The design and evaluation of an automatic watering system by using Fuzzy Mamdani

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Abstract. The fruits and vegetables are high demand commercial commodities recently. In this work, small spaces are addressed as modern vegetable cultivation in order to fulfill family member vegetables daily needs. The automatic watering system with a soil moisture sensor, a temperature sensor, and periodically watering based on Fuzzy Logic can provide water to vegetables according to their needs is proposed. In the practical, the Chinese Green Cabbage has been watered with the automatic system consists of raspberry pi, temperature sensor, soil moisture sensor, and timer. Both data of soil moisture sensor and temperature sensor are sent to Raspberry Pi that set an optimum condition of the Chinese Green Cabbage cultivation. The watering system is working when the conditions of the soil moisture less than 35% and the temperature of more than 29°C, respectively. However, the automatic watering by using the timer as 30 seconds of watering on 09.00 AM and 03.00 PM is needed. This system has succeeded in applying the Fuzzy Mamdani method to determine the length of watering on Chinese Green Cabbage. As a result, the automation system is promising for the cultivation of vegetable plants around the home living.

1. Introduction

Recently, awareness of Indonesian people on consuming fruits and vegetables becomes government concerns due to the national health programmers. Indonesia is one of tropical country which has a lot of fruits and vegetables. The diversity of colours in vegetables provides benefits and attractiveness in attracting consumers, such as Chinese Green Cabbage [1]. Chinese Green Cabbage classified as a vegetable that is consumed by many Indonesians. Its sweet taste can be used as sweets and has a high nutritional content. The content of water, protein, carbohydrates, fat, anti-cancer nutrients, natural sugars, pectin, glutathione, minerals, and vitamins provide good benefits for health.

Chemical pesticides considered to be the most effective in controlling pest diseases by most farmers [2]. This has encouraged excessive use of pesticides. Farmers often use pesticides as a preventive measure by spraying 1-7 days after planting in the field [3-4]. In terms of production costs, the use of pesticides in vegetable farming reaches 20-30% of the total cost and is the second largest expenditure after labour costs.

Limited production of organic vegetable farming is one of the reasons to develop urban farming with limited locations where may drive small space around the home living. The cultivations do need to treat
perfectly, such as watering and nutrition. The automatic watering system becomes necessary to be implemented by several busy people or farmers for their cultivation [5].

In a previous study conducted by [6] about the Prototype of Raspberry Pi-Based Watering Plants Through Twitter at PT. Dian Surya Global used twitter as a media control for monitoring plants. Watering based on the plant's need through soil temperature, so that the watering will be more scheduled and routine. A system that is simple and capable of processing data on soil moisture and temperature so that it can determine the best condition for plants [7].

Starting from the problems that occur, the authors interested in designing a Raspberry Pi based system using the YL-69 moisture sensor and DHT11 temperature sensor. The automation helps reducing consumption of electricity, decreases the wastage, uses less manpower, and helps in energy saving [5]. The results received from the sensor will be processed by Raspberry Pi so that it will get the status of the condition of soil moisture in Chinese Green Cabbage that can be monitored by the owner through the website.

2. Description of the systems

The proposed of automatic watering system designed by using a soil moisture sensor embedded to a breadboard then connected to Raspberry Pi to convert data from analogue to digital and a temperature sensor DHT11 also connected to a Raspberry Pi [8]. The data obtained from soil moisture sensors and temperature sensors stored in the database due to website base monitoring. The REST API used as an intermediary between Raspberry Pi and the database in order to send the sensor data to the database and also relay as a switch to control the water pump when it turns on or off. The description of the automatic watering system is shown in figure 1.

![Figure 1. The description of the automatic watering system.](image)

In the automatic watering system of Chinese Green Cabbage, the temperature and soil moisture data obtained is calculated by using the Fuzzy Mamdani method. The final result of the Fuzzy Mamdani calculation process corresponds to the on or off of the water pump system automatically and used to determine the duration of watering [9-10]. However, the automatic watering by using the timer as 30 seconds of watering has been arranged twice a day at 09.00 AM and 03.00 PM. The farmers may monitor the watering systems as website base by using the data from Raspberry pi.
3. Results and discussion

The automatic watering system with a soil moisture sensor, a temperature sensor, and periodically watering based on Fuzzy Logic can provide water to vegetables according to their needs [11-12]. In the practical, the Chinese Green Cabbage has been watered with the automatic system consists of raspberry pi, temperature sensor, soil moisture sensor, and timer. Both data of soil moisture sensor and temperature sensor are sent to Raspberry Pi that set an optimum condition of the Chinese Green Cabbage cultivation.

![SOIL MOISTURE](image1)

**Figure 2.** The graph of soil moisture.

![TEMPERATURE](image2)

**Figure 3.** The graph of temperature.

Figure 2 and figure 3 shows a graph of soil moisture data and temperature on Chinese Green Cabbage that taken for 24 hours on 3 consecutive days every 45 minutes. The graph shows that this automatic watering system works when the condition of soil moisture is less than 35% and the temperature is more than 29°C. The system continues to watering and stops automatically until the needs of soil moisture
and a suitable temperature in Chinese Green Cabbage obtained so that the soil moisture and temperature remain maintained.

![Figure 4. The system prototype.](image)

The system prototype is shown in figure 4. The system consists of Raspberry Pi which functions to control the entire system, the temperature sensor (DHT11) used to detect the temperature and connected to a Raspberry Pi where the temperature sensor has a datasheet, among others, VCC on pin 1 is 3.3 volts, Out on pin 7 and Ground on pin 6. Also, the soil moisture sensor (YL69) is used to detect soil moisture. This sensor is connected to breadboard because the output of the soil moisture sensor is analogue so it requires a breadboard to convert analogue data to digital. The relay is used to switch on or off that regulates the on and off from watering where the command obtained from the Raspberry Pi [9-10].

4. Conclusion
The automatic watering system has been designed and evaluated. This system has successfully implemented the Fuzzy Mamdani method to determine the length of watering in Chinese Green Cabbage according to their needs. The watering system is working when the dry conditions of the soil moisture less than 35% and the temperature of more than 29°C, respectively. However, the automatic watering by using the timer as 30 seconds of watering on 09.00 AM and 03.00 PM is needed. The data obtained by the system can be monitored directly by using a website so that it makes it easier for farmers to monitor their Chinese Green Cabbage plants. As a result, the automation system is promising for the cultivation of vegetable plants around the home living.

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