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Weather Determination Prediction Using Expert Fuzzy Logic Mamdani Method

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Abstract

The current climate and weather patterns are very extreme. This kind of weather conditions can harm many people. In recent years, heavy rains have resulted in flooding. So far, computers can be used to help people solve problems. The smarter the system and the higher the level of information handling, the more active the role played by the Weather computer is the condition of the air at a certain time and in a certain area that is relatively narrow and in a short period of time. The weather is formed from a combination of weather elements and the weather period can only be a few hours. For example: morning, afternoon or evening, and the situation can be different for each place and every hour. The purpose of this research is to help predict the weather as information. This research uses the mamdani method. This mamdani method uses 4 stages to produce an output value, namely, determining the input value (fuzification), determining the value of x (impplication function application), Combination of Rules (Rules) and finally determining the final value or (Defuzification). This research produces an output value of 35 which is located in the Panas range.

Keywords: *Prediction, Weather Conditions, Expert System, Mamdani Method*

1. Introduction

Batam is a city that is growing rapidly because it is close to neighboring areas, namely Malaysia and Singapore. Besides being close to foreign countries, Batam City has a temperature and weather that changes every day. Weather is one of the most influential things in the life of living things. Uncertain weather changes exist in several areas in Batam City. However, with the development of the times, advances in science and technology can be approached to predict the weather changes that occur. Weather and climate predictions are part of an information system that is used to see natural conditions for the future. In essence, a weather or climate information system is a way to optimize monitoring efforts [1]. The most popular intelligence technique today can be interpreted as a computer software that has a knowledge base for a particular domain and uses inference reasoning like an expert in solving a problem. Where when it is associated with humans in weather forecasting or predicting today's weather, a computer system can be created whose job is to find out and analyze weather symptoms that exist today so that Fatmawati Metrology Station can notify that today's weather prediction is how, the symptoms caused the weather that the author means specifically Weather, which consists of many kinds and variations of symptoms encountered by weather forecasts [2].

Fuzzy logic (fuzzy logic) itself is a logic that deals with the concept of partial truth, where classical logic states that everything can be expressed in binary (0 or 1) terms. Fuzzy Logic 96 Determination of Production Amount Using the Application Method allows membership values between 0 and 1. Various theories in the development of fuzzy logic show that basically fuzzy logic can be used to model various systems. Fuzzy logic is considered capable of mapping an input into an output without ignoring the existing factors. Fuzzy logic is believed to be very flexible and has tolerance for existing data. Based on fuzzy logic, it will produce a model of a system that is able to estimate the

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amount of production. Factors that influence in determining the amount of production with fuzzy logic include the number of requests and quantities [3].

The Fuzzy Inference System originated from the Fuzzy Set theory proposed by Lofti Zadeh around 1965. With the Fuzzy Set, various uncertainty parameters can be represented and handled, which in this case can mean doubt, inaccuracy, incomplete information, and partial truth [4]. The processes that run in the Fuzzy Inference System consist of fuzzyfication, inference, and defuzzyfication. Defuzzyfication in this study using the Weight Average method. To determine the membership function limit, the FCM algorithm is used according [5]. There are several things that need to be known in understanding the fuzzy system:

a. Fuzzy Variables
b. Fuzzy set
c. The universe of talk
d.Domain

In the late 19th century until the end of the 20th century, probability theory played an important role in solving the problem of uncertainty. This theory continued to be developed until finally in 1965, Lotfi A. Zadeh introduced the fuzzy set theory, which implies that not only probability theory can be used to represent uncertainty problems. However, fuzzy set theory is not a substitute for probability theory. In fuzzy set theory, the main component that is very influential is the membership function. The membership function represents the degree of proximity of an object to a certain attribute. While the probability theory is more on the use of relative frequencies [6]. As with conventional sets, there are several operations that are specifically defined for combining and modifying fuzzy sets. The membership value as a result of the operation of 2 sets is often known as fire strength or -predicate [7]. There are 3 operators created by Zadeh, namely [8]:
Operator *AND*, Operator *OR and* Operator *NOT*. Fuzzy Inference System Mamdani Method The Mamdani method is often also known as the min – max method. This method was introduced by Ebrahim Mamdani in 1975. To get the output required 4 stages, including:

a) Formation of fuzzy sets In the Mamdani method, both input and output variables are divided into one or more fuzzy sets.
b) Application of the implication function In the Mamdani method, the implication function used is min.
c) Composition of rules The method used in performing fuzzy system inference is the Max (Maximum) method.
d) Confirmation (defuzzy) Defuzzyfication on the composition of mamdani rules using the centroid method. Where in this method, the crisp solution is obtained by taking the central point of the area [8]. The fuzzy / linguistic model was developed from the beginning using formal logic. However, the original formulation based on the predicate version of, so called, fuzzy logic with the evaluated syntax turned out to be untidyly satisfactory. The new formulation that uses a high-level mathematical fuzzy logic language is much more appropriate and transparent [9].

2. Research Methodology

This helper relation collects related and unrelated clones Clone In Section, we study the compatibility of a given crisp relationship with the last complementary relation. The results are exploited in Section 5 to characterize the fuzzy tolerance and fuzzy equivalence relationships. Appropriate shutter relationship corresponds to. This marking turns out to be pleasingly elegant and insightful. Finally, we present some conclusions and discuss future research [10]. From the initial observations, it can be put forward or developed to avoid errors and minimize the interval of the researcher's guess by collecting

and analyzing the information received by several hypotheses, problems that need to be solved as outlined in the introductory chapter. These problems are:

a) There are still frequent errors in predicting the weather that occurs in the city of Batam.
b) Lack of information and knowledge about developing technology so that it causes harm to the people of Batam.

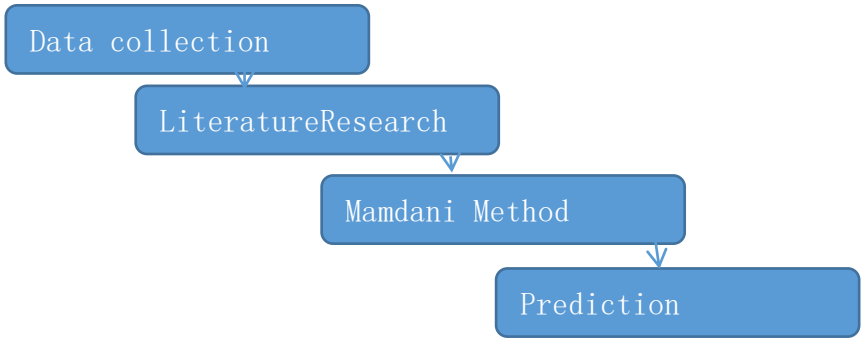

Figure 1. Research Methodology

3. Results and Discussion

This study aims to determine the weather as information to users. To answer these problems, the researchers conducted a verification analysis. Based on the data obtained through the state of the user using Matlab. Basically, the activities carried out at this stage of the analysis have two parts, namely the stage of data collection and structured analysis which in general is to obtain an understanding of the problems, efficiency and considerations that lead to system development. Estimating the obstacles that will be faced in the development of the system and determining the preliminary alternative solutions. System analysis aims to determine the needs in designing an application by considering several factors that exist.

3.1. Fuzzyfication

a) Determine the variables used

This study used 3 main variables for input consisting of wind, humidity, and rainfall variables. The data taken and observed directly at the research site will be represented and analyzed in the form of the Mamdani fuzzy method. To build fuzzy inference, a universe of conversation is needed. As seen in table 1.

Table 1. The Universe of Speech

	Variable Name	**Universe of Conversation**
Input	Wind Variable	[0-16]
	Variable Air Humidity	[0-200]
	Rainfall	[0-8]
Output	Decision -Hot -Cold -Currently	[0-20] [20-40] [40-60]

b) Wind Variable Membership Degree Function

For the Wind variable, which is the value for the size, namely in terms of wind conditions consisting of Slow, Medium, Fast. The classification can be seen in table 2 below:

Table 2. Table of Wind Variable Fuzzy Sets

Universe	Sets	Domain	Parameter
0 – 16	Slow currently tight	[0-4] [4-8] [8-16]	[0 0 2 4] [2 4 8] [4 8 16 16]

For more details, it can be seen in the image of the variable membership function below:

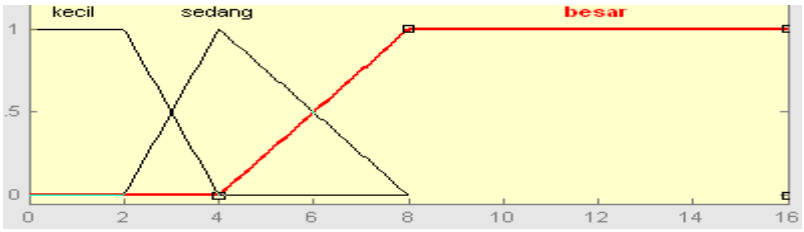

Figure 2. Wind Fuzzy Set

Input Size = 1 is in the linguistic value Slow [0 2 4]. By using the trapezoid function For small linguistic values, the degree of membership is calculated using the formula:

$$\mu\ Small = \begin{cases} 1 ; x \leq 1 \\ \frac{1-x}{1,5} ; 1 \leq x \leq 4 \\ 0 ; x \geq 4 \end{cases}$$

As for the Medium linguistic value [2 4 8] using the triangle function, the degree of membership is calculated using the formula:

$$\mu\ \text{Currently} = \begin{cases} \frac{x-2}{1} \; 0 ; \quad x \quad \leq 2 \\ \qquad\qquad ; 1 \leq x \leq 8 \\ \frac{4-x}{1} ; 4 \leq x \leq 8 \\ 0 \; ; \; x \geq 8 \end{cases}$$

The wind is considered small if the wind is 0 to 4, while if the wind is moderate between 4 and 8, it is said to be large between 8 and 16.

$$\mu\text{Tight} = \begin{cases} 4 \quad ; x \leq 4 \\ \frac{1-x}{1,5} \; ; 1 \leq x \leq 8 \\ 0 \quad ; x \geq 16 \end{cases}$$

Manual calculation for the Wind variable.
If the wind condition is 0.5 then the fuzzy membership value in each set is:

1) Small fuzzy set = 0.5
   Number 2 is included in the small set of wind variables, so the value for the fuzzy set can be calculated by the following equation:
   $\mu Variabel\ Lmabat\ [2] = (d - x) / (d - c)$
   $= (4–2) / (4-0)$
   $= 2/4$
   $= 0,5$
2) Medium fuzzy set = 0
   The value of 2 is not included in the classification of the medium wind set, the results obtained are = 0
3) Fast fuzzy set = 0
   The value of 2 is not included in the classification of the Fast size set, the results obtained are = 0

c) Fuzzy Set of Air Humidity Variables

From the price variable, three fuzzy sets are defined, namely hot, medium and cold. To represent the air humidity variable, the left shoulder curve for cheap fuzzy sets, triangular curves for normal fuzzy sets, and right shoulder curve forms for expensive fuzzy sets. The following table contains the fuzzy set of air humidity variables.

Table 3. Table of Fuzzy Sets of Air Humidity Variables

Variable Name Fuzzy	Parameter	Range
Cool	[0 0 20 40]	0 – 40
currently	[20 40 80]	40 - 80
Hot	[40 80 100 100]	80- 200

For more details, it can be seen in the image of the variable membership function below:

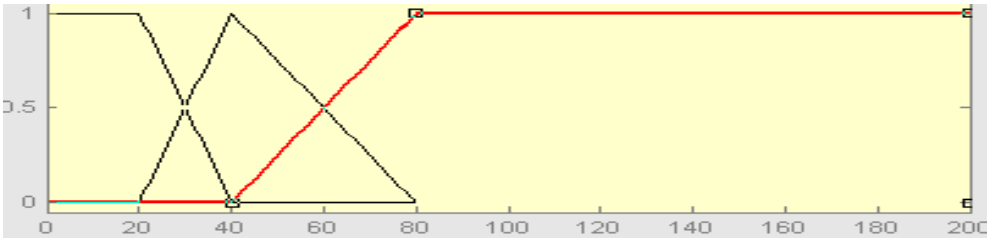

Figure 3. Fuzzy Set of Air Humidity

On the horizontal axis is the input value of the Air Humidity variable, while the vertical axis is the membership level of the input value. The membership function is as follows:

$$\mu\,Cool = \begin{cases} 1 \;; x \leq 1 \\ \dfrac{40 - x}{30} \;; 1 \leq x \leq 40 \\ 0 \;; x \geq 40 \end{cases}$$

$$\mu\ \text{currently} = \begin{cases} \dfrac{x-60}{40} \quad 0 \;; x \leq 60 \\ \qquad\qquad ;60 \leq x \leq 70 \\ 80\dfrac{-x}{40} \;; 70 \leq x \leq 80 \\ 0 \;;\; x \geq 80 \end{cases}$$

$$\mu\,Hot = \begin{cases} 0 \;; x \leq 200 \\ \dfrac{x - 200}{100} ; 100 \leq x \leq 200 \\ 1 \;; x \geq 200 \end{cases}$$

Air Humidity is considered Cold if it is between 0 to 40, is considered normal when Air Humidity is between 40 to 80, is considered Hot when Air Humidity is 80 to 200. Manual calculation for price variables.

If the given Air Humidity is 40, then the fuzzy membership value in each set is:

1) Cold fuzzy set = 1

Number 40 is included in the cold fuzzy set on the Air Humidity variable, therefore the value for the fuzzy set can be calculated by the following equation:

Cold [40] = (x - a) / (b - a)
= (40– 20) / (40-20)
= 20/20 = 1

2) Fuzzy set of variables Normal humidity = 0
   The number 40 is not included in the normal fuzzy set on the Air Humidity variable, then the value for the fuzzy set = 0
3) Fuzzy set Heat = 0
   The number 40 is not included in the Heat set for the Air Humidity variable, therefore the value for the fuzzy set = 0.

d) Variavel Fuzzy Rainfall

Table 4. Table of Fuzzy Set of Rainfall Variables

Variable Name Fuzzy	Parameter	Range
Small	[0 0 1 2]	[0-2]
currently	[1 2 4]	[2-4]
Big	[2 4 6 6]	[4-6]

The form of its representation can be seen in Figure 3. The degree of membership function of the weight variable is defined as follows:

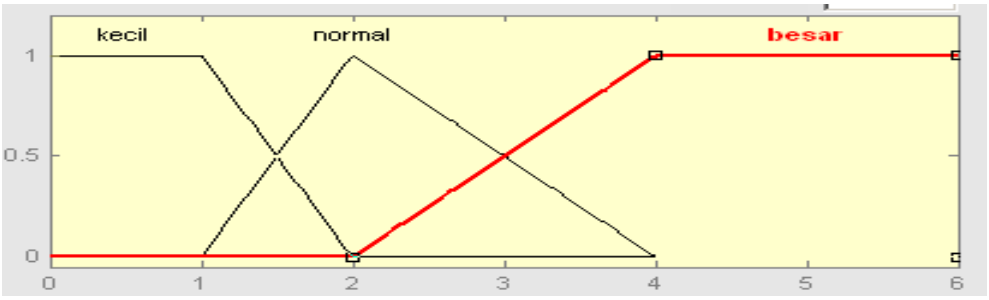

Figure 4. Rainfall Fuzzy Set

$$\mu\,Small = \begin{cases} 1\ ; x \le 2 \\ \frac{1-x}{2}\ ; 0 \le x \le 2 \\ 0\ ; x \ge 2 \end{cases}$$

$$\mu\,\text{currently} = \begin{cases} \frac{x-2}{2}\ ; 0 \le x \le 2 \\ \frac{4-x}{2}\ ; 2 \le x \le 4 \\ 0\ ;\ x \ge 4 \end{cases}$$

$$\mu\,Big = \begin{cases} 0\ ; x \le 2 \\ \frac{x-4}{2}\ ; 2 \le x \le 6 \\ 1\ ; x \ge 6 \end{cases}$$

Rainfall is considered small if it is between 0 to 2, considered normal between 2 to 4, considered expensive between 4 to 6.
Manual calculation for Rainfall variable
1. If Rainfall is given 1, then the fuzzy membership value in each set is:
a) Small fuzzy set = 1
   Small Precipitation [1] = (x - a) / (b - a)
   = (1– 0) / (1-0)
   = 1/1 = 1

b) Fuzzy set Normal Rainfall = 0
Number 1 is not included in the normal set for the Rainfall variable.
c) Fuzzy set large = 0
Number 1 is not included in the normal set for the Rainfall variable.

3.2. *Defuzyfication*

The input of the defuzzification process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the domain of the set. So if given a fuzzy set within a certain range, it must be able to take a certain crisp value as output. At this stage the method used is the centroid method.

$$Z = \frac{35*0.5 + 35*0.5}{0.5 + 0.5}$$
$$= 35 / 1$$
$$= 35$$

Criteria for Determining Weather with Wind 4, Air Humidity 4, Rainfall 8, the degree of membership is based on manual calculations 35, while using the 67.7 system the decision is Heat.

3.3. Inference

The next stage of the fuzzy calculation process is the stage of reasoning (inference). This process serves to find a fuzzy output value from fuzzy input. The process is as follows: an input value comes from the fuzzyfication process and then entered into a rule that has been created to be used as a fuzzy output. From the two fuzzy inputs, we will determine the rules to be set. Based on the data values on the input size input in the form of wind, humidity, weather and the output in the form of decision variables and 9 linguistic values, 27 rules are obtained as shown below:

The rule is a determination for cell phone selection data with three inputs and outputs.

[R1] IF (Wind is Slow) AND (Moisture is Cold) AND (Rainfall is Small) THEN (Cold Decision);
[R2] IF (Wind is Slow) AND (Air Humidity is Normal) AND (Rainfall is Small) THEN (Cold Decision);
[R3] IF (Wind is Slow) AND (Moisture is Cold) AND (Rainfall is Large) THEN (Cold Decision);
[R4] IF (Wind is Slow) AND (Air Humidity is Normal) AND (Rainfall is Small) (Heat Decision);
[R5] IF (Wind is Slow) AND (Air Humidity is Normal) AND (Rainfall is Large) (Heat Decision);
[R6] (Wind is Slow) AND (Humidity is Normal) AND (Rainfall is Large) (Heat Decision);
[R7] IF (Wind is Slow) AND (Moisture is Hot) AND (Rainfall is Small) THEN (Normal Decision);
[R8] IF (Wind is Slow) AND (Moisture is Hot) AND (Rainfall is Small) THEN (Normal Decision);
[R9] IF (Wind is Slow) AND (Moisture is Hot) AND (Rainfall is Large) THEN (Normal Decision);
[R10] IF (Wind is Moderate) AND (humidity isCold) AND (Rainfall is Small) THEN (Normal Decision);
[R11] IF (Wind is Moderate) AND (Moisture is Cold) AND (Rainfall is Small) THEN (Normal Decision);
[R12] IF (Wind is Moderate) AND (Moisture is Cold) AND (Rainfall is Small) THEN (Normal Decision);
[R13] IF Want is Medium) AND (Moisture is Normal) AND (Rainfall is Small) THEN (Normal Decision);

[R14] IF Wind is Moderate) AND (Air humidity is Normal) AND (Rainfall is Normal) THEN (Normal Decision);
[R15] IF (Wind is Moderate) AND (Moisture is Normal) AND (Rainfall is Large) THEN (Normal Decision);
[R16] IF(Wind is Moderate) AND (Moisture is Hot) AND (Rainfall is Large) (Decision Heat);
[R17] IF (Wind is Moderate) AND (Moisture is Hot) AND (Rain is Normal) (Decision Heat);
[R18] IF(Wind is Moderate) AND (Moisture is Hot) AND (Rainfall is Heat) (Decision Heat);
[R19] IF(Wind is Strong) AND (Air Humidity is Cold) AND (Rainfall is Small) (Cold Decision);
[R20] IF (Wind is Strong) AND (Air Humidity is Normal AND (Rainfall is Large) (Cold Decision);
[R21] IF IF(Wind is Moderate) AND (Moisture is Hot) AND (Rainfall is Large) (Decision Heat);

4. Conclusion

Based on this research, it can be concluded:

a) To predict the weather, it can be seen from three aspects, namely 1.Wind, 2nd, humidity and 3rd Rainfall.
b) The results of the defuzzification obtained a value of 35 which is in the heat range
c) The fuzzy inference system using the Mamdani method can be used as a reference in predicting the weather.

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