Irrigation forecasting by using fuzzy logic on sensor data

A Puspaningrum*, E Ismantohadi and A Sumarudin
Department of Informatics Engineering, Politeknik Negeri Indramayu, Indonesia

*alifia.puspaningrum@polindra.ac.id

Abstract. Water irrigation is one of the most critical resource in developing agriculture. Furthermore, increasing of domestic demand has been divert water supply in agriculture. However, the efficiency of irrigation is very low. Besides that, soft computing tools like Fuzzy Logic has been used widely in many areas. Fuzzy logic has a good performance to solve the problem precisely. In particular, this method has been found useful in the area of agriculture. So that, this paper proposes irrigation forecasting by using Fuzzy Logic. The irrigation is forecast by using several sensor data such as soil, air temperature, and humidity to calculate opening of valve. Experimental result shows that the proposed method can give the prediction of valve opening for irrigation.

1. Introduction
Precision agriculture provide an integrated information about farming in order to minimizing unintended impacts [1]. So that, there are many technologies used various sensor to automate process of collection, communication, and prediction [2,3].

Many model has been conducted during few last decades [4]. It helps in estimating much unintended risk in many kind of area, especially agriculture [5]. One of the most robust approaches is fuzzy logic approach. Fuzzy logic has been widely used in various area, such as transportation [6], medical, control system, etc. [7]. In addition, fuzzy logic approach was strongly recommended and some models using the fuzzy logic were developed in agriculture area, such as climate control [8], rainfall prediction [9], livestock finding [10], measuring agricultural soil quality [11], water quality [12], land grab [13], water efficiency [14], soil erosion detection [15], etc.

One of area that important to be controlled is irrigation. Irrigation help grower to monitor soil moisture and get an optimum level of crop parameter [16]. There are different types of irrigation such as Surface irrigation, Localized irrigation, Drip irrigation and Sprinkler irrigation. In the field of agriculture, use of proper method of irrigation and its control is important [17]. However, grower has to watch the irrigation process regularly. When the process is failed, water will be more consumed, or when it is getting late, crop gets dried. Irrigation has traditionally resulted in excessive labour and non-uniformity in water application across the field. Hence an automatic irrigation system based on sensing technology is required to reduce the labour cost and to give uniformity in water application across the field. In this era, there has been many techniques that can be used to irrigate the land according to its condition.

One of control that can be process is valve control. This paper propose fuzzy logic to process three parameters into percentage of valve opening, namely soil moisture, air temperature, and humidity. For designing, Fuzzy Mamdani model is used in fuzzy logic tool to control different parameters of automatic irrigation control system. With the passage of time, requirement for food and crops are
increasing. Water is main component for agriculture. The power source is main requirement, if we use valve well for irrigation purpose

2. Methods

![Diagram of fuzzy logic stages]

There has been many problems that can be solved by Fuzzy Logic precisely. Fuzzy logic can calculate value between 0 and 1 because of its function named fuzzy sets [18]. There are four stages of fuzzy logic, namely: Fuzzification, Rule base of fuzzy, Fuzzy Inference, and Defuzzification as shown as Figure 1. Fuzzification is a process to define input, output, and its membership functions. Fuzzy Rule base is a set of rule written in IF-THEN linguistic variables. In this research, Trapezoidal fuzzy is used. There are three attributes that are used in this research based on analysis of the problem as shown in Table 1.

| Name             | Measured as | Linguistic Variable                |
|------------------|-------------|------------------------------------|
| Soil Moisture    | CentiBars   | Dry, Normal, Adequately Wet, Saturated |
| Humidity         | %           | Low, Medium, High, Extremely High   |
| Temperature      | Degree C    | Very Cold, Cold, Normal, Hot, Very Hot |
| Output           | Valve Opening | %                |
|                  |             | 10%, 25%, 50%, 75%, 100%          |

*Figure 1. Stages of fuzzy logic.*

*Table 1. Attributes description.*
According to Table 1, soil moisture, humidity, and temperature as inputs and valve opening as output are well processed by using Fuzzy Logic.

Table 2 describes Soil Moisture range. It describes the quantity of water contained in soil. If the crops are moist, the supply of the water can be over than it should be. So that, it can damage the crops. Soil moisture is registered in centibars (cb) or kilopascals (kPa) in certain devices.

**Table 2. Soil Moisture range.**

| Sensor Name   | Level (CentiBars) | Linguistic Variable | Range         |
|---------------|-------------------|---------------------|---------------|
| Soil Moisture | 10                | Saturated           | [0 0 6 12]    |
|               | 20                | Adequately Wet      | [6 12 18 24]  |
|               | 30                | Normal              | [18 24 30 36] |
|               | 40                | Dry                 | [30 36 60 60] |

**Temperature around the soil:** Temperature has optimal effect for seeds germination. If the temperature is high, evaporation will be happened. So that, temperature is considered in irrigation process. Degree C is the expression for temperature. The range of temperature is described in Table 3.

