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A New Approach of Expert System for Rainfall Prediction Based on Data Series

[1]Indrabayu, [2]Nadjamuddin Harun, [3]M.Saleh Pallu, [4]Andani Achmad
[1] Student of Doctoral Program Civil Engineering, Hasanuddin University
[1,2,4] Department of Electrical Engineering, Hasanuddin University
[3] Department of Civil Engineering, Hasanuddin University

ABSTRACT

This paper proposed a new approach for rainfall prediction method, which combines the Support Vector Machine (SVM) and Fuzzy Logic methods.The performance of the proposed method is compared to the Neural Network (NN)–Fuzzy.The climatological data is obtained from PT LAPAN Bandung and the Meteorology, Climatology and Geophysics Region IV Makassar Indonesiafor 10 years (2001-2010) and is analysed by MATLAB 7.6.The results confirm that the SVM-Fuzzy achieves higher accuracy than NN-Fuzzy.

Keywords-Rainfall prediction, SVM-Fuzzy, Expert system and NN-Fuzzy.

I. INTRODUCTION

Rain is a natural phenomenon which has an important role in tropical countries like Indonesia.However, heavy rainfall may cause flooding and landslides that disturb the human activities, social economy, and the environment.Therefore, rainfall forecast is an essential and vital process nowadays.

Several methods have been developed to predict the rainfall in recent years, such as Neural Network (NN), Fuzzy logic and Support Vector Machine(SVM).To determine the performance of those methods, many studies have been conducted based on quantitative approach for rainfall forecasting [1]-[7].Therefore, a new approach of the rainfall prediction, which is called the SVM-Fuzzy method, is proposed in this paper which is more on qualitative based rainfall prediction.

In this paper, the rainfall data are obtainedfrom BMKG (Meteorology, Climatology and Geophysics Berau), region IV Makassar, Indonesia for 10 years (2001 - 2010) with predictor variables, such as wind speed (*W*), temperature (*T*), humidity (*H*) and Rainfall (*R*).

The rest of this paper is organized as follows.In Section II, rainfall prediction methods are described.In Section III, a new approach of rainfall predictionis proposed.In Section IV, results and analysis are discussed.Finally, Section V concludes the paper and lists the futureworks.

II. RAINFALL PREDICTION METHODS

In this section, the two rainfall prediction methods are described.It comprises of algorithms and assumptions made in each method.

II.1 Support Vector Machine (SVM)

A Support VectorMachine (SVM) is a computer algorithm that learns by example to findthe best function of classifier /hyperplaneto separate thetwoclasses in the inputspace.The SVM analyzedtwo kinds of data, i.e. linearly and non-linearly separable data [8].The example of linearly separated data is shown in Fig.1.Besthyperplanebetween twoclassescan be foundby measuring the hyperplanemarginand find out the maximumpoints.Margin is defined as the distance betweenhyperplaneand the closest pattern of each class, which is called support vector.The best hyperplaneis defined as the following equation.

$$f(x) = w^T x + b \quad (1)$$

where$x$ refers to a training pattern, w is referred to as the weight vector and $b$as the bias term.

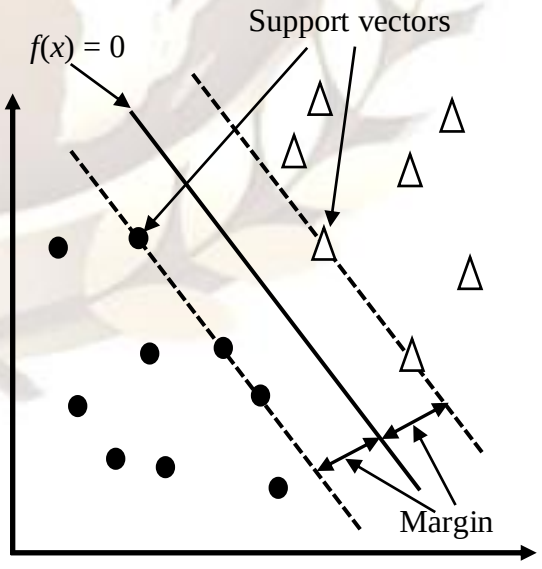

Fig.1 The example of linearlyseparated data

II.2 Fuzzy Logic (Fuzzy)

Fuzzy Logic is a type of reasoning based on the recognition that logical statements are not only true or false (white or black areas of probability) but can also range from "almost certain" to "very unlikely" (gray areas of probability).Fuzzy logic has proven to be particularly useful in expert system and other artificial intelligenceapplications.

Fuzzy inference systems, also known as fuzzy rule-based systems or fuzzy models, areschematically shown in Fig.2.They are composed of five conventional blocks;arule-basecontaining a number of fuzzy if-then rules, adatabasewhich defines the membershipfunctions of the fuzzy sets used in the fuzzy rules, adecision-making unitwhich performs the inference operations on the rules, afuzzification interfacewhich transform thecrisp inputs into degrees of match with linguistic values, adefuzzification interfacewhichtransform the fuzzy results of the inference into a crisp output.Fig.3 shows the example of temperature membership function.

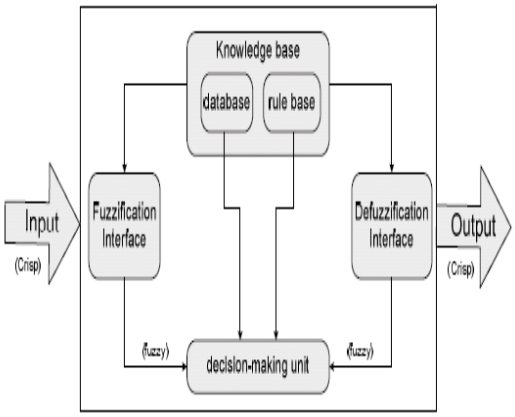

Fig.2 The general structure of a fuzzy inference system[9]

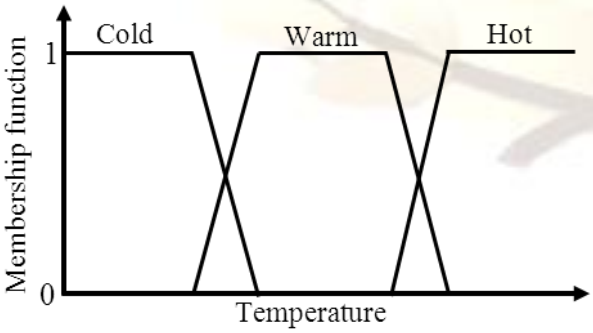

Fig.3 The example of membership function

II.3 Neural Network (NN) :Backpropagation

The field of neural networks can be thought of as being related to artificial intelligence, machine learning, parallel processing, statistics, and other fields.The attraction of neural networks is that they are best suited to solving the problems that are the most difficult to solve by traditional computational methods.

Most people would consider the backpropagationnetwork to be the quintessential Neural Network.Any network structure can be trained by backpropagationwhen the desired output patterns exist and each function has been used to calculate the actual output patterns is differentiable.The example of backpropagationnetwork is shown in Fig.4.

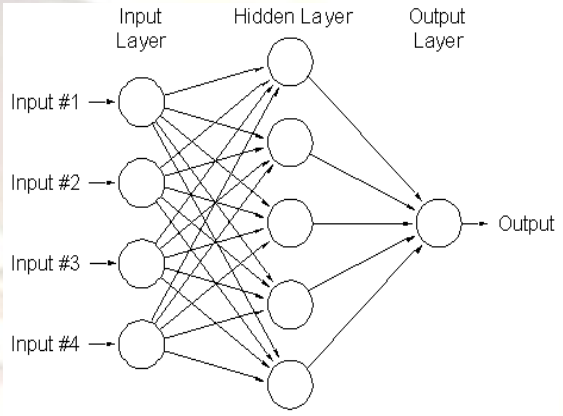

Fig.4 The example of backpropagationnetwork

III. THE PROPOSED SYSTEM

The proposed system combines the SVM and Fuzzy methods to achieve high accuracy of the rainfall prediction.The input parametersof the proposed system are humidity (*H*), wind velocity (*W*), temperature (*T*), and rainfall (*R*) for 8 years data (2001-2008).The concept of the SVM-Fuzzy and its flowchartare shown in Fig.5.and Fig.6, respectively.The SVM-Fuzzy was simulated by Matlab7.6 in this paper.

In SVM, eightyears data (2001-2008) prepared as training data aiming on 2009 observation data.Re-trainingconducted over 2001-2009 periods for predicting the humidity, wind and temperature in 2010.The input data are used in kernel Radial Basis Function (RBF) to determine the support vectors.The position of support vectors is neededto figure out the weight vector (*w*) and bias (*b*) as predictionparameters.

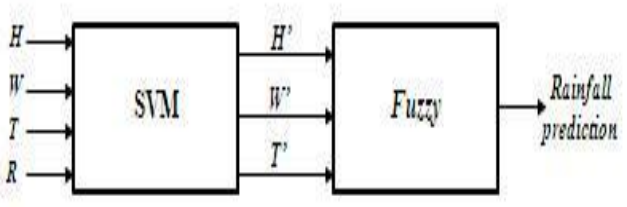

Fig.5 The concept of SVM-Fuzzy

In fuzzy, there are three input variables, one output and 36 rules.Humidity and temperature havethree membership functions, i.e. low, medium and high. While wind speed has four membership functions, i.e. calm, moderate, strong, very strong.The rainfallprediction as an output of the fuzzy system is classified into sunny, very light rain, light rain, moderate, heavy rain, and very heavy rain.The rainfall classifications are shown in Table 1.

Table 1. Rainfall Classifications

Rain type	Rainfall (mm)	
	1 hour	24 hours
Very light	< 1	< 5
Light	1 s/d 5	5 s/d 20
Moderate	5 s/d 20	20 s/d 50
Heavy	10 s/d 20	50 s/d 100
Very heavy	> 20	> 100

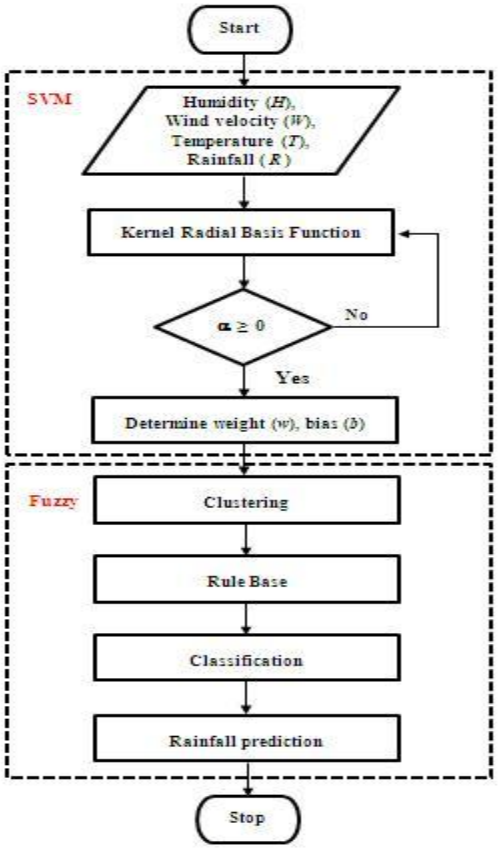

Fig.6 Flowchartof SVM-Fuzzy method

IV. RESULTS AND DISCUSSIONS

Ten years meteorological data (2001-2010) are collected from BMKG Indonesia forMakassar City.The decision of having Makassar as sample city simply because Makassar lies in Monsoonal region.

The prediction results of humidity, temperature, and wind speed of the SVM method in November 2009 are shownin Fig.7.to Fig.9, respectively.

Fig.7 The prediction results of humidity

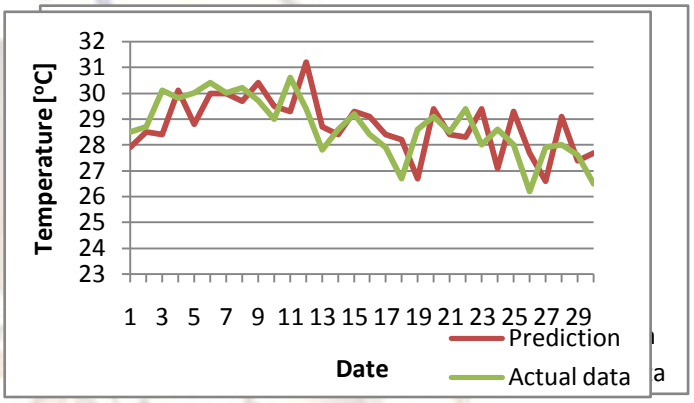

Fig.8The prediction results of temperature

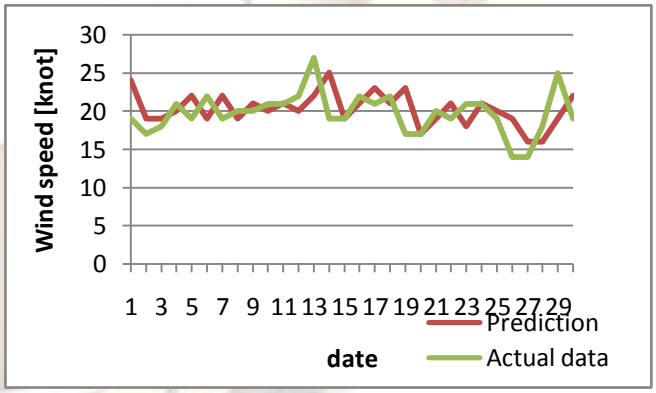

Fig.9 The prediction results of wind speed

From Figure 7-9, a quantitative meteorological daily prediction are generated by SVM to be fed into Fuzzy. It can be seen that prediction is quite accurate and also following the trend of actual data.

From Figure 7 to 9, the SVM has shown great performance of predicting the next day parameter. The data trend between predicted and actual data are similar.

The highintensity of the rainfall is obtained in Februaryand the results are shown in Fig.10 and Fig.11.

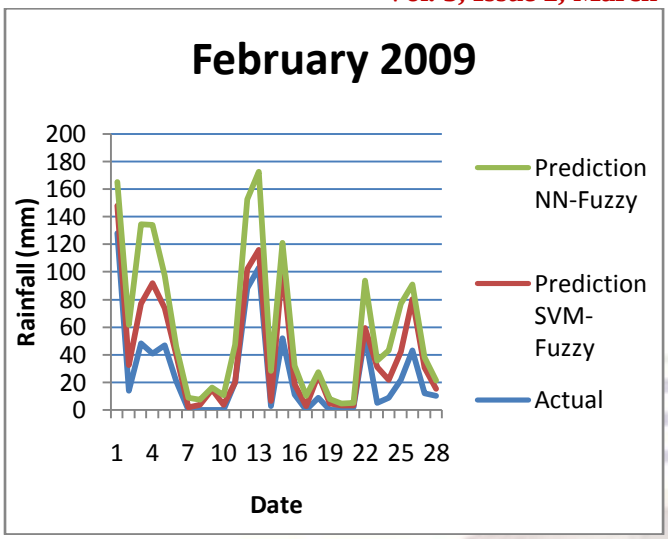

Fig.10 Rainfall in February2009

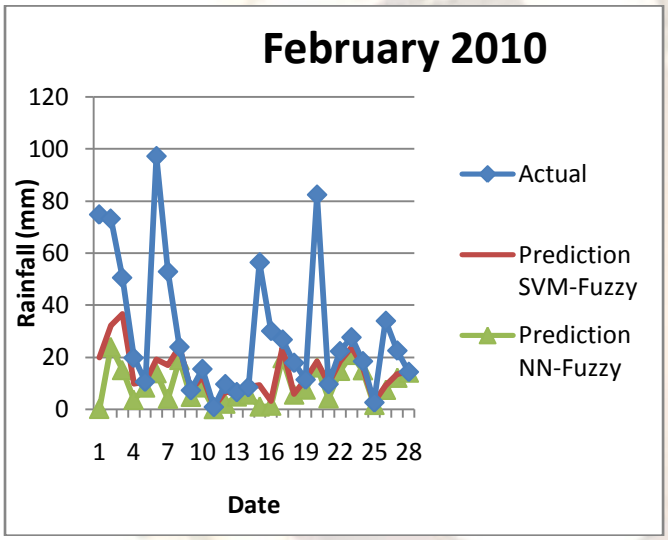

Fig.11 Rainfall in February2