Fuzzy Mamdani Implementation for Hydroponic Water Content Automation

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Abstract. The technique used in this hydroponic planting is DIS (Drip Irrigation System). DIS is an irrigation alternative for arid and semi arid regions because it is more efficient in terms of water and electricity. Several IoT-based devices were developed for automation of DIS techniques in agricultural hydroponics. The problems that arose in this study were in determining the water content of hydroponic plants using 3 (three) variables namely PPM, PH and TEMPERATURE while each plant has different needs. Fuzzy logic is one method for analyzing systems that contain uncertainty. In this study mamdani method, often also known as the Min-Max method, is used. System design to get output is done in stages (a) the formation of fuzzy sets, (b) Application of implication functions, (c) forming rules, and (d) confirmation (defuzzyfication). In this study defuzzyfication is done using centroid method.

Keywords: smart vertical agriculture, DIS, fuzzy, hydroponics.

1 Introduction

Hydroponic systems have been used as one of the standard methods for plant biology research and are also used in commercial production for several plants [1].
Hydroponics in the community in general still use manual systems and are relatively expensive in terms of time, including measurement of acid levels (pH) and nutrients in plants that use hydroponic plant maintenance methods and determine the volume of water used to optimize the system that has been realized. The technique used in this hydroponics is DIS (Drip Irrigation System). it has become one of the most common irrigation systems [2] , especially in arid and semi arid regions in Indonesia because of its advantages, more efficient in terms of water and electricity with automatic functions for the switch to turn it on and off. [3]

Drip irrigation is one such technology that has been introduced to reduce water consumption in the agriculture sector [4]. So the advantage of this method is the use of highly efficient irrigation water [5]. The Irrigation system that is given automation is done to automatically regulate the water concentrate [6]

This study aims to produce devices that can regulate the water content of both nutrients, PH and temperature levels automatically, which are adjusted to the type of plant that is being planted. To solve these problems we tried to determine the value of water content such as nutrition, pH, and temperature of each vegetable on IoT devices by using the Mamdani fuzzy inference method or often known as the min-max method [7] . The design of the system to get output is done in several stages, namely the formation of fuzzy sets, the formation of rules, the

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determination of the composition of the rules, and confirmation (defuzzyfication). Fuzzy selection is done because one of the most common data needs to be overcome is data streaming[8], where the incoming data has a very high speed and is always accompanied by a non-stationary phenomenon. [9] The Fuzzy Mamdani model is implemented on the Smart Vertical Agriculture device. Smart Vertical Agriculture System is a modern technology development on vertical garden systems where the control parameters on the plant are done by the sensor devices and actuators to manage the treatment on the system, thus minimizing the human role that can reduce labor and work automation. In this system the application of agent system becomes the main points developed. [10]

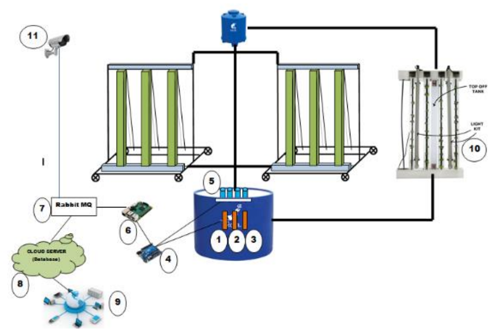

Fig. 1. Architecture of Smart Vertical Agriculture.

1,2,3 is a sensor that identifies the water content that will be sent to the microcontroller (4), the data is received by the IoT device (6) and shone to the Data Server (7,8,9) The calculation results will be received by the Actuator (5) to regulate water content

Fig. 2. Smart Vertical Agriculture Prototype.

2 Fuzzy Mamdani

Fuzzy logic with Mamdani's fuzzy inference method can be applied to the microcontroller [11]. The essence of programming in microcontroller on defuzzification (output) is to determine the crisp value of output of inference used in space-sharing methodology [12]. The implementation in the engine of the application of fuzzy logic systems does not require a detailed systemic model of the system, and the optimal performance of the designed control system can be achieved using human logic, fuzzification formula, knowledge base, inference, and defuzzification [13]

3 Results of 7 (Seven) Crops

3.1 Create Fuzzy Bundles and Inputs

Table 1. Value of Provisions for Hydroponic Vegetables.

No	Plant Name	Ph	PPM	TEMPERATURE
1	Pakcoy	7,0	1050-1400	25-28
2	Kangkung	5,5-6,5	1050-1400	25-28
3	Caisim	5,5-6,5	1050-1400	25-28
4	Red Spinach	5,5-6,6	1260-1610	25-28
5	Spinach	5,5-6,6	1260-1610	25-28
6	Strawberry	5,5-6,5	1260-1540	25-28
7	Celery	7,0	1260-1680	25-28

Table 2. Decision Rule.

No	Variable	Decision Value	Decision
1	PH	<5,5 or >7	Not suitable
2	PPM	<1050 or > 1680	Not suitable
3	TEMPERATURE	<25 or >28	Not suitable

3.2 Form a fuzzy set

The fuzzy set used for each variable is shown in the table below:

Table 3. Fuzzy Collection of Seven Plants.

Variable	Fuzzy Set Names	Domain
	LOW	[0; 6 ; 6,125]
pH	MID	[6 ; 6,125 ; 6,25]
	HIGH	[6,125 ; 6,25 ; 100]
	LOW	[0 ; 1225 ; 1347]
PPM	MID	[1225 ; 1347 ; 1470]
	HIGH	[1347 ; 1470 ; 5000]

TEMPERATURE	LOW	[0 ; 25 ; 26,5]
	MID	[25 ; 26,5 ; 28]
	HIGH	[26,5 ; 28 ; 100]
DECISION	SUITABLE	[0 ; 20 ; 60]
	NOT SUITABLE	[20 ; 60 ; 100]

3.3 Determination of Variable PH of 7 (Seven) Plants

To present the PH variable shoulder shape curves (for LOW & HIGH fuzzy sets) and Triangle shape curves (for MEDIUM fuzzy sets) are used as shown below:

Level of
Membership
μ [z]

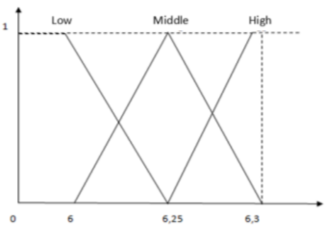

Fig. 3. Ph Curve of 7 Plants.

The membership function is:

$$\mu \text{ pH low}[x] = \begin{cases} 1 ; x \leq 6 \\ \frac{6,25-x}{6,25-6} \quad ; 6 < x < 6,25 \\ 0 ; x \geq 6,25 \end{cases}$$

$$\mu\text{pH mid } [x] = \begin{cases} 1 ; x = 6,25 \\ 0 ; x \leq 6 \text{ dan } x \geq 6,3 \\ \frac{6,3-x}{6,3-6,25} ; \text{lainnya} \end{cases}$$

$$\mu\text{pH high } [x] = \begin{cases} 0 ; x \leq 6,25 \\ \frac{x-6,3}{6,3-6,25} ; 6,25 < x < 6,3 \\ 1 ; x \geq 6,3 \end{cases}$$

If the pH of 7 plants is 6.3 then the fuzzy membership value in each set is:

1) LOW fuzzy set, μpH low [6.3] = 0, (b). MEDIUM fuzzy set, μpH is [6.3] = 0 (c). HIGH fuzzy set, μpH high [6.3] = 1,
2) PPM Variables of 7 Plants. To present PPM variables of 7 (Seven) plants shoulder shape curves (for LOW & HIGH fuzzy sets) and Triangle shape curves (for MEDIUM fuzzy sets) are used as shown in Figure 4.

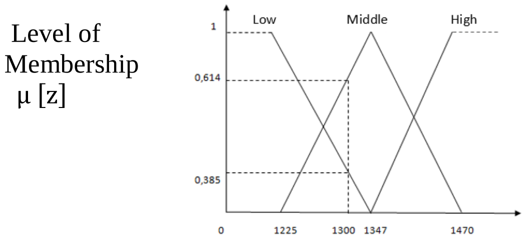

Fig. 4. PPM Curve of 7 Plants

The membership function is :

$$\mu \text{ ppm low } [y] = \begin{cases} 1 \,; x \leq 1225 \\ \frac{1347-x}{1347-1225} \,; 1225 < x < 1347 \\ 0 \,; x \geq 1347 \end{cases}$$

$$\mu \text{ ppm mid } [y] = \begin{cases} 1 \,; x = 1347 \\ 0 \,; x \leq 1225 \text{ and } x \geq 1470 \\ \frac{x-1225}{1347-1225} \,; \text{others} \end{cases}$$

$$\mu \text{ ppm high } [y] = \begin{cases} 0 \,; x \leq 1347 \\ \frac{x-1470}{1470-1347} \,; 1347 < x < 1470 \\ 1 \,; x \geq 1470 \end{cases}$$

If the ppm of 7 (seven) plants are 1300 then the fuzzy membership value in each set is: (a). LOW fuzzy set, low µppm [1300] = 0.385, (b). MEDIUM fuzzy set, medium µppm [1300] = 0.614. (c) HIGH fuzzy set, high µppm [1300] = 0

3.4 Defuzzication

Defuzzication is done using the Centroid method. Determining the area of each: A1, A2, A3 is done to determine the crips z value and Moments to the respective membership values are: M1, M2 and M3. Below is the completion of the input value of pH, ppm, and temperature of all plants. Calculating Moments:

M1 = 0 – 0 = 0
M2 = 241,7448 – (-33,3333) = 275,07809
M3 = 1106,557 – 611,1525 = 495,4049
M result = 0 + 275,07809+ 495,4049 = 770,48299
A1 = 0
A2 = 7,558452
A3 = 9,47326
A result = 0 + 7,558452 + 9,47326 = 17,0171
Calculates the center point (against z):

$$Z = \frac{770{,}48299}{17{,}0171} = 45{,}23814$$

So determining the decision whether the values that have been input is standard or not for 7 plants is:

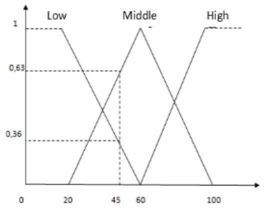

Fig. 5. Decision Result Curve**.**

$$\mu \text{ not suitable} = \begin{cases} 1 \,; z \leq 20 \\ \frac{60-z}{60-20} \,; 20 < z < 60 \\ 0 \,; z \geq 60 \end{cases}$$

$$\mu \text{ suitable} = \begin{cases} 0 \,; z \leq 20 \\ \frac{z-20}{60-20} \,; 20 < z < 60 \\ 1 \,; z \geq 60 \end{cases}$$

Results from input z values:
µtidak cocok = 0,369046
µcocok = 0,630954

4 Conclusion

In previous research hydroponic using automation machine has been developed, but the system is not accurate and need development [14]. and system can't detect acidity levels of pH solution, and viscosity, oxygen, and other aspects [15].

In this study, we developed automation systems for hydroponics with multi plants, and improved the accuracy of nutrient content in water by using fuzzy mamdani. It can be concluded that the ph, ppm, and temperature values that have been input for the 7 (seven) plants are STANDARD or SUITABLE. By using the fuzzy method, the determination of the amount of water content can be adjusted according to the parameters that have been released by the system.

Table 4. Comparison result fuzzy mamdani and other method.

No	Method	Number of Plants	Accuration
1	Crisp Logic	1	100%
2	Venn Diagram	3	70%
3	Fuzzy	7	70%
4	-	1	0%

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References

[1] N. T. Nguyen, S. A. McInturf, and D. G. Mendoza-Cózatl, "Hydroponics: A Versatile System to Study Nutrient Allocation and Plant Responses to Nutrient Availability and Exposure to Toxic Elements," J. Vis. Exp., vol. 8, no. 113, pp. 1–9, 2016.
[2] J. Ja¨germeyr, D. Gerten, J. Heinke, S. Schaphoff, M. Kummu, and W. Lucht, "Water savings potentials of irrigation systems: Global simulation of processes and linkages," Hydrol. Earth Syst. Sci., vol. 19, no. 7, pp. 3073–3091, 2015.
[3] G. Kavianand, V. M. Nivas, R. Kiruthika, and S. Lalitha, "Smart drip irrigation system for sustainable agriculture," Proc. - 2016 IEEE Int. Conf. Technol. Innov. ICT Agric. Rural Dev. TIAR 2016, no. Tiar, pp. 19–22, 2016.
[4] A. Narayanamoorthy, N. Devika, and M. Bhattarai, "More Crop and Profit per Drop of Water: Drip Irrigation for Empowering Distressed Small Farmers," IIM Kozhikode Soc. Manag. Rev., vol. 5, no. 1, pp. 83–90, 2016.
[5] D. S. Kumar and K. Palanisami, "Impact of Drip Irrigation on Farming System : Evidence from Southern India," Agric. Econ. Res. Rev., vol. 23, no. December, pp. 265–272, 2010.
[6] M. Yildirim and M. Demirel, "An Automated Drip Irrigation. System Based on Soil Electrical Conductivity," Philipp. Agric. Sci., vol. 94, no. 4, pp. 343–349, 2011.
[7] S. R. Chaudhari and M. E. Patil, "Comparative Analysis of Fuzzy Inference Systems for Air Conditioner," Int. J. Adv. Comput. Res., vol. 4, no. 4, pp. 922–927, 2014.
[8] O. Horovitz, S. Krishnaswamy, and M. M. Gaber, "A fuzzy approach for interpretation and application of ubiquitous data stream clustering," Present. 2nd Int. Work. Knowl. Discov. Data Streams (IWKDD), Porto, Port., vol. 11, no. 1, pp. 89–108, 2005.
[9] X.-J. Zeng and D. Ge, "Learning evolving Mamdani fuzzy systems based on parameter optimization," IEEE Int. Conf. Fuzzy Syst., 2017.
[10] A. Cucus and M. S. Febrianti, "Implementation of Sensor Ph Meter , Ec Meter and Temperature on Smart Vertical Agriculture System .," no. Icetd, pp. 446–452, 2017.
[11] B. Wyrwoł and E. Hrynkiewicz, "Decomposition of the fuzzy inference system for implementation in the fpga structure," Int. J. Appl. Math. Comput. Sci., vol. 23, no. 2, pp. 473–483, 2013.
[12] I. Sakti, "Methodology of Fuzzy Logic," 2014 I st Int. Conf. Infonnation Technol. Comput. Electr. Eng. (ICIT ACEE), pp. 93–98, 2014.
[13] P. Tarigan, S. Sinurat, and M. Sinambela, "Implementation of a Mamdani fuzzy logic controller for building automation using electronic control based on AT89S51," Proc. 2015 Int. Conf. Technol. Informatics, Manag. Eng. Environ. TIME-E 2015, pp. 87–92, 2016.
[14] R. lochan Mishra, Preet Jain, "Design and Implementation of Automatic Hydroponics System using ARM Processor," Int. J. Adv. Res. Electr. Electron. Instrum. Eng., vol. 4, no. 8, pp. 6935–6940, 2015.
[15] P. Sihombing, N. A. Karina, J. T. Tarigan, and M. I. Syarif, "Automated hydroponics nutrition plants systems using arduino uno microcontroller based on android," J. Phys. Conf. Ser., vol. 978, no. 1, 2018.