IT FOR SOCIETY, Vol. 10, No. 01
ISSN 2503-2224

Plant Monitoring System using Raspberry Pi

Williem
Faculty of Computer Science
President University
Bekasi, West Java
williem@president.ac.id

Abstract*— Computers, internet, and smartphones are essential parts in human life nowadays. Every aspect in life is related to computers, connected with the internet and utilized via smartphones. The usage of smartphones and internet in life has increased circa 2009. Nowadays, people can do almost any activity from the smartphone. Chatting, checking e-mail, and even controlling household applicants could be done using smartphones combined with the concept of Internet of Things or IoT. By utilizing the IoT and smartphones or computers, people can now do activities in their daily life such as feeding pets, turning lamps on or off, monitor plants and control them as they want. The work helps users to automatically water plants and monitor plant condition and help the plant to learn about its surrounding condition.

Keywords*— Internet of Things, Fuzzy Logic, Plant Monitoring

I. Introduction

Starting in the 2000's, technology has penetrated every aspect of human life. Humans gain advantages in utilizing technology such as using social media to ease communication, developing applications to help daily activities, even creating robots to do dangerous jobs, but the most successful inventions of humanity are, indeed, the computer and the internet.

Nowadays, the internet is not only used in phones or personal computers, but also the ordinary entities surrounding people such as television, lamp, fan, and any other entities. The Internet of Things or usually abbreviated as IoT exists to simplify human life. The IoT is an internetworking of physical devices such as vehicles, buildings and other items that are embedded with sensors, electronics, software, actuators and network to allow these devices to collect and exchange data. Turning the lamp could be done by using a smartphone. Feeding pets could now be done by utilizing the feeder with sensors, then transmitting the data to a smartphone to identify if the feeder has run out of food or water. Even watering plants could also be done automatically by measuring the condition of soil and temperature of the plant.

As stated above, the internet, combined with smartphones and computers have caused a major impact in people's activities. People tend to do most of their activities via smartphones. However, people started to forget or abandon less significant activities such as feeding pets, or even watering plants. It is better if the smartphones could be utilized as a medium to maintain these activities while doing another one. This work is intended to help plant owners to monitor the plant condition starting from soil moisture, temperature, and humidity, let the owner know if there is a lack of water, and let the plant learn the condition surrounding it and decide whether to water the plant or not. By utilizing the application, the owner of the plant will not forget to pay attention to the plant while doing another activity.

The objectives of this work are to create an application that is able to:

- Monitor plant condition
- Let the system learns about plant's surrounding condition
- Let the system waters a plant by itself
- Notify user if the water reservoir is low

This work focuses on monitoring plant conditions and letting the plant learn from its surrounding environment. The limitation of the application is it needs proper adjustment of the threshold value for each sensor to increase the accuracy of the plant condition. The placement of the plant and sensors will affect the value of data collected and this work is intended only for indoor and small-potted plants.

Another limitation of the application is the amount of time taken for communication between the mobile application and the sensors connected to the computer which depends on the internet connection strength. The connection strength and heavy use of thread also limit the running time of the application.

II. Method

The approach used in creating the application is fuzzy logic. Fuzzy logic, or usually called "grey logic" is an approach to computing based on "degrees of truth" or "many-values". Different with Fuzzy logic, Boolean logic is an approach with discrete or "crisp" values as 0 or 1, true or false. The idea of fuzzy logic was proposed by Dr. Lotfi Zadeh of University of California at Berkeley in the 1960s. The supporting tools used in creating the application are Raspberry Pi 3 Model B, Soil Moisture Sensor YL-69, Water Level Sensor, DHT11 Humidity and Temperature Sensor, and Water Pump RS-360SH.

1.1 Raspberry Pi 3 Model B

Raspberry Pi is an open source single board computer developed by Raspberry Pi foundation that is used as a media

for learning computer science and hardware. It has an embedded processor and memory with built-in Wi-Fi and Bluetooth module in the model 3 B. The board is illustrated in Figure 1.

Figure 1. Raspberry Pi 3 Model B

1.2 Python Programming Language

Python was created by Guido von Rossum in late 1980 and is a multi-purpose programming language. The language provides cleaner and shorter syntax compared to languages such as C, C++, and Java. Although Python is an interpreted language, the Python program is compiled in the background making the script run faster. It is based on C programming language and adopted by Raspberry Pi foundation as the main development language. This language also comes with another variant such as Jython (Java Python) and Iron Python (.NET Python).