**Table 3. Temperature range.**

| Sensor Name   | Level (C) | Linguistic Variable | Range         |
|---------------|-----------|---------------------|---------------|
| Environment   | 10        | Very Cold           | [0 0 10 15]   |
| Temperature   | 20        | Cold                | [10 15 20 25] |
|               | 30        | Normal              | [20 25 30 35] |
|               | 40        | Hot                 | [30 35 40 45] |
|               | 45        | Very Hot            | [40 45 50 50] |

**Humidity:** Humidity is expressed as a percentage of moisture in the air around the soil surface. Table 4 indicates the Humidity Range. Relative humidity is the percentage of maximum water content at a given temperature. Humidity is expressed in %. RH 100% means extremely humid condition and for instant 50% indicate very dry air condition.

**Table 4. Humidity range.**

| Sensor Name | Level (%) | Linguistic Variable | Range         |
|-------------|-----------|---------------------|---------------|
| Humidity    | 10        | Low                 | [0 0 10 20]   |
|             | 20        | Medium              | [10 20 30 40] |
|             | 30        | High                | [30 40 50 60] |
|             | 40        | Extremely High      | [50 60 60 60] |

Valve opening has five membership functions as illustrated in Figure 2. They are denoted by 10%, 25%, 50%, 75%, and 100% valve is opened.

**Figure 2. Membership function for ValveOpening (opening).**
In this research, 83 rules are generated for the fuzzy logic model of the problem. Some of rules are described in Table 5.

| Rule No. | Rule |  |
|----------|------|---|
| R1       | Soil Moist Dry dan Air Temperature Very Hot and Air Humid Low Then open full |  |
| R2       | Soil Moist Dry dan Air Temperature Very Hot and Air Humid Medium Then open full |  |
| R3       | Soil Moist Dry dan Air Temperature Very Hot and Air Humid High Then open full |  |
| R4       | Soil Moist Dry dan Air Temperature Very Hot and Air Humid Extreme Then seventy-five |  |
| R5       | Soil Moist Dry dan Air Temperature Hot and Air Humid Low Then open full |  |
| R80      | Soil Moist Saturated dan Air Temperature cold and Air Humid Extreme Then ten |  |

### 3. Result and discussion

#### 3.1. Dataset

This study uses modified publicly available dataset [4]. In this experiment, we predict the opening of valve by using three parameters namely: soil moisturation, air temperature, and humidity. There are 71,802 records after pre-processed used in this research.

#### 3.2. Experimental result

| Table 6. Recommendation using fuzzy logic. |
|------------------------------------------|
| ID | Data | Soil Moisures | Air Temperature | Humidity | Output |
|---|------|----------------|-----------------|----------|--------|
| 1 | 26.421 | 15 |  | 93 | 10 |
| 2 | 18.293 | 27.2 |  | 46 | 25 |
| 3 | 24.969 | 15 |  | 86 | 10 |
| 4 | 18.578 | 25.5 |  | 36 | 25 |
| 5 | 18.578 | 30.5 |  | 37 | 25 |
| 6 | 18.578 | 29.4 |  | 37 | 25 |
| 7 | 20.899 | 22.7 |  | 74 | 10 |
| 8 | 22.065 | 26.099 |  | 62 | 10 |
| 9 | 25.837 | 38.3 |  | 22 | 50 |
| 10 | 25.837 | 38.3 |  | 20 | 50 |
| 11 | 25.837 | 37.699 |  | 26 | 50 |
| 12 | 25.552 | 37.699 |  | 25 | 50 |
| 13 | 25.552 | 37.699 |  | 23 | 50 |

As a final step, the opening of valve is recommended using Fuzzy Logic as described in Section 1. Some of result recommendation is shown in Table 6. Based on the result, fuzzy logic can give a good recommendation result in a valid way. As described in rule extraction of the proposed method, the result of the output depends on the value of the membership function and the attribute itself.

For the next research, the using of another attribute can be acquired to not only recommend the opening value of valve, but also the fertilization process [19]. Besides that, the system can be enhance to predict future irrigation needs in order to monitor system performance in real time and consider environmental and climatic factors along with the time and duration of irrigation as well as the amount of water being sourced were recorded.
4. Conclusion
The implementation of Fuzzy Logic is proposed to predict valve opening in irrigation. The experimental result shows that proposed method can obtain prediction of valve control in a valid way. For the future work, the using of another attribute can be acquired to not only recommend the opening value of valve, but also the fertilization process. Besides that, the system can be enhance to predict future irrigation needs in order to monitor system performance in real time and consider environmental and climatic factors along with the time and duration of irrigation as well as the amount of water being sourced were recorded.

Acknowledgments
We would like to thank Indramayu State Polytechnic for its support, financial assistance and encouragement.

References
[1] Thompson N M, Bir C, Widmar D A and Mintert J R 2019 Farmer perceptions of precision agriculture technology benefits Journal of Agricultural and Applied Economics 51(1) 142-163
[2] Touati F, Al-Hitmi M, Benhmed K and Tabish R 2013 A fuzzy logic based irrigation system enhanced with wireless data logging applied to the state of Qatar Computers and electronics in agriculture 98 233-241
[3] Morais R, Silva N, Mendes J, Adão T, Pádua L, López-Riquelme J A and Peres E 2019 Mysense: A comprehensive data management environment to improve precision agriculture practices Computers and Electronics in Agriculture 162 882-894
[4] Kale S S and Patil P S 2019 Data mining technology with fuzzy logic neural networks and machine learning for agriculture In Data Management Analytics and Innovation.
[5] Sami M, Shiekhdavoodi M J, Pazhohanniya M and Pazhohanniya F 2014 Environmental comprehensive assessment of agricultural systems at the farm level using fuzzy logic: a case study in cane farms in Iran Environmental modelling & software 58 95-108
[6] Puspaningrum A, Suheryadi A and Sumarudin A 2019 Pre-Collision Warning and Recommendation System for Assistant Driver using Least Square Support Vector Machine and Fuzzy Logic In 2019 International Seminar on Intelligent Technology and Its Applications (ISITIA)
[7] Mushtaq Z, Sani S S, Hamed K, Ali A, Ali A, Belal S M and Naqvi A A 2016 Automatic Agricultural Land Irrigation System by Fuzzy Logic In 2016 3rd International Conference on Information Science and Control Engineering (ICISCE)
[8] Heidari M and Khodadadi H 2017 Climate control of an agricultural greenhouse by using fuzzy logic self-tuning PID approach In 2017 23rd International Conference on Automation and Computing (ICAC)
[9] Heidari M and Khodadadi H 2017 Climate control of an agricultural greenhouse by using fuzzy logic self-tuning PID approach In 2017 23rd International Conference on Automation and Computing (ICAC)
[10] Kurniasih D, Jasmi K A, Basiron B, Huda M and Maseleno A 2018 The uses of fuzzy logic method for finding agriculture and livestock value of potential village International Journal of Engineering & Technology 7(3) 1091-1095
[11] Rodríguez E, Peche R, Garbisu C, Gorostiza I, Epelede L, Artetxe U and Etxebarria J 2016 Dynamic quality index for agricultural soils based on fuzzy logic Ecological indicators 60 678-692
[12] Mirabbasi R, Mazloumzadeh S M and Rahnama M B 2008 Evaluation of irrigation water quality using fuzzy logic Research Journal of Environmental Sciences 2(5) 340-352
[13] Fraser A 2019 Land grab/data grab: precision agriculture and its new horizons The Journal of Peasant Studies 46(5) 893-912
[14] Bonfante A, Monaco E, Manna P, De Mascellis R, Basile A, Buonanno M and Belfiore O 2019 LCIS DSS—An irrigation supporting system for water use efficiency improvement in precision agriculture: A maize case study Agricultural Systems 176 102646.

[15] Saha S, Gayen A, Pourghasemi H R and Tiefenbacher J P 2019 Identification of soil erosion-susceptible areas using fuzzy logic and analytical hierarchy process modeling in an agricultural watershed of Burdwan district India Environmental Earth Sciences 78(23) 649

[16] Izzuddin T A, Johari M A, Rashid M Z A and Jali M H 2018 Smart irrigation using fuzzy logic method ARPN Journal of Engineering and Applied Sciences 13(2) 1819-6608

[17] Patil P, Kulkarni U, Desai B L, Benagi V I and Naragund V B 2012 Fuzzy logic based irrigation control system using wireless sensor network for precision agriculture Agro-Informatics and Precision Agriculture (AIPA)

[18] Huda S, Sarno R and Ahmad T 2015 Fuzzy MADM approach for Rating of Process-based Fraud Journal of ICT Research and Applications 9(2) 111-128

[19] Papadopoulos A, Kalivas D and Hatzichristos T 2011 Decision support system for nitrogen fertilization using fuzzy theory Computers and electronics in agriculture 78(2) 130-139