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IoT-based temperature and humidity monitoring system for smart garden

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Abstract. The main objective of this paper is to design an IoT (Internet of Things) to monitor temperature and humidity for smart gardens. Temperature sensors and humidity sensors measure environmental conditions and are processed by a microcontroller. The actuator used is a spray pump that is used to spray water into the air to lower the temperature. Data from the sensors and status from the actuators are sent to the server and can be monitored via a smartphone. The data collected can be analyzed for various purposes. The result obtained is the effect of spraying on temperature reduction.

Keywords—Internet of Things, smart garden, spray pump.

1. Introduction

Internet of Things-IoT is part of Industry 4.0, which transforms conventional lifestyles into smart, dynamic, and modern lifestyles. In agriculture, several terms are used related to IoT, such as smart garden [1], smart farming [2], smart agriculture [3], and other similar terms. Smart Garden is a term that utilizes automation technology [4] in garden management using mechanical and electronic devices by using information technology and the internet [5]. Smart Garden is a solution for monitoring environmental conditions (temperature, humidity, soil moisture, light intensity, etc.) and maintaining ideal climate parameters that can be controlled to increase garden yield. The main agricultural product of Central Sulawesi province is shallots (Allium cepa L. Var. Aggregatum Group). The ideal environment for growing shallots is temperature at 27.7-30.0oC and humidity at 61.22-68.90%. The potential productivity of shallots is 9.7 tonnes/ha, but the productivity of farmers is lower. This is due to the application of cultivation techniques that are not according to standards and changes in ideal environmental parameters[7]. Several studies related to the application of IoT in agriculture are the implementation of IoT in agriculture for environmental monitoring with temperature sensors, soil pH, soil moisture, humidity, motion sensors and water volume sensors [2]. Other studies include monitoring and data transmission using the API service from Blynk which is used to monitor temperature, humidity, and control of watering plants [8], monitoring systems and controlling nutrients, temperature, and water levels in website-based hydroponic farming using NodeMCU [9] and IoT hydroponics management systems using Rapsberry Pi to monitor pH, water level, air temperature and air humidity [10]. Fuzzy systems are used for wireless sensor networks (WSN) for controller heating, cooling, irrigation, lighting, and shading in a greenhouse [11]. This study proposed a prototype of the Smart Garden system for shallots based on the Internet of Things (IoT) with the fuzzy logic controller method which functions to monitor temperature and humidity and perform mist spraying under certain conditions. The goal is to maintain the ideal temperature and humidity for the shallots. In contrast to other studies, in this study fuzzy logic functions as a spray pump control method for spraying mist water into the air to reduce the temperature.

2. Proposed Method

The monitoring of temperature and humidity uses sensors that will be read and processed by a microcontroller. The fuzzy method embedded in the microcontroller will activate the spray pump under certain conditions. Data from sensors and actuators are sent continuously over the internet to the server. The server receives a data reading request from the client so that monitoring can be seen and carried out anytime and anywhere. To maintain the ideal temperature and humidity conditions for shallots, a spray pump is used for spraying. The fuzzy method is used to regulate spraying. The smart garden system design is shown in Figure 1.

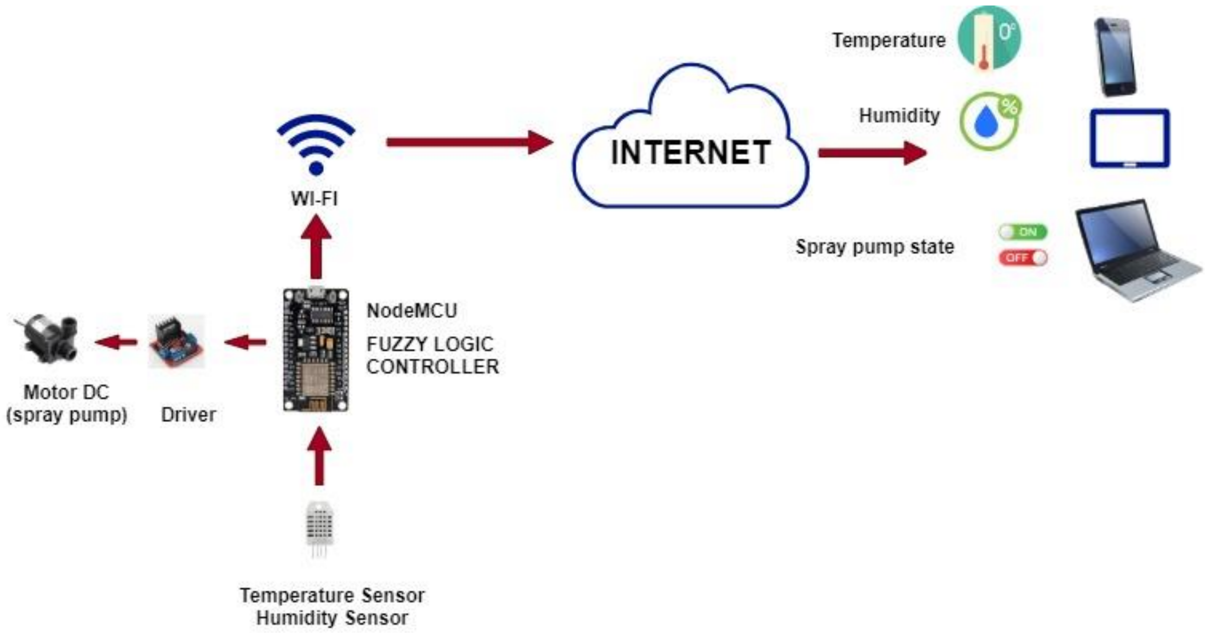

Figure 1. Smart Garden System

The application design for the proposed smart garden is shown in Figure 2.

Step 1: initialize the NodeMCU, temperature and humidity sensor (DHT22).
Step 2: connect NodeMCU to the internet via WIFI.
Step 3: NodeMCU reads the data sent by the sensor.
Step 4: NodeMCU processes the sensor data using fuzzy logic and controls the spraying when the conditions meet. Next, NodeMCU sends sensor reading data and readings of the state of spraying pump to the server.
Step 5: Smartphones, tablets, and computers read data from the server.

The hardware used consists of sensors, microcontrollers, and actuators. The sensors are temperature and humidity sensor (DHT22), microcontroller (NodeMCU ESP8266), and the actuator is spray pump. The control function is performed by fuzzy logic. Fuzzy logic is a computational method used for a complex nonlinear problem to model or an ambiguous problem [13]. Fuzzy logic follows the human way of thinking in natural linguistics of an object such as very low, low, medium, high, and very high. Fuzzy set is a set with each element that has degrees of membership which has an interval of 0 to 1.The architecture of fuzzy logic shown in Figure 3.

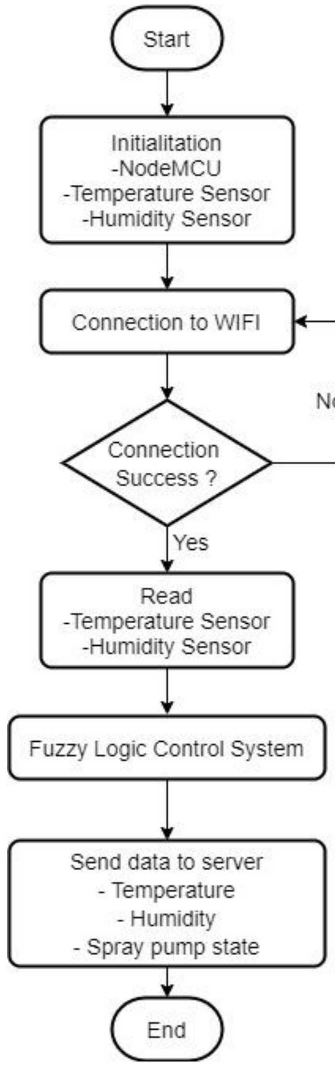

Figure 2. Flowchart proposes method

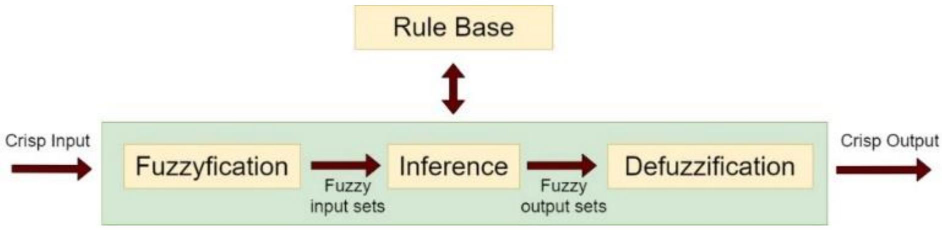

Figure 3. Fuzzy logic architecture

Fuzzy logic functions as a method of controlling the climate parameters (temperature and humidity) of a smart garden which has two inputs and one output. Input data consists of temperature (ºC) and relative humidity (%), the output is a spray pump for spraying water in the air. Figure 4 shows a representation of the temperature variable and figure 5 shows a representation of the variable humidity. In the picture VL: Very Low, L: Low, M: Medium, H: High, and VH: Very High.

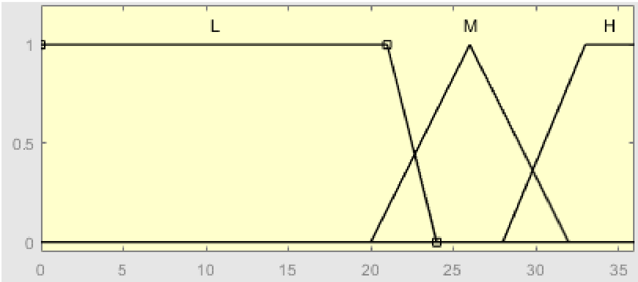

Figure 4. State variable temperature

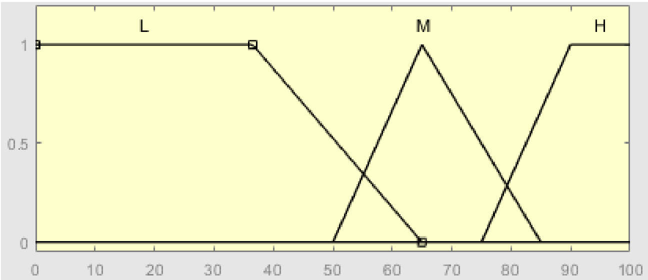

Figure 5. State variable humidity

After defining the membership function, the next is to set up a rule base. The relation and effects of temperature and humidity on the spray pump are shown in Table 1.

Table 1. Fuzzy logic rule tables

T \ H	L	M	H
L	S	Off	Off
M	M	Off	Off
H	L	L	M

where : Off, Short, Medium, Long

The rules set to regulate the motor state based on the input temperature and humidity. Based on the rule base, if the temperature is low and humidity is low, the spray pump will spray in a short time. This is aimed at increasing humidity. If the temperature is low and the humidity medium, the pump spray will be off due to the humidity in the medium. Likewise for conditions of low temperature and humidity high. For the next rule, if the temperature is medium and humidity is low, the motor will spray with medium time, this is to increase the humidity. For the rule base temperature, medium and high humidity, spray pump off. For the rule base temperature high and humidity low and medium, the spray pump will spray for a long duration because it aims to lower the temperature and increase the humidity. If the temperature is high and humidity high, the spray pump will spray with a medium duration because it aims to reduce the temperature.

3. Results

The application is designed using the Blynk server. There are three visual monitoring in the application, namely a gauge for temperature and humidity and visual information about the state of the motor. High for spray pump on and low for off. Hardware and applications made can be seen in Figure 6. and Figure 7.

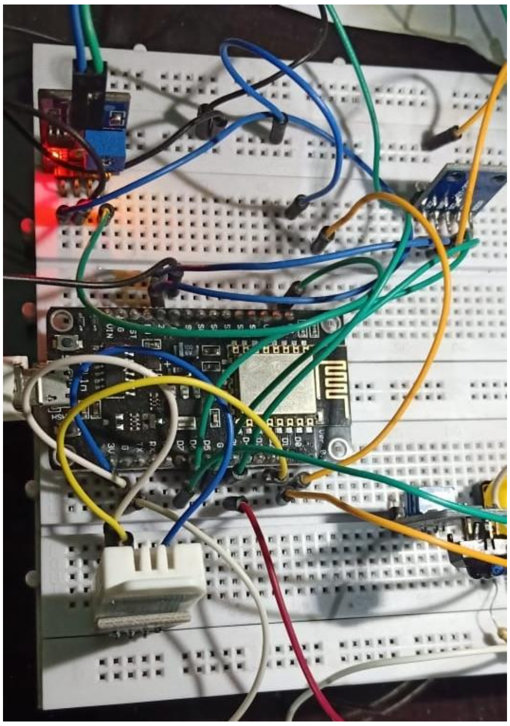

Figure 6. Hardware

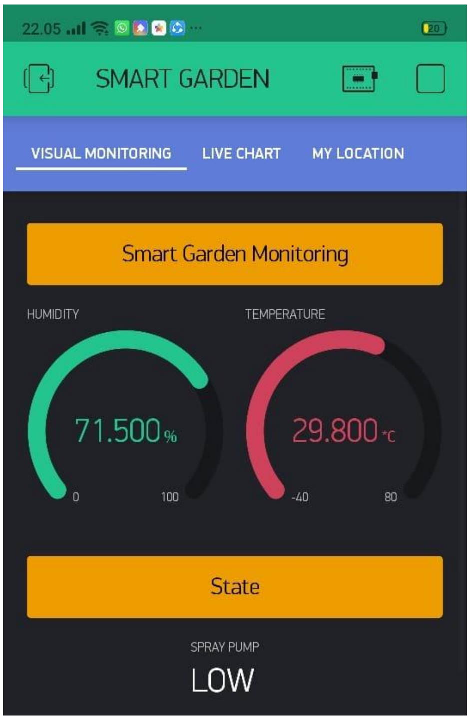

Figure 7. Smart garden monitoring

To check the performance of a smart garden with fuzzy is done by the measure of the temperature and humidity and getting the temperature and humidity values as in table 2.

Table 2. Temperature and humidity, before dan after spraying

Time	Temp (C)	Humidity (%)	Spray Pump state (On/ Off)	Temp. after spraying (C)	Humidity after spraying (%)
6	21	63	Off	21	63
7	27	57	On	27	60
8	32	45	On	27	55
9	32	42	On	28	57
10	34	35	On	28	62
11	34	34	On	28	62
12	35	32	On	28	63
13	34	32	On	28	60
14	33	34	On	27	63
15	31	34	On	27	64
16	29	37	On	27	66
17	28	41	On	26	68
18	28	43	On	26	69
AVERAGE	30.61	40.69		26.76	62.46

At a temperature of 21 °C and a humidity of 63%, the spray pump state turned off and this is by the predetermined fuzzy logic rule base. This condition is still considered ideal so that no spraying is carried out. When the temperature rises to 27 °C and the humidity drops to 57%, the spray pump turns on and starts spraying. Likewise, for temperatures above 27 °C, the spray pump remains on. After spraying, there is a decrease in temperature and an increase in humidity. From table 2, it is found that the temperature decrease between the temperature before spraying and the temperature after spraying is an average of 3.8 oC as shown in Figure 11 and the change in the increase in humidity is an average of 21.7 as shown in Figure 12. The average temperature after spraying is 26.76 oC and the average humidity after spraying is 62.4%. This shows that the presence of spraying is a decrease in the value of temperature and an increase in the value of humidity.

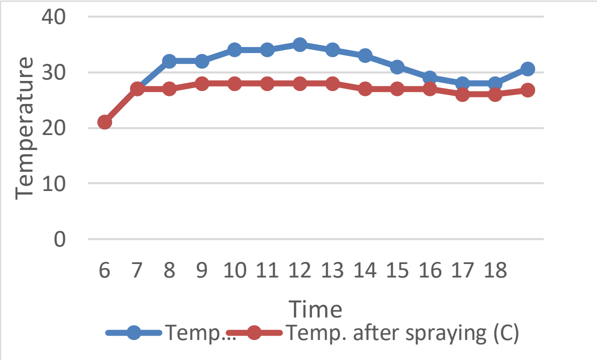

Figure 8. Temperature before and after spraying

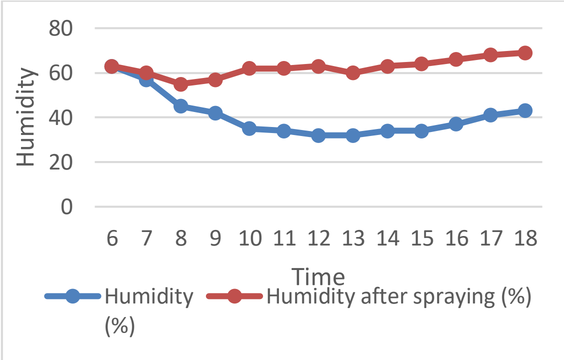

Figure 9. Humidity before and after spraying

The results prove that the smart garden with the fuzzy logic system can maintain the parameters of the ideal temperature and humidity for the growth of shallot

4. Conclusion

The prototype of smart garden with fuzzy logic system is made using NodeMCU as a controller and temperature sensor (DHT22). This smart garden prototype can monitor temperature and moisture parameters online and in real-time. This system also monitors the on / off state of the spray pump. The average temperature after spraying was carried out at 26.76 oC and the average humidity after spraying was 62.4%. Smart garden with fuzzy logic system can maintain ideal temperature and humidity parameters for growing.

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