Soil Irrigation Fuzzy Estimation Approach Based On Decision Making In Sugarcane Industry

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***Abstract*— A soil irrigation with Fuzzy Estimation Approach based on Decision Making in Sugarcane Industry is a system to control and evaluate soil moisture content. The main purpose is to maintain soil moisture content which is very influential for optimizing soil fertility levels, especially in the field of sugar cane farming. This method is using an automatic irrigation system, and it can control soil water uses to be more effective and economical in the irrigation process. First stage of this system, The fuzzification process is performed on three types of data used as input parameters, which are then used as the criteria for assessment, then selected the most relevant criteria of each assesment alternatives. The process is done until it gets the best judgment from each alternatives. The next stage, Membership function is made to estimate the next process and defuzzification process. This model provides an estimate of quantitative water requirements, then it provide the precise water demand required on sugarcane farms, and maintain soil moisture conditions to remain constant according to the needs of sugarcane.**

Keywords—component; Fuzzy Logic; defuzzification; Soil irrigation;

I. INTRODUCTION

In 21st Century, technology in agriculture sector has growing rapidly, ranging from the process of selecting seeds until harvesting process [6]. Indonesia is an agrarian country, so many people of Indonesia work as farmers, especially island of Java. One of the most needed market commodities is sugar produced by sugarcane. Sugarcane is a plant that requires a fairly high water content. The current problem, sugarcane farmers in Indonesia have not appropriate technological assistance to manage the irrigation process, Which can further optimize crop yields and water consumption more efficiently in accordance with plant nutrients. In addition, currently the effectiveness of water utilization is very useful for the surrounding environment [9]. This system is based on the concept of precision agriculture, involving the assessment of spatial variables that affect soil fertility, such as the type and characteristics of soil and water content in the field [7]. Therefore, it is significant enough to assess soil fertility based on the potential of soil irrigation systems [10].

In previous research, there have been many irrigation methods developed to handle the problem of plant irrigation system. One of them is water irrigation method, based on plant moisture value using fuzzy logic method. The system uses a fuzzy method to set the soil moisture value at a particular set point. This system uses an integrated suite of sensors consisting of Temperature, Rain, Solar Radiation, Wind Speed, Evapotranspiration. This system requires internet connection, so it is less suitable to be applied in remote areas. Another disadvantage of previous research, has not been specifically explained for the type of plant used on the system.

Generally, the system uses an integrated sensors and the measurement process was not directly in contact with the ground that became the measuring medium (using the radio signal frequency). The sensors used in this system are planted in several locations that become regional plots. The advantage of this system, in addition to the smaller error rate, the cost required for the implementation of this system is also much less, then the system is suitable for implementation on small to large farms.

This journal discusses the regulation of irrigation systems on sugar cane farming. The objective is to provide system who can control the soil moisture content, and manage the efficient use of water as possible so as to obtain more optimal results. This system uses three sensors as input variables, humidity sensor, pH sensor, and temperature sensor. The data from sensors is processed using fuzzy method to get evaluation criteria and determine the appropriate output, that is the time of the process of watering plants.

II. EASE OF USE

A. *Internet of Things*

In the development of Internet of Things (IoT), create an software application more powerful, and it can help people to manage their activities, be it daily routines or in the field of work [4]. Before Internet of Thing concept was introduced, users must be in the same place to get data about their system and operating their system [1]. The very easy system as shown in fig. 1, Users can monitor agricultural data such as Soil Humidity, Temperature, and Soil pH captured through the sensor. Data interacts with other components over the wireless network.

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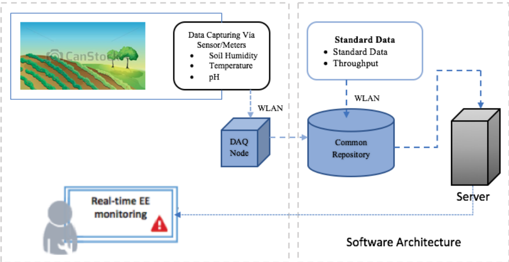

Fig. 1. Internet of Things Concept

B. Plotting regional for enhancing soil humidity measuremen

Measuring soil moisture levels can not be done only at one point, this is because the soil conditions are not always the same between one location and another [8]. This can be due to several things, uneven lighting, or the degree of inclination of different places even if located in one location. Then it needs plot estimation in some area to increase sensor accuration value [5]. That is used for create variable value in irrigation system automation. Therefore, the system attempts to estimate the soil humidity conditions on the basis of the pre-selected checkpoint. Determination of soil humidity value is also based on soil moisture value, temperature, and soil pH level which is very influential on the condition of plant fertility.

In this automatic irrigation system, each area measured the soil moisture value, thus requiring high complexity for determine measurement area. Thus, the system is suitable for use in various agricultural areas.

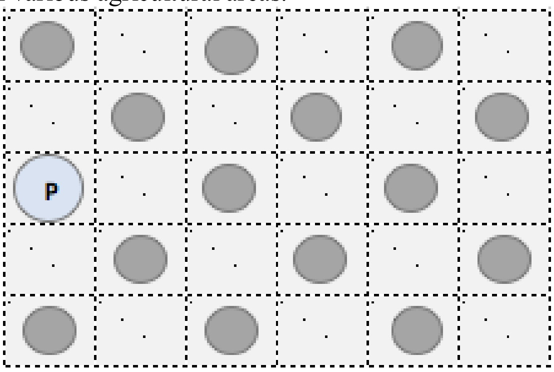

Fig. 2. Regional Estimation Checkpoint

In Fig. 2, present a land mapping based on a predetermined checkpoint or called a regional estimation. The sensors used are placed on each checkpoint, while the main system is placed on the main checkpoint, so the data from each checkpoint is processed at the main checkpoint to obtain the most appropriate decision variable to be assigned to each checkpoint.

C. Soil Moisture Sensor YL-69

Soil moisture YL-69 is a sensor use to moisture and detect humidity of the soil. This sensor has two part, electronic board, and the probe with two pads. The module of YL-69 has 4 pins:

- VCC : 3.3 – 5 V
- GND : Ground Pin
- AO : Analog Output that can read by Raspberry Pi
- DO : Digital Output (low or high) depending preset value

The sensor has a built-in potentiometer for sensitivity adjustment of the digital output (D0), a power LED and a digital output LED.

D. pH Sensor

This sensor use to detect pH level of the soil. The soil pH pH sensor can work in serial or via I2C protocol. This is a passive device that detects a current generated from soil ion activity. Soil pH sensor spesifications :

- pH Range : 0 – 14 (N_a+ error at > 12.3 pH)
- Isopotential point : pH 7.00 (0 mV)
- Operating temperature : 1ºC – 99ºC

The current output is very weak and can not be detected with an analog to digital converter or multimeter.

E. Temperature Sensor

Temperature sensor lm-35 has an output voltage linearly proportional to the centigrade temperature and has an advantage over linear temperature sensors calibrated in Kelvin. This sensor has some advantages feature :

- Operates from 4 V – 30 V
- 0.5ºC Ensured Acuracy (at 25ºC)
- Calibrated directly in celcius.

This sensor use to detect and measure heat of soil with an electrical output proportional to the temperature from a distance.

III. Design System

This paper present a Soil irrigation fuzzy estimation system based on decision making in sugarcane industry. This system is designed to assist farmers in optimizing their agricultural products, especially in sugar cane farming. One of the success factors in this farm is based on soil fertility level that is influenced by water humidity and acid-base soil [3].

This system using three types of sensors, soil moisture sensor YL-69 , pH sensor, and temperature sensor. Sensors are located in checkpoint system, and send data to primary system to be processed in real time with raspberry Pi. The data received by raspberry pi are used as input parameters, which are then processed using the fuzzy algorithm method to obtain the assessment criteria. Of the data used as assessment criteria, selected the most relevant criteria. For further membership functions are made to be used in the defuzzification process.

A. Diagram System

The system of Soil irrigation fuzzy estimation approach based on decision making has three block diagram, input, process, and output.

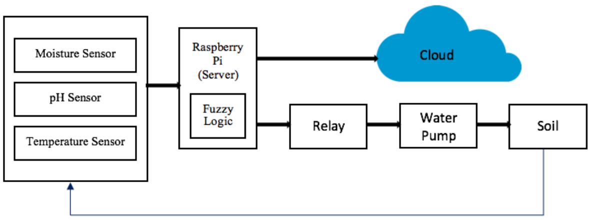

Fig. 3. Block Diagram of Control System

This system was designed to make sugar cane irrigation system automatically based on input value of three sensors, ie moisture sensor, pH sensor, and temperature sensor. Of the three values on the sensor, the data is processed by fuzzy logic method in raspberry pi. The output data is used to control the relay on / off water pump. In addition, the output value is also displayed in realtime on the user's device to facilitate the process of monitoring the data.

TABLE I. FUZZY RULE BASE SYSTEM

Code	**Condition 1**				**Condition 2**				**Condition 3**			
	Humidity	*Temperature*	*pH*	*Watering Time*	*Humidity*	*Temperature*	*pH*	*Watering Time*	*Humidity*	*Temperature*	*pH*	*Watering Time*
1	Dry	Too Cold	Normal	Close Slow	Normal	Too Cold	Normal	Close Fast	Wet	Too Cold	Normal	Close Very Fast
2	Dry	Cold	Normal	Normal	Normal	Cold	Normal	Close Slow	Wet	Cold	Normal	Close Fast
3	Dry	Normal	Normal	Open Slow	Normal	Normal	Normal	Normal	Wet	Normal	Normal	Close Slow
4	Dry	Warm	Normal	Open Fast	Normal	Warm	Normal	Open Fast	Wet	Warm	Normal	Normal
5	Dry	Hot	Normal	Open Very Fast	Normal	Hot	Normal	Open Slow	Wet	Hot	Normal	Open Slow
6	Dry	Too Cold	Liming	Close Slow	Normal	Too Cold	Liming	Close Fast	Wet	Too Cold	Liming	Close Very Fast
7	Dry	Cold	Liming	Normal	Normal	Cold	Liming	Close Slow	Wet	Cold	Liming	Close Fast
8	Dry	Normal	Liming	Open Slow	Normal	Normal	Liming	Normal	Wet	Normal	Liming	Close Slow
9	Dry	Warm	Liming	Open Fast	Normal	Warm	Liming	Open Fast	Wet	Warm	Liming	Normal
10	Dry	Hot	Liming	Open Very Fast	Normal	Hot	Liming	Open Slow	Wet	Hot	Liming	Open Slow
11	Dry	Too Cold	Acid	Close Slow	Normal	Too Cold	Acid	Close Fast	Wet	Too Cold	Acid	Close Very Fast
12	Dry	Cold	Acid	Normal	Normal	Cold	Acid	Close Slow	Wet	Cold	Acid	Close Fast
13	Dry	Normal	Acid	Open Slow	Normal	Normal	Acid	Normal	Wet	Normal	Acid	Close Slow
14	Dry	Warm	Acid	Open Fast	Normal	Warm	Acid	Open Fast	Wet	Warm	Acid	Normal
15	Dry	Hot	Acid	Open Very Fast	Normal	Hot	Acid	Open Slow	Wet	Hot	Acid	Open Slow

C. Fuzzy Logic System

The ability of fuzzy logic is to solve the problems associated with precision. A fuzzy approach was used to weigh the PBF attribute values. This is useful for investigating conditions whose values are in intervals [11] [12].

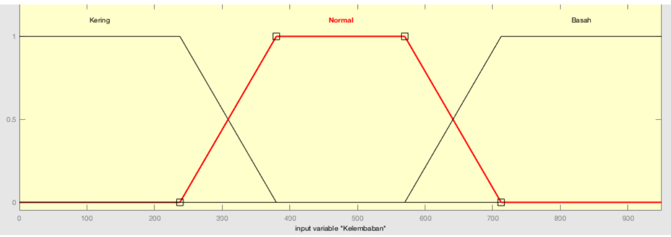

Fig. 4. Membership Function Soil Moisture Sensor

The values of each sensor are grouped in the membership function fuzzy logic. In Fig. 4, the membership function of the soil moisture sensor value is classified into three groups, Dry with range 0-380, normal in range between 237.5 - 712.5, wet in range between 570 - 950.

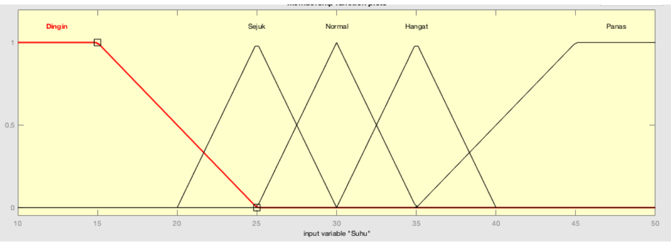

Fig. 5. Membership Function Temperature Sensor

In fig. 5, Based on the data of sample test results obtained by the value of temperature sensor as follows:

- Cold : 10°C – 25 °C
- Sejuk : 20 °C - 30 °C
- Warm : 30 °C - 40 °C
- Hot : 35 °C - 45 °C

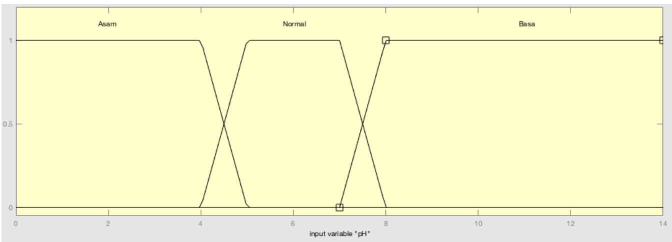

Fig. 6. Membership Function pH Sensor

To maximize growth, fertility and produce high sugarcane yield, soil need to keep the condition in good structure. The optimum pH condition for fertility is about 6.0 to 6.5. But, sugarcane can gworing in soil with pH in range 5.0 to 8.0. In fig. 6, Obtained the value of membership based on sample testing as follows, Acid in range between 0.0 to 5.0, Neutral in range between 4.0 to 8.0, Liming in range between 7.0 to 14.0.

From the measurements on the three sensors (Moisture, temperature, and pH Sensor), the value will be processed in raspberry pi. The value is processed using fuzzy method to obtain criteria which are then used to activate the duration of watering depend on soil conditions.

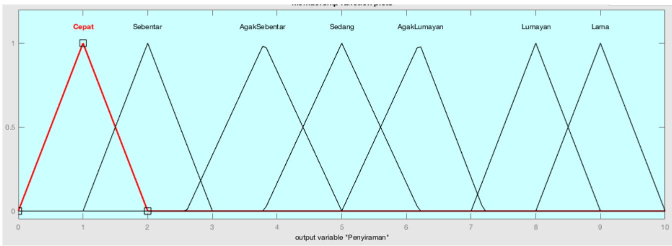

Fig. 7. Membership Function Output Water Pump

Variable output is used for water sprinkling. This means the time it takes the system for watering plants. In Fig. 7, the result of grouping output variables based on duration of watering is divided into six membership functions.

The next phase determines the fuzzy rule based on the linguistic relation between variables, for example "if A then B". In that correlation, A is called by the premise and B is consequence. The impact of using this rule, raises the tolerance value for inaccuracy and uncertainty. The equation of fuzzy rule based system has the following form as in (1) [2].

$$If\ a_1\ is\ A_{i,1}\ \Theta\ a_2\ is\ A_{i,2}\ \Theta \ldots..\Theta\ a_k\ is\ A_{i,k}\ then\ B_i \quad (1)$$

Based on the value of fuzzy logic membership, it can be described fuzzy rule based system values as in table 1.

D. Flowchart Diagram System

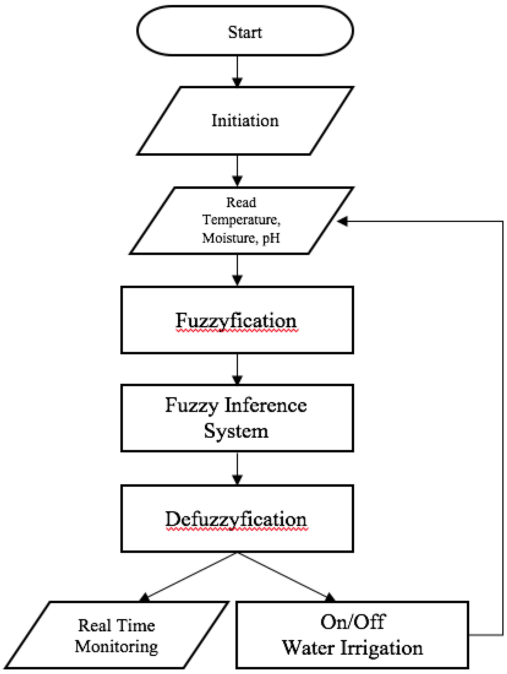

Fig. 8. Flowchart Diagram System

In fig 8, the system starts when the sensor has started to read data by the pH sensor, moisture sensor and temperature sensor. Results of data readings will be classified according to the respective function of each sensor on raspberry pi. From the data that has been classified, selected data that meet the relevant criteria, which is used to determine the duration of the process of watering plants and display data in realtime to the user device. The water pump system will automatically off when the soil has reached the ideal conditions.

IV. IMPLEMENTATION

The system of this paper based on Internet of Things concept in agriculture, uses the main features of control and realtime monitoring. The main components of the system consist of mini computer Raspberry pi, Sensors (humidity, pH, temperature). And the decision making method using fuzzy logic method, which is one of the methods of some mathematical methods. The output data from the processing of fuzzy logic method is also displayed in realtime utilizing cloud computing technology, and it was displayed to the user's hardware.

A. *Validation of the soil moisture sensor, temperature Sensor and pH Sensor*

The sensor validation process used in this system is different for each sensor. At the temperature sensor, a calibration process with a thermometer is conducted to determine whether the temperature released by the temperature sensor corresponds to the value of the thermometer. For validation of pH sensors acid and alkaline fluids are used as calibration. Liquid vinegar and soap have been measured pH value using universal pH indicator, obtained the pH value of vinegar 3 and pH soap 9. Then, the process of taking data with pH sensor in vinegar and soap solution to get the sensor value. After all data obtained, the next process is to compare data from sensor output with universal pH indicator.

In the soil moisture sensor YL-69 testing process, the test process is the same as pH sensor, by comparing the value of the humidity sensor output to the value of soil moisture meter.

TABLE II. SENSOR OUTPUT DATA

code	**Output Sensors**					
	Soil Moisture Sensor			**Soil Temperature Sensor**		**Soil pH Sensor**
	Output Sensor	*% Rh*	*Voltage (V)*	*Output Sensor °C*	*Termometer °C*	*Output Sensor*
1	15	1.46	0.05	39	39	6.137
2	389	38.025	1.25	33.3	34	6.306
3	572	55.9	1.84	29.9	30	6.402
4	645	63.05	2.08	26.5	28	6.384
5	775	75.8	2.5	24.7	25	6.453
6	856	83.7	2.76	21.2	23	6.632

B. *Implementing System*

The system is tested by taking data on the soil used as a sample, as in table 2. Data obtained from three sensors, namely soil moisture sensors, temperature sensors, and pH sensors. Output data from the sensor is processed in raspberryPi and processed by fuzzy logic that has been created and then the system determines the action in accordance with the draft decision of the water pump system. Which, obtained the accuracy level in the process of watering.

V. CONCLUSION

This paper applies a fuzzy method to control agricultural irrigation systems for determining quantitative water quantities. Membership function on the fuzzy logic control system is designed based on the sensor input data. This system applies fuzzy logic to adjust and stabilize the system in overcoming the water demand problem for sugarcane crops. The results show that the system designed with fuzzy method is very effective in increasing the effectiveness of water use and also increased transient stability of the system as a whole during the condition of the water shortage. Significant effects of the system used have been shown particularly in the analysis of water shortage plants due to temperature, as well as soil pH levels. In addition, the steady state performance of the system used is analyzed using soil moisture variables and the result of soil moisture terminal voltage has random variation but can be controlled constantly

The recommended approach to improve the performance of this system is by adding image processing system to the process of recognition of pests or insects, so it can be done with the insecticide prevention, in addition required process image recognition to determine the level of plant fertility by processing image data from sugar cane leaves.

I. FUTURE WORK

In the rapidly evolving world of technology, system automation has to be done to assist human activities. In this paper, some fuzzy logic is applied to the stability of soil moisture conditions. There are still some techniques and methods that can be developed in agriculture, such as estimating crop production and its application using fuzzy logic and K-means, estimating ideal weather conditions for harvesting and seed planting and some agricultural related technologies such as pest control and fertility measurement plant.

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