1.3 Fuzzification

Fuzzification is a process in assigning a crisp value to represent an input's degree of membership in one or more qualitative groupings called "fuzzy sets" using a membership function. There are several approaches in determining membership function such as:

1. Triangle Function

As the name infers, the shape of the function resembles a triangle and is represented in the formula below.

$$Triangle(x,a,b,c) = \begin{cases} 0, x \le a, x \ge c \\ \dfrac{x-a}{b-a}, a < x \le b \\ -\dfrac{x-c}{c-b}, b < x \le c \end{cases}$$

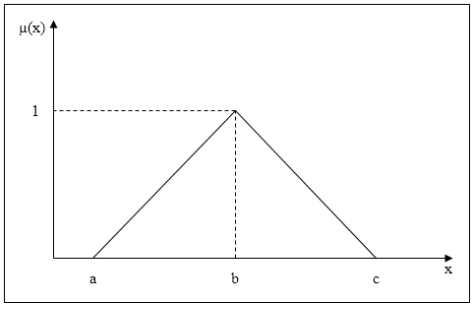

Figure 2. Triangle Function

2. Trapezoid Function

As the name infers, the shape of the function resembles a triangle and is represented in the formula below.

$$Trapezoid(x,a,b,c) = \begin{cases} 0, x \le a, x \ge d \\ (x-a)/(b-a), a < x < b \\ 1, b \le x \le c \\ -(x-d)/(d-c), c < x \le d \end{cases}$$

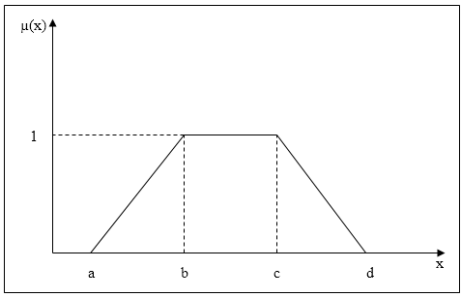

Figure 3. Trapezoid Function

1.4 Rules Inference

The process of inferencing is done to compare the fuzzy values to all the rules gathered prior to the creation of the fuzzy system. This process is done to obtain the value that is used in the de-fuzzification process. There are mainly two popular models used in fuzzy logic to do rules inferencing. They are named as Mamdani model and Sugeno model.

- Mamdani Model

Mamdani model was proposed in 1975 by Ebrahim Mamdani. This model accepts fuzzy sets as the output of the membership function and has several advantages such as the intuitiveness of the process, widely used in fuzzy systems design and suited well for human input.

- Sugeno Model

Sugeno, or Takagi-Sugeno-Kang (TSK) model is introduced in 1985 and similar to the Mamdani model in fuzzifying inputs and applying fuzzy operator, but has a linear or constant value as the output membership function and represents them as singleton rather than a set. This model has several advantages such as computationally fast, works well with linear techniques, and suited well when used in mathematical analysis.

The rules applied as the benchmark in the fuzzy logic used in the application are:

- Rule 1—No Watering

The rule states that "*If Soil Moisture is high or Soil Moisture is normal and Humidity is not low and Temperature is not high then No Watering"*

- Rule 2—Short-Timed Watering

The rule states that "*If Soil Moisture is low and Humidity is high or Soil Moisture is normal and either Humidity is low or Temperature is high then Water for Short time*"

- Rule 3—Long-Timed Watering

The rule states that "*If Soil Moisture is low and Humidity is not high*"

1.5 De-fuzzification

De-fuzzification is a process to decipher the vague values produced in the membership functions into a crisp or discrete value. There are several methods of de-fuzzification process such as Centroid method, Height method, First or Last of Maxima method, and Mean-Max method.

The method used in this work is the Centroid method that produces crisp output by calculating the sum of the moment area or the center of the gravity of a plane. This is done by evaluating all rules and the interpreted value or the membership degree. After the rules are combined altogether, the data will be assumed as a two-dimensional plane.

The next process is to evaluate all respective values in the plane which will have different shapes, mainly triangle, rectangle or trapezoid. The center of gravity of each plane will be summed as also the area. The result is then obtained by calculating the total moment area divided by the total area of the planes. In this case, the crisp output obtained is used as watering time.

III. Experimental Results

In order to evaluate the effectiveness of the proposed method in the previous section, there is some implementation testing such as shown in the tables below.

Table 1. Rules Inferencing Evaluation

No.	Scenario	Expected Result
1	Soil Moisture is high or Soil Moisture is normal and Humidity is not low and Temperature is not high	Plant is not watered
2	Soil Moisture is low and Humidity is not high	Plant is watered for a long time
3	Soil Moisture is low and Humidity is high or Soil Moisture is normal and either Humidity is low or Temperature is high	Plant is watered for a short time

Table 1 represents the testing result for rules inferencing in order to obtain watering time based on values received by sensors that are connected to Raspberry Pi Model 3 B

Table 2. Plant Watering Evaluation

No.	Scenario	Expected Result
1	Water plant, water is available	Pump is activated and water will be decreased
2	Water plant, water is unavailable	Pump is not activated and the user is notified

Table 2 represents the testing result for checking the water amount and watering process.

Table 3. Sensor Reading Evaluation

No.	Scenario	Expected Result
1	Read value from soil moisture sensor	Soil moisture value is read successfully
2	Read value from humidity sensor	Humidity value is read successfully
3	Read value from temperature sensor	Temperature value is read successfully
4	Read value from water level	Water level value is read successfully

Table 3 represents the testing result for sensors' reading process.

Table 4. Monitor Page Evaluation

No.	Scenario	Expected Result
1	Go back to Home page, user clicks back button	Application will go back to main menu
2	Displays plant's condition: soil moisture, humidity, and temperature	The condition of plant is displayed in the page and updated every 5 seconds
3	Displays water level	Water level is displayed in the page and updated when there is a change as in plant watering
4	Notify user if water level is low, application is in running state	Notification is displayed when the application is running
5	Notify user if water level is low, application is in dormant state	Notification is displayed when the application is not running

Table 4 represents the testing result for monitoring the plant's condition.

IV. Discussion

In this section, there are some discussion why the system is created with fuzzy logic approach and using Python Programming Language

- Fuzzy Logic

The system implements the fuzzy logic for the reason of the uncertain condition that the fuzzy logic could handle. The fuzzy logic is used to determine how long the plant needs to be watered by checking the condition of the plant's surrounding environment.

The advantage of applying fuzzy logic is:
The system can handle fuzzy or vague values better than using conventional condition-checking programming. This

approach could represent a more intuitive reasoning model than range-based model.

- Python Programming Language

The system is created using Python programming language for the reason of tidier syntax, faster execution time, and syntax that enhance data processing in more intuitive way compared to another language.

The advantage of using Python is:
Systems can be developed faster and with cleaner, more understandable syntax and fast processing time compared to another language.

V. Conclusion

The system could help a plant owner to monitor the plant condition by utilizing soil moisture sensor, humidity and temperature sensor, water level sensor connected to a Raspberry Pi and send the value via data stream network. It also helps plant owners to monitor the water level left and sends notification if the water level is low by using the service in Android. The system also represents a plant to learn and reason about the surrounding condition and helps to decide whether it is necessary to automatically water the plant or not by applying a fuzzy logic system approach.

In the future, the project will utilize better quality sensors to ensure the integrity of data, speech synthesis API to simulate the "communication" between human and plant, wired connection using Ethernet cable, and user interface enhancement.

VI. REFERENCES

1. Zadeh, L. A. (1988). Fuzzy Logic. IEEE.
2. Sakti. I. (2014). *Methodology of fuzzy logic with mamdani fuzzy models applied to the microcontroller.* IEEE.
3. Russel, S. J., Norvig, P. (2021). *Artificial Intelligence, A Modern Approach 4th Edition*. Pearson.
4. Microchip. (2025). *MCP3008 Analog to Digital Converter*. Retrieved from http://www.microchip.com/wwwproducts/en/MCP3008.
5. PubNub. (2025). *PubNub Data Stream Network*. Retrieved from https://www.pubnub.com.
6. Raspberry Pi. (2025). *Raspberry Pi 3 Model B*. Retrieved from https://www.raspberrypi.org/products/raspberry-pi-3-model-b/.
7. Suyanto. (2014). *Artificial Intelligence*, 2nd ed. Bandung, Indonesia: Penerbit Informatika Bandung.
8. TechTarget. (2025). *What is Fuzzy Logic?*. Retrieved from http://whatis.techtarget.com/definition/fuzzy-logic
9. TechTarget. (2025). *What is the Internet of Things?*. Retrieved from http://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT