Rain Detection System for Estimate Weather Level Using Mamdani Fuzzy Inference System

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***Abstract*—High rainfall can cause floods in some communities. Therefore, we need a tool and system to monitor rainfall. This tool and system is designed by using Arduino Uno Microcontroller which is integrated with Rain sensor, Humidity, and Temperature sensor to monitor the weather. This application is designed to provide warnings and reports on the size of the rainfall level that can minimize the potential for flooding from the beginning. Analog and digital input data from Arduino are sent one by one to the Fuzzy Interface using serial protocols, the data processed using the Fuzzy Algorithm is used comparing the results of the Rain sensor, Humidity and Temperature sensor outputs. Comparison of sensor data will be generated a condition of the rule in accordance with the perception of a person in assessing a rain condition, the five conditions of this rule are, first Sunny, Cloudy, Drizzle, Wet, Heavy Rain. Testing of this system will be determined one rule as an alternative and the final decision of rainfall monitoring. This model provides an estimate of rainfall weather to remain rain level detection.**

Keywords - rain sensor, humidity, temperature, sunny, cloudy, drizzle, wet, heavy rain, fuzzy logic

I. INTRODUCTION

In general, floods result from rainfall with long duration of time. In a certain time, rain resulted in overflow water flow and volume of water widened. The volume of water and the velocity of the water flow is not proportional to the level of rainfall and the velocity of water flow to the river and finally to the sea. So, we need a measurement of the intensity of rainfall levels to anticipate and control how big the potential for flooding.

The development of microcontroller today makes the microcontroller. equipped with advanced equipment, for example, Arduino Uno microcontroller that can be used to calculate the intensity of rainfall in a predetermined condition. The supporting modules used are Rain, Humidity and Temperature sensors. These three sensors will produce water and temperature intensity data, in the process will be compared with a Fuzzy algorithm to provide data that is real and accurate, so it can be used to anticipate flood disaster since early.

Rain detection system and modeling have been studied for decades in various ways. For Example, using A Rain Prediction with FIS Tsukamoto implemented in Tengger Malang area [6]. Fuzzy logic for Wiper system on a car [2]. Analysis of Defuzzification method for Rain Event. [3]. Weather parameter optimization using ANFIS and Linear Progression methods [4]. Soil Irrigation Fuzzy Estimation Approach Based on Decision Making in Sugarcane Industry [5], A Rainfall Forecasting using Fuzzy System Based on Genetic Algorithm [6], Comparison of Fuzzy Logic and Neuro-Fuzzy Algorithms for Air Conditioning System [7], Analysis of Defuzzification Method for Rainfall Even [8]. In this study the authors contribute to provide an analysis of rain detection system using single board rain and humidity sensors that can produce reliable rule conditions using Mamdani FIS.

II. PREVIOUS RESEARCH

A. Related Work

1. Ahmad Arif Alfin, Riyanarto Sarno, 2017 [5] Soil Irrigation Fuzzy Estimation Approach Based On Decision Making In Sugarcane Industry. has discussed to a fuzzy method to control agricultural irrigation systems for determining quantitative water quantities

2. Ida. Wahyudi, Wayan. Firdaus Mahmudy, Atiek Iriany, 2016 [6], Rainfall Prediction in Tenger Region Indonesia using Tsukamoto Fuzzy Inference System, has explained prediction of Tsukomoto fuzzy inference system (FIS) to forecast seasonal rainfall in the Tengger, East Java.

3. Nhita. Fhira., Adiwijaya., 2013 [7], A Rainfall Forecasting using Fuzzy System based on Genetic Algorithm (GA), has discussed rainfall forecasting system using fuzzy with combination of GA to produce higher accuracy model probability.

4. Arshdepp. Kaur, Amrit. Kaur, 2013 [8], A Comparison of Fuzzy Logic and Neuro Fuzzy

Algorithms for air Conditioning system. Has discussed The Simulation result of both system using fuzzy logic and neuro-fuzzy are shown as well as compared to signify better of the two.

5. K. K. Uraon and S. Kumar, 2016 [2] "Analysis of Defuzzification Method for Rainfall Event. has analyzed of several Defuzzification method to explore basic concept of Defuzzification method for the rain fall event.

6. Z. Muka, E. Maraj and S. Kuka, 2017 [3] "Modeling the Amount of Rainfall Using Fuzzy Logic, has discussed the construction of a fuzzy logic model for the amount of rainfall with MATLAB.

7. S.A. Asklany, K. Elhelow, I.K. Youssef and M. Abd El-Wahab, 2011, " Rainfall Events Prediction Using Rule-based Fuzzy Inference System. [4]"

8. Dr. Shipra Banik, Dr. Mohammed Anwer, A.F.M Khodadad Khan, Rifat Ara Rouf, Farah Habib Chanchary, in 2009 [10],"Forecasting Bangladeshi monsoon rainfall using neural network and genetic algorithm approaches" has discussed rainfall forecasting is important for many areas of human activities such as agriculture, water resources, Hydroelectric power project, happening of droughts flood and others using neural network and genetic algorithm.

B. Problem Statement and Contribution

Many of the studies are trying to design a rain detection system using a neural network and genetic algorithm with a variety of methods. But from the existing system will be developed again by designing the application interface rain detection system using Rain, Humidity, and Temperature sensor to produce a right decision, and in the development of the side of its rule base is renewed again.

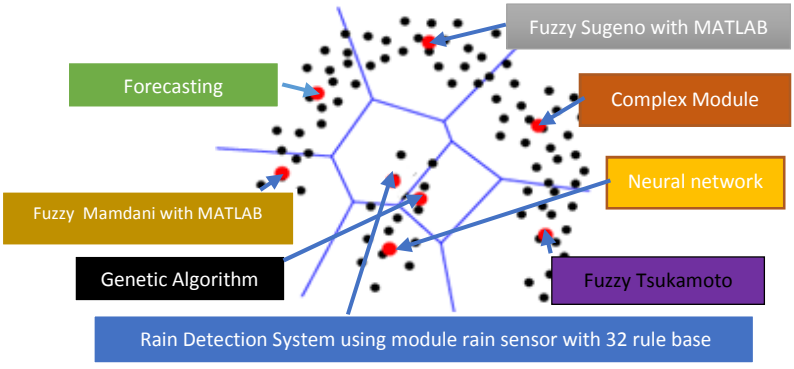

Fig 1. Diversity of Rain System Project and Method

It has been a lot of research on various areas of the rain detection system with various methods and ways, but there is still little research that develops the rain detection by combining the rain sensor module, humidity, and Temperature using fuzzy logic Mamdani The main topics of this paper include:

- This research only refers to rainfall level detection system using three sensors as input value according to the condition at that time Design Interface fuzzy logic application rain detection for estimating rain level.
- Implementation of weather forecasting requires accurate data from reliable sources to be used as material forecasting in the future. The use of forecasting in the rainfall detection system may reduce the accuracy of the initial concept by using the Fuzzy Mamdani method to determine a precise and real time rainfall decision level.

III. METHODOLOGY

This section will explain the literature review or the theoretical basis used in completing this paper.

1) Arduino Microcontroller

Arduino is a single board microcontroller that is open source. Arduino is designed to make it easier for users in the field of electronics. Software for Arduino consists of a standard boot-loader programming language compiler. The programming language used is C. In an Arduino microcontroller secured various libraries that are useful to support the complexity of hardware and software integration.

2) Humidity and Temperature Sensor, DHT 22

DHT 22 is a digital sensor used to measure the Temperature and Humidity of the surrounding air. calibration coefficients are stored in OTP program memory, so when the internal sensor detects something, then this module will instantly provide a temperature value corresponding to its surroundings. Humidity sensor specification;

- Supply Voltage: 5 V
- Range of Temperature Measurements: -40 - 80 □
- Humidity Measurement Range: 0 - 100% RH
- Size: 15.1 mm x 25 mm x 7.7 mm

3) Rain Sensor

The rain sensor is one of the sensors that are sensitive to rainwater. The workings of this rain sensor when the sensor is exposed to rainwater then the port path and a ground path is connected so that there is no voltage because, the port is connected directly to the ground (Suleman, 2010). The rain sensor provides input value at the rainwater electrolysis level.

Fig 2. Rainfall Sensor

The characteristics of the rain sensor are;

Tab 1. Rain Sensor Characteristics

Sensitive Area		Capacitance	Ratio Capacitance
Range % Dry	Range % Water	pF	%
81-100	0-20	100	0
61-80	21-40	176	76
41-60	41-60	232	232
21-40	61-80	300	300
0-20	81-100	359	359

Analog data collected from Arduino is set from 0-100% range, the small sensitivity of the area then the sensor detects dry conditions, but on the contrary, if the greater the sensitivity of the area the sensor detects wet conditions.

On the bottom side of Rain Sensor, you have one temperature sensor like NTC by Epcos p/n B57620C0102K with a nominal resistance value of 1000 Ohm @ 25 0C.

4) Fuzzy Logic

Fuzzy logic is used to represent problems that uncertainty contains and lack of mathematical model control processes. Fuzzy logic provides a method of formula for representation, manipulation, and implementation based on the user experience of control system [5]. Membership function or membership function plays an important role to repress the problem in order to produce an accurate decision. A fuzzy rule-based system consists of three main components, fuzzification, inference, and defuzzification.

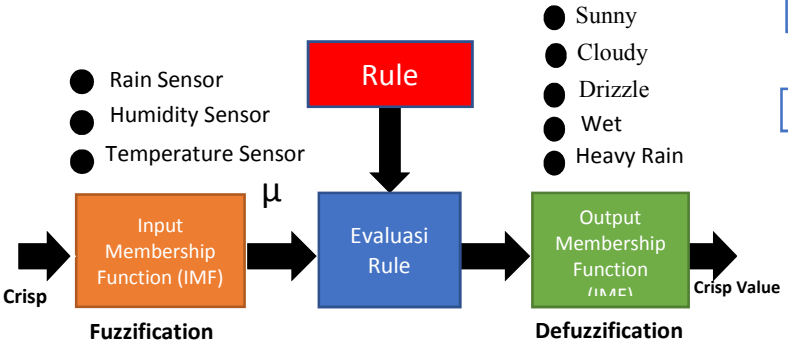

Fig. 3 Fuzzy Inference System

(Fuzzification interface) Fuzzification process, is the process of calculating the value of crisp or insert a membership degree value. Fuzzification process aims to change the input of a definite value into a Fuzzy input. In this fuzzification process, the system converts the input value corresponding to linguistic and can be compared to rule base. Fuzzy inference is a system that implement calculations based on the fuzzy rule, and into the value of a crisp. The final step of this fuzzy is the Defuzzification process where we find the value of the output in the value of crisp that aims to change the results obtained from the rule base so that it becomes one degree of membership with the premises "crisp".

IV. EXPERIMENTAL SETUP

This system works by receiving inputs from two types of sensors. First the rainfall sensor for the air discharge every time. Then used humidity sensor for humidity temperature. This system uses the fuzzy logic method to be able to present perception of rainfall. The results of the three sensors data for the rules according to the real conditions. Below is a view of the fuzzy application interface.

A. Diagram System

This rainfall detection system has three parts of the process being implemented. That is the input process where both sensors will work to detect weather conditions and temperature. This second part is the process of comparing data from both sensors using the fuzzy method, to get accurate and real time results. and the final part of the duty to provide decisions and data in accordance with existing weather and temperature conditions.

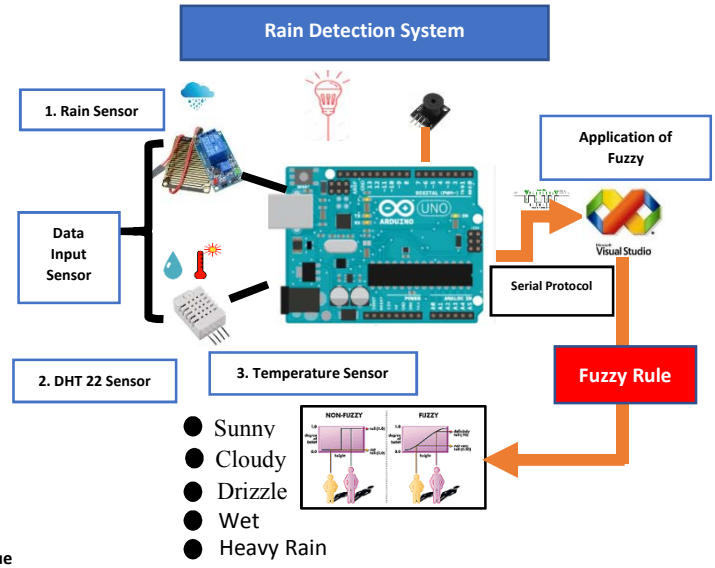

Fig 4. Rain Detector System Architecture

B. Input System

This system works by receiving input from three sensors, rain sensor, humidity sensor, and temperature sensor. Data obtained from each sensor output. The sensor output data are obtained from actual analog and digital data via Arduino. The following is an example of the data obtained.

a. Input Data of Rain Sensor

The output value of the rain sensor has a range of 0 -100% sensitivity value. If the value is close to 100% then the resulting response is in the sensitivity of dry areas. However, if the value is

close to the minimum value, the resulting response will be in the wet and humid areas.

b. Input Data of Humidity Sensor
Humidity sensor input data managed from Arduino has a range of humidity data from 20% -95%, with a response time 25^{0}C of 6 seconds, the higher the percentage value, the result of the measurement is getting wet and moist. Humidity sensor data is used as input parameter comparison between rain sensor and temperature sensor.

c. Input Data of Temperature Sensor
The third input data is a temperature sensor. Specifications of this temperature will work maximally in the range 0-50 ^{0}C, with a response time of 10 seconds. The input value of the temperature sensor represents the temperature level during weather measurement. The inputs of these three sensors are used as the comparator parameters used to provide the appropriate decision.

C. Flow Chart

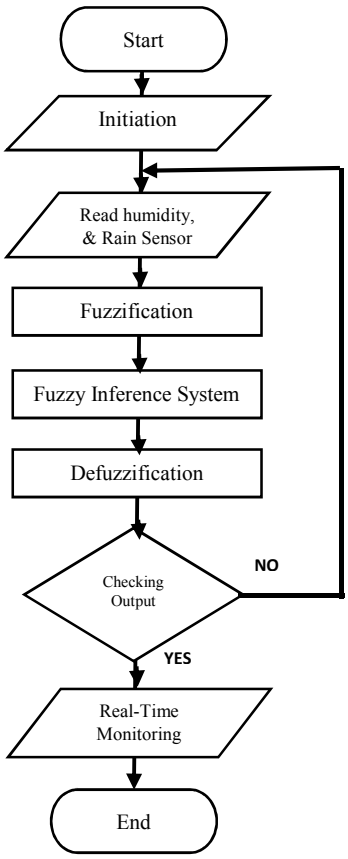

Fig 5. Flowchart Rain Detector

This system begins when the Rain sensor, Humidity, and Temperature sensor reads the data from the intensity of water and the existing temperature in the environment. Data received from the sensor will be grouped into a membership that represents the degree of membership value that represents a representation of a person's perception. When the system detects the rain then the buzzer will sound as a warning sign. The message displayed is a message that already uses fuzzy logic to generate data that conforms to human understanding.

D. Process System

The result of system process based on thirty-two criteria is used to determine one existing rainfall level decision. There are three input sensors namely, humidity sensor, temperature, and rain sensor. These three sensors will be compared to each other. Here the authors will explain the results of some tables rule base above to provide an overview of the system process response.

Tab 2 Rule Base System

Code	First Condition of Rule Base			
	Humid	**Temp**	**Rain Sensor**	**Response**
1	Dry	Cool	Very Low	Wet
2	Dry	Cool	Low	Drizzle
3	Dry	Cool	Medium	Drizzle
4	Dry	Cool	High	Cloudy
5	Comfort	Medium	Very Low	Wet
6	Comfort	Medium	Low	Drizzle
7	Comfort	Medium	Medium	Cloud
8	Comfort	Medium	High	Cloud
9	Humid	Warm	Very Low	Wet
10	Humid	Warm	Low	Wet
11	Humid	Warm	Medium	Drizzle
12	Humid	Warm	High	Drizzle
13	Sticky	Hot	Very Low	Drizzle
14	Sticky	Hot	Low	Drizzle
15	Sticky	Hot	Medium	Cloudy
16	Sticky	Hot	High	Sunny

Code	Second Condition of Rule Base			
	Humid	**Temp**	**Rain Sensor**	**Response**
17	Dry	Medium	Very Low	Drizzle
18	Dry	Medium	Low	Drizzle
19	Dry	Medium	Medium	Sunny
20	Dry	Medium	High	Sunny
21	Comfort	Warm	Very Low	Drizzle
22	Comfort	Warm	Low	Drizzle
23	Comfort	Warm	Medium	Cloudy
24	Comfort	Warm	High	Sunny
25	Humid	Hot	Very Low	Wet
26	Humid	Hot	Low	Wet
27	Humid	Hot	Medium	Drizzle

28	Humid	Hot	High	Sunny
29	Sticky	Cool	Very Low	Heavy
30	Sticky	Cool	Low	Heavy

In the first column of first table, the response result is rain (wet) when the humidity sensor is Dry (0-35%), The temperature sensor is Cool (0-15%), and rain sensor is Very Low (0-25%). In fourth column of the first table, it's explain that result of temperature is Cloudy, if the Humidity sensor is Dry (0-35%), the Temperature is Cool (0-15%), and the rain sensor is High Value (76- 100%). then, In the sixteenth columns in first table, when the Hots (Sunny) condition so, the humidity sensor gets Sticky (66-100%), Hot (46-100%), and rain sensor is High (76-100%).

E. Fuzzy Logic System

The ability of the fuzzy logic method provides representative levels of representation of existing conditions. In this case, the conditions in the rain when applied to the computerized system then only provide indicator Rain or Clear. The Fuzzy logic system is designed to solve problems that have a value of range 1-0. The output value of fuzzy logic can monitor such as Sunny, Cloudy, Drizzle, Wet, Heavy Rain. here is a rain sensor fuzzification graph.

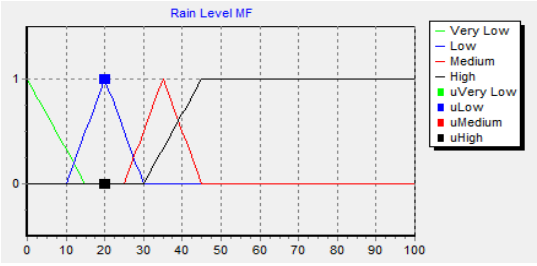

Fig 6. Graph of the Rain Sensors Membership

The membership function of the rain sensor is divided into four parts, Very Low, Low, Medium, and High. This value range refers to the rain sensor datasheet, where the smaller the degree of membership it can be categorized sensors to detect the presence of rain. and if the degree of membership is large then the sensitivity of the area is dry. following the rule base membership of the Rain sensor data.

- Very Low = 0 - 25 % ➔ Output **Heavy**
- Low = 26 - 50 % ➔ Output **Drizzle**
- Medium = 51-75 % ➔ Output **Cloudy**
- High = 76 - 100% ➔ Output **Sunny**

31	Sticky	Cool	Medium	Wet
32	Sticky	Cool	High	Cloudy

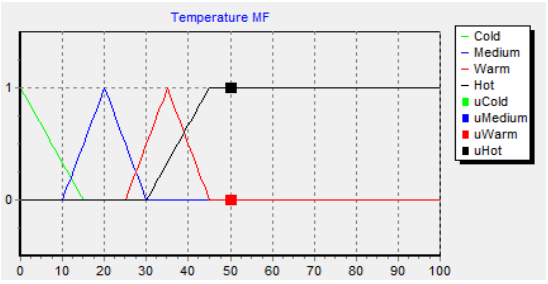

Fig 7. Graph of the Temperature Membership

In Figure 6. Humidity sensor graphs are divided into four membership groups, namely the value of this sensor is processed by using the fuzzy logic system so that it can produce a degree of membership that can be compared with the input of the rain sensor.

- Cool = 0 - 15 % ➔ Output **Cool**
- Medium = 16- 30 % ➔ Output **Medium**
- Warm = 31- 45 % ➔ Output **Warm**
- Hot = 46 -100 % ➔ Output **Hot**

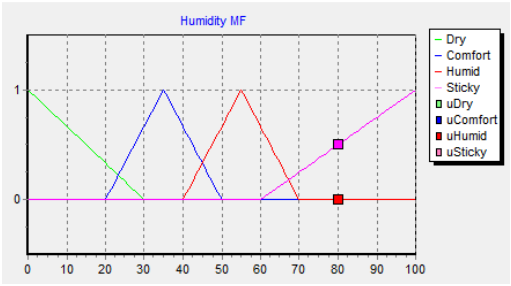

Fig 8. Graph Membership Sensor Humidity

In Figure 7. Humidity sensor graphs are divided into four membership groups, namely the value of this sensor is processed by using the fuzzy logic system so that it can produce a degree of membership that can be compared with the input of the rain sensor.

- Dry = 0-35 % ➔ Output **Hot**
- Comfort = 36-40 % ➔ Output **Comfortable**
- Humid = 41-65 % ➔ Output **Moist**
- Sticky = 66- 100 % ➔ Output **Cool**

V. IMPLEMENTATION (Output System)

The research of this system contributes an analysis of rain detection system using single board Rain, Humidity, and Temperature sensors that can generate reliable rule conditions using Mamdani FIS. The main components of this system are Arduino Uno, Sensor (Rain Sensor, Humidity, Temperature), Fuzzy control interfacing Visual Studio 2006, and methods for making decisions using a fuzzy logic method which is one of the mathematical method models.

Tab 3. Output Data Sensor

Code	Output Sensor						
	Humidity Sensor		Temperature		Rain Sensor		Output Response
	Output Sensor %	Thermometer °C	Output Sensor °C	Thermometer °C	% Dry	% Water	
1.	18	41	35	43	88,2	95	Sunny
2.	35	32	29	33	79	81	Cloudy
3.	57	28	25	28	55	35	Drizzle
4.	61	25	22	25	25	25	Wet
5.	76,5	22	19	21	5	15	Heavy Rain

A. Validation of Rain Sensor, Temperature and Humidity Sensor

The validation process on the sensor provides strong evidence from this study. There are three processes. Humidity and Temperature sensor on the validation process using the Thermometer room. Humidity Sensor is calibrated with a Thermometer in time of weather according to the rules base. If Output Humidity sensor 61 ^{0}C and Thermometer 25 ^{0}C then produced a response that is Wet. For the validation of Temperature Sensor using calibrated with a Thermometer in time of weather according to the rules base. If Output sensor under 20 ^{0}C and Thermometer 19 ^{0}C then produced a response that is Cold. For the validation process on Rain sensor based on Thick Film Technology datasheet – *Telecontrolli* Rain Sensor [7]. The experiment was conducted thirty-two times according to the number of rule bases. The output value of the rain sensor for bright conditions is 75-100%, and for rain conditions, it is 25-0% in mm.

VI. CONCLUSION

In this study, we attempted to fuzzy method for detecting rainy weather and knowing rainfall levels. The input of the membership function on the fuzzy control logic system is designed based on the input sensor. The single board rain sensor module makes it easy to design rain detection systems. When compared to using more complex module equipment.

From this research stated that human perception about rainfall level can be represented by using fuzzy logic which's can know the value of the degree of percentage of rainfall level. The results of this study indicate that the design of the system with a fuzzy method is very effective, more responsive in providing information about the level of rainy weather.

B. System Implementation

The system was tested using five weather conditions, first Sunny, Cloudy, Drizzle, Wet, and Heavy rain to prove the accuracy of the rule base system. Data obtained from three sensors namely Humidity, Temperature and Rain Sensor. The output of this sensor will be processed on Sketch Arduino, then the data will be sent to Fuzzy Logic application interface designed using Visual Studio 2006 to compare the output of both sensors. If the resulting response is Cloudy then the output criteria of both sensors are Humidity 35 °C, Temperature 29 °C, and Rain Sensor 81%. The design of this system provides information about Rain Warning level. Human needs and desires are increasingly varied. Supported with advanced equipment, all can be used to assist human activities. Some applications of fuzzy logic help in monitoring, control, and forecasting weather forecasts.

I. FUTURE WORK

In today's era of information technology is growing rapidly. There are still some techniques that can be developed again in the field of prediction of a weather forecast, many areas of human activities such as agriculture, water resources, Hydroelectric power project, happening droughts of flood and others using a neural network and genetic algorithm.

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