hot**
Humidity	**Low**	Stop	Slow	Normal
	Normal	Slow	Normal	Fast
	Tall	Normal	Fast	Fast

Table 2. Lamp Rule Base

	Light intensity		
Mark	**Dark**	**Normal**	**Bright**
	$x \leq 5$	$25 \leq x \leq 75$	$x \geq 75$

f. Defuzzification

In the defuzzification stage, the automatic fan has a predetermined value and becomes a rule used to determine the correct output value in the form of PWM (Pulse Width Modulation). In Figure 17, the PWM function is used for fan output so that it works as needed. Meanwhile, in Figure 18, the PWM function is used to output the lights so they work as needed.

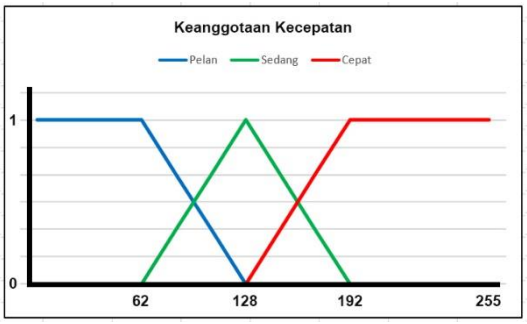

Figure 17. Fan Speed Membership PWM Function

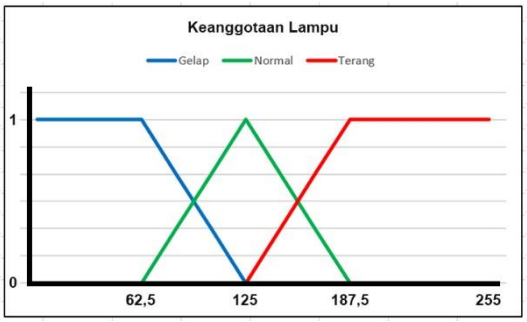

Figure 18. Lamp Membership PWM Function

4.2. Monitoring Page Display

On the Monitoring Page Display there are several sensor columns such as pir sensors, light sensors, temperature sensors, fire sensors and earthquake sensors. With the value and status of each sensor

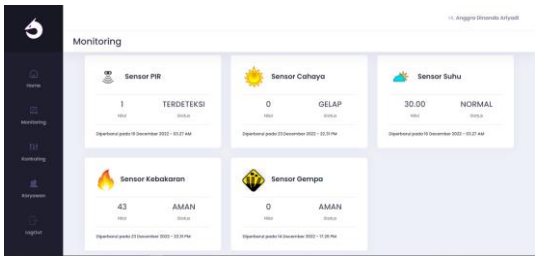

Figure 19. Monitoring page display

4.3. Control Page Display

On the Control Page Display there are several columns such as lights, fans and doors with on and off buttons.

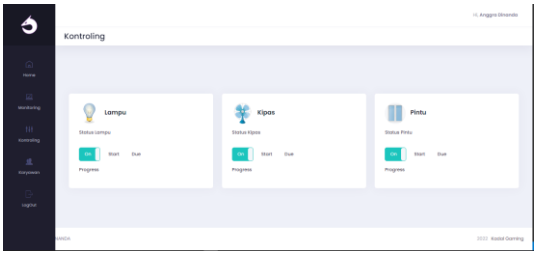

Figure 20. Controlling

4.4. Employee Page Views

The Employee Page displays data in the form of a list of employees with columns for full name, username, status and actions that can be changed or deleted. The employee menu display only appears if the account used is admin.

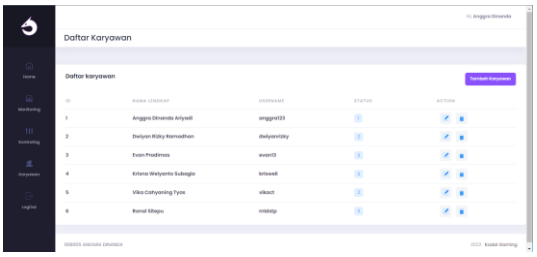

Figure 21 Employee Page View

4.5. Add Employee Page View

On the add employee page display, enter full name, username, password and login options.

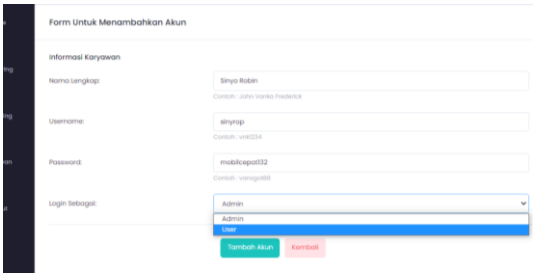

Figure 22. Add Employees

4.6. View the Change Account Page

On the Change Employee Account page display, there is previous employee data whose account you want to change.

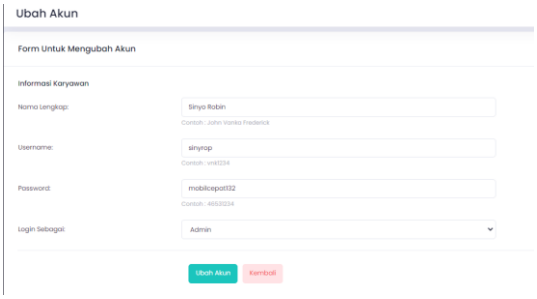

Figure 23. Change Account Page Display

5. CONCLUSION

The valuetakenThe PIR sensor is kept for 3 seconds to let people in because when the PIR sensor doesn't pick up a person's signal it will automatically close. The DHT sensor can detect room temperature and humidity well, both outputs can be used as a reference in using Mamdani fuzzy logic. The LDR sensor can work well with the intensity value which is used as a reference for PWM in adjusting the light brightness level. The SW420 sensor can detect vibrations well and successfully sends a danger signal via the buzzer. In using Mamdani fuzzy logic, temperature membership values are divided into 3, namely cold, normal, hot. The humidity membership value is divided into 3, namely low, normal, hot and the results of the fan speed membership value are divided into 3, namely slow, medium, fast.

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