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Prediction the Number of Dengue Hemorrhagic Fever Patients Using Fuzzy Tsukamoto Method at Public Health Service of Purbalingga

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Abstract

DHF (Dengue Hemorrhagic Fever) is still a major health problem in Indonesia. One of the factors that led to an increase in dengue cases is uncertain climate that causes dengue fever is difficult to be predicted. Prediction is an important thing that is used to determine future events by identifying patterns of events in the past. When knowing the events that happen, it will make everyone to make better preparation for everything. This research is aimed at determining the accuracy of Tsukamoto Fuzzy method in the number of dengue patients in Puskesmas Purbalingga. Tsukamoto Fuzzy method can be used for prediction because it has the ability to examine and identify the pattern of historical data. Tsukamoto fuzzy that used to predict the number of dengue fever patients at Puskesmas Purbalingga has several stages. The first stage is the collection of climate data includes precipitation, humidity, water temperature and the data of dengue fever patients in Puskesmas Purbalingga. The next stage is processing the data that has been obtained. The last stage is to make predictions. Based on the results of the implementation by Tsukamoto Fuzzy method in predicting the number of dengue fever patients in Purbalingga for twelve months in 2016, it was obtained a percentage error (MAPE) of 8.13% or had an accuracy rate of 91.87 %. With the small value of MAPE and high accuracy, it shows that the system can predict well.

Keywords: Prediction, Tsukamoto Fuzzy Method, Hemorrhagic Fever

1. INTRODUCTION

Dengue Hemorrhagic fever is a major health problem in Indonesia. The number of cases and the spread of this deadly disease is increasing in line with the increasing mobility and population density. The population of Indonesia is more than 250 million people and the fourth rank in the country with the highest population in the world. WHO records Indonesia as the country with the highest dengue Hemorrhagic fever case in Southeast Asia [1]. Global warming that causes the weather becoming erratic makes the number of dengue Hemorrhagic fever is now difficult to know.

According to Health Department of Purbalingga Regency among the regencies in Indonesia, Purbalingga Regency is an area suffering from dengue Hemorrhagic fever. It can be seen from the figures incidence of Dengue Hemorrhagic Fever (DHF) equal to 64 per 100,000 population or 572 cases with 3 deaths (CFR = 0,5%) during 2013. This happened because until now there is no vaccine for dengue Hemorrhagic fever that can be used to humans. DHF control efforts in Indonesia are still focus on surveillance programs, Mosquito Nest Eradication (MNE), and Periodic Monitoring (PM).

The increase of number of patients and victims who died showed the less prepared precautions taken. Health Department is still waiting for reports of dengue cases before fogging [2]. This rationale makes it necessary to make models that describe the dynamics of the number of cases of dengue fever. Models with sufficient accuracy can be used as a tool for decision-making and distribution of resources to cope with epidemics [3].

Prediction is an important thing used to know the future events by recognizing the patterns of events in the past. While knowing the events that will happen, it makes everyone better prepare everything, both for human life and their property.

Basic Fuzzy logic is a fuzzy set theory. Fuzzy logic contained within the membership function. According to [4] the membership function is a curve that shows the mapping of points of input data into membership values that have intervals between 0 and 1. One application of fuzzy logic that has developed today is immense Fuzzy Inference System (Fuzzy Inference System/FIS), a computational framework that is based on fuzzy set theory, fuzzy rules IF THEN shaped and Fuzzy reasoning. There are three methods in Fuzzy inference systems that often used, namely Tsukamoto, Mamdani and Takagi Sugeno. This study uses Tsukamoto Fuzzy method because this method has several advantages among others, this method can do faster computation, more intuitive, accepted by many, and better suited to the input received from the man not by machines [5].

Fuzzy logic can be used on systems that have non-precise inputs or more linguistic inputs. Research related to fuzzy logic, including the ranking of construction projects [6], analysis of learning relationships with student satisfaction [7], detection of reasoning ability [8], employee performance appraisal [9], best decision making [10], [11], prediction Number of visits [12], [13] and predicted number of students [14].

Based on the background above, it is discussed regarding: (1) how to implement the Tsukamoto Fuzzy method in predicting the number of dengue patients at health public service of Purbalingga (2) what level of accuracy resulting in the number of dengue patients at health public service of Purbalingga

2. METHODS

There are several stages performed systematically in this study, starting from the preparation stage, then data processing, and predict the number of dengue hemorrhagic fever patients.

2.1. Preparation phase

The preparation phase begins with a literature study that supports the success of the research. In addition, this study also conducted a search of data needed for this research, namely by taking data to the health public service of Purbalingga to obtain data on the number of patients and BMKG to obtain data of weather variables for three years from 2014 until 2016.

2.2. Data processing

After getting the required data, then the data is processed. This is necessary so that the secondary data obtained can be incorporated into the prediction method Tsukamoto Fuzzy. In addition, a standard is required to process the data, in this case related to the determination of data types and also the determination of predictive time limits. Data on the number of patients and weather variables used are data per month for twenty months. The predicted month limit used in this study is twenty months before the prediction month (2014-2016), ie, the first twenty months (2014-2015) function as training data, the next twelve months (2016) as test data.

2.3. Prediction the Number of DHF Patients

The procedure of prediction the number of DHF patients using Tsukamoto Fuzzy method is as follows.

a. Determine the scope of training parameters
b. Determine the election limit for months to be trained
c. The training process uses Fuzzy Tsukamoto against the preceding months
d. Incorporate test data on training system to get corrections
e. Prediction the number of DHF patients

According to Kusumadewi [15] in Tsukamoto's method, any consequence of the if-then-form rule must be represented by a fuzzy set with a monotonous membership function. As a result, the inference output of each rule is given explicitly (crisp) based on α-predicate (fire strength). The end result is obtained by using weighted averages. To obtain the crisp output value / Z value firmly, searched by changing the input (a fuzzy set obtained from the composition of fuzzy rules) into a number in the fuzzy set domain. This method is called the method of defuzification (affirmation). The defuzification method used in the Tsukamoto method is the Center Mean Defuzzifier (CAD) centered defuzification method presented in the equation below Equation 1.

$$Z = \frac{\sum a_i . z_i}{\sum z_i} \quad (1)$$

According to the above description then the rules that can be formed can be presented as in Table 2.

Table 2. Results of Rule Base

Rules	**Temperature**	**Humidity**	**Rainfall**	**Function Implications**	**Number of Patients**
R1	Normal	Moist	Low	=>	Being
R2	Hot	Moist	Low	=>	Bit
R3	Cool	Moist	Intermediate	=>	Being
R4	Cool	Moist	Very high	=>	Lot
R5	Cool	Wet	Very high	=>	Lot
R6	Cool	Moist	High	=>	Being

Based on the results in accordance with the rule-based knowledge base, as shown in Table 2, it can be inferred rules that formed on fuzzy inference as follows.

[R1] IF air temperature NORMAL + humidity MOIST, and rainfall LOW, then number of patients BEING;
[R2] IF air temperatures HOT + humidity MOIST, and rainfall LOW, then the patient LITTLE;
[R3] IF air temperature COOL + humidity MOIST, and rainfall INTERMEDIATE, then the patient BEING;
[R4] IF air temperature COOL + humidity MOIST, and rainfall VERY HIGH, then the number of patients LOT;
[R5] IF air temperature COOL + humidity WET, and rainfall VERY HIGH, then the patient LOT;
[R6] IF air temperature COOL + humidity MOIST, and rainfall HIGH, then the patient BEING;

The final stage in the above case is the defuzzification process using the fuzzy tsukamoto method in Matlab software which will produce data or prediction in the form of the number of dengue patients during the next year.

3. RESULTS AND DISCUSSION

In this study, predictions were made using monthly input data for twenty months before the prediction month. The data used for the prediction is data of Public Health Service of Purbalingga dengue patients from May 2014 through December 2015. Completion of the problem in this research is using Fuzzy Tsukamoto as follows.

a. Form the input variables and output variables
   The input variables used are the air temperature, humidity, and rainfall while the output variable is the number of dengue fever patients.
b. Forming a fuzzy set
   According to the data obtained in this study formed the fuzzy sets for each variable as follows.
   1) Air temperature variable by forming three fuzzy set linguistic variable that is cool, normal, and heat.
      $\mu_{cool} \quad = x < 27$

μ_{normal} = 26 < x < 29
μ_{hot} = x > 28

2) Moisture variable to form two sets of fuzzy linguistic variables, that is damp and wet.
μ_{moist} = x < 88
μ_{wet} = x > 87

3) Rainfall variable formed four fuzzy set with the value of linguistic variables, namely, low, medium, high, and very high.
μ_{low} = x < 200
μ_{medium} = 100 < x < 300
μ_{high} = 200 < x < 400
$\mu_{veryhigh}$ = x > 300

4) Numbers of patients variable into three fuzzy set linguistic variable with a value that is, a little, being, a lot.
μ_{bit} = x <7
μ_{being} = 5 < x <15
μ_{lot} = x > 12

c. Establish a universal set of conversations
The universe of speech of each variable is the range of possible values of the existing data. The fuzzy variable can be shown in Table 1.

Table 1. Fuzzy Variables

Function	Variable	Value
	Air temperature	[25, 30]
Input	Humidity	[79, 89]
	Rainfall	[1, 760]
Output	Number of Patients	[1, 26]

d. Specifies the membership function of each variable
To get a membership value, then determined the membership function of each variable through a function approach. The membership functions of each variable are as follows.

1) Air temperature
Variable air temperature up three fuzzy sets, namely: cool, normal, and heat. Membership function can be seen in Figure 2.
μ_{cool} (x) = trapmf (x; 25, 25, 26, 27)
μ_{normal} (x)= trapmf (x; 26, 27, 28, 29.01)
μ_{hot} (x) = trapmf (x; 28, 29, 30, 30)

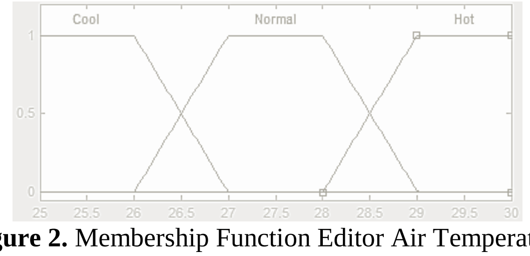

Figure 2. Membership Function Editor Air Temperature

2) Humidity
   The humidity variable forms two fuzzy sets, namely: moist and wet. Membership function can be seen in Figure 3.
   μ_{moist} (x) = trapmf (x; 79, 79, 87, 88)
   μ_{wet} (x) = trapmf (x; 87, 88, 89, 89)

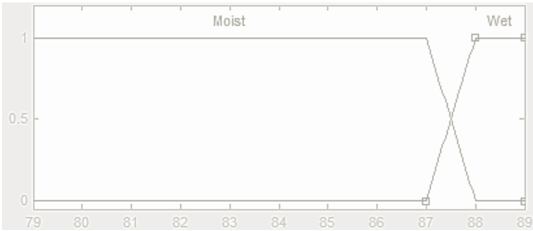

Figure 3. Membership Function Editor Humidity

3) Rainfall
   Variable rainfall forming four fuzzy set, namely: low, medium, high, and very high. Membership function can be seen in Figure 4.
   μ_{low}(x) = trimf (x; 1, 100, 200)
   $\mu_{intermediate}$(x) = trimf (x; 100, 200, 300)
   μ_{high}(x) = trimf (x; 200, 300, 400)
   $\mu_{veryhigh}$(x) = trapmf (; 300, 400, 760, 760)

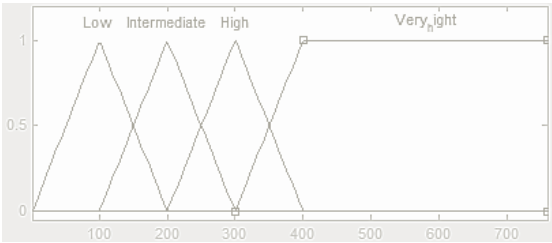

Figure 4. Membership Function Editor Rainfall

4) Number of Patients
   Variable numbers of patients into three fuzzy sets, namely: small, medium, and more. Membership function can be seen in Figure 5.
   μ_{bit} (x) = trapmf (x; 1, 1, 2.5, 7)
   μ_{being} (x) = trimf (x; 15, 10, 15)
   μ_{lot} (x) = trapmf (x; 12.5, 15, 26, 26)

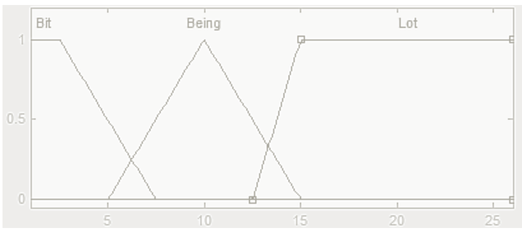

Figure 5. Membership Function Editor Rainfall

In the training process of predicting the number of dengue fever patients, the input data is the number of dengue patients and climatic variables for twenty months from 2014-2015. The exposure of the results will be presented in the form of tables and graphs. Table 3 shows the comparison of predicted results with targets for 2014-2015 while the comparison comparison of predictive training results for the 2014-2015 targets is shown in Figure 7.

Table 3. Comparison of Predicted results with year 2014-2015

No	Month	Target	Results Predicted Number of Patients Dengue fever	$\lvert PE_t \rvert$
1	May 2014	9	10	11.11
2	Jun 2014	9	10	11.11
3	Jul 2014	5	6	20
4	August 2014	3	3	0
5	Sept 2014	10	10	0
6	Oct 2014	20	19	5
7	Nov 2014	18	19	5.55
8	Dec 2014	19	19	0
9	Jan 2015	19	19	0
10	Feb 2015	19	19	0
11	Mar 2015	10	10	0
12	Apr 2015	10	10	0
13	May 201	7	9	28.57
14	Jun 2015	9	10	11.11
15	Jul 2015	8	10	25
16	August 2015	6	10	66.66
17	Sept 2015	9	9	0
18	Oct 2015	9	10	11.11
19	Nov 2015	19	19	0
20	Dec 2015	19	19	0
MAPE				**9.76**

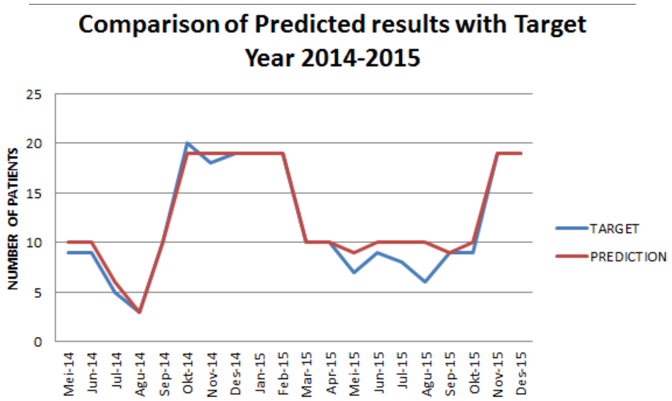

Figure 7. Graph Comparison of Predicted by Target Training Results Year 2014-2015

When conducting the test, the weight gained from the training was called and processed with different input from the training process but similar. Testing is done with the data for twelve months and produce MAPE is 8.13% which can be seen in Table 4, while the graph of test results using Tsukamoto Fuzzy method in predicting the number of dengue patients during the twelve months of 2016 is shown in Figure 8.

Table 4. Comparison of Predicted to Target Results with Target Year 2016

No	Month	Target	Results Prediction Number of Dengue Fever Patients	$\mid PE_t \mid$
1	January 2016	18	19	5.55
2	Feb 2016	16	19	18.75
3	Mar 2016	10	10	0
4	Apr 2016	9	10	11.11
5	May 2016	9	10	11.11
6	June 2016	10	10	0
7	Jul 2016	3	3	0
8	August 2016	5	6	20
9	Sept 2016	9	10	11
10	Oct 2016	21	19	9.52
11	Nov 2016	20	19	5
12	Dec 2016	18	19	5.55
MAPE				**8.13**

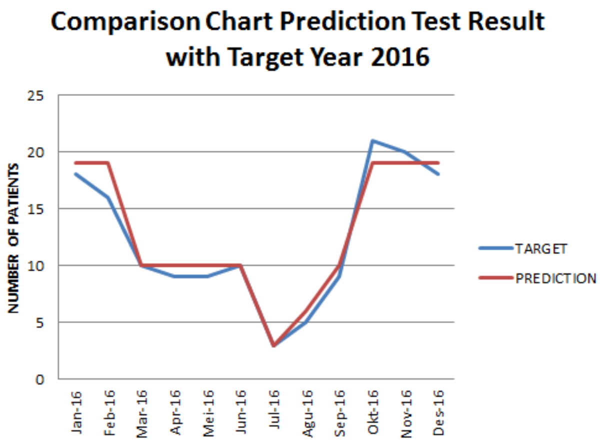

Figure 8. Comparison Chart Prediction Test Result with Target Year 2016

4. CONCLUSION

Tsukamoto Fuzzy logic implementation in predicting the number of dengue fever patients in Purbalingga health center has several stages. The stages: (1) The first stage is collecting data, (2) The second stage is processing the data that has been obtained by determining the type of data and predictions month limit, and (3) The third stage is a training method Tsukamoto Fuzzy with a predetermined input. The results shows that the percentage error (MAPE) is currently 8.13% predicted or otherwise has an accuracy rate of 91.87%. The MAPE value is small enough and the accuracy is high enough then it shows the system can predict well.

5. REFERENCES

[1] Pusat Data dan Surveilance Epidemiologi Kementrian Kesehatan Republik Indonesia. 2010. *Jendela Epidemiologi*. Kementrian Kesehatan Republik Indonesia. Jakarta.

[2] Barrios, J., Piétrus, A., Marrero, A., de Arazoza, H., & Joya, G. 2011. Dengue model described by differential inclusions. *Advances in computational intelligence*, 540-547.

[3] Whitehead, S. S. & Durbin, A. P. 2010. *Prospects and challenges for dengue virus vaccine development.* Caister Academic Press: Portland, OR, USA.

[4] Arifin, S., Muslim, M. A., & Sugiman. 2015. Implementasi Logika Fuzzy Mamdani untuk Mendeteksi Kerentanan Daerah Banjir di Semarang Utara. *Scientific Journal of Informatics*, Vol. 2(2):179-192.

[5] Caraka, A. A., Haryanto, H., Kusumaningrum, D. P., & Astuti, S. 2015. Logika Fuzzy Menggunakan Metode Tsukamoto untuk Prediksi Perilaku Konsumen di Toko Bangunan. *Techno. Com*, Vol. 14(4), 255-265.

[6] Sihombing, D. J. C., Santoso, A. J., & Rahayu, S. 2015. Model Perangkingan Proyek Kontruksi pada Asosiasi Kontraktor Menggunakan Fuzzy AHP. *Scientific Journal of Informatics*, Vol. 2(1):73-81.

[7] Widaningrum, I. 2015. Analisis Hubungan Proses Pembelajaran dengan Kepuasan Mahasiswa Menggunakan Logika Fuzzy. *Scientific Journal of Informatics*, Vol. 2(1):91-98.

[8] Sutoyo, M. N. & Sumpala, A. T. 2015. Penerapan Fuzzy C-Means untuk Deteksi Dini Kemampuan Penalaran Matematis. *Scientific Journal of Informatics*, Vol. 2(2):129-136.

[9] Alamsyah & Muna, I. H. 2016. Metode Fuzzy Inference System untuk Penilaian Kinerja Pegawai Perpustakaan dan Pustakawan. *Scientific Journal of Informatics*, Vol. 3(1):88-98.

[10] Sam'an, M. & Alamsyah. 2015. Implementasi Fuzzy Inference System Sebagai Sistem Pengambilan Keputusan Pemilihan Program Studi Di Perguruan Tinggi. Unnes *Journal of Mathematics*, Vol. 4(1):68-74.

[11] Prasetiyo, B., & Baroroh, N. (2016). Fuzzy Simple Additive Weighting Method in the Decision Making of Human Resource Recruitment. *Lontar Komputer: Jurnal Ilmiah Teknologi Informasi*, *7*(3), 850-857.

.[12] Mubin, L. F., Anggraeni, W., & Vinarti, R. A. 2012. Prediksi Jumlah Kunjungan Pasien Rawat Jalan Menggunakan Metode Genetic *Fuzzy* Systems Studi Kasus: Rumah Sakit Usada Sidoarjo. *Jurnal Teknik ITS*, Vol. 1(4): 82-487.

[13] Rahmadiani, A. & Wiwik, A. 2012. Implementasi Fuzzy Neural Network untuk Memperkirakan Jumlah Kunjungan Pasien Poli Bedah di Rumah Sakit Onkologi. *Jurnal Teknik ITS*, Vol. 1(1):403-407.
[14] Adibah, S. 2016. Analisis Komparasi Metode Tsukamoto dan Sugeno dalam Prediksi Jumlah Siswa Baru. *Jurnal Bianglala Informatika*, Vol. 1(4):1-5.
[15] Kusumadewi. 2004. *Aplikasi Logika Fuzzy untuk Pendukung Keputusan*. Yogyakarta :Graha Ilmu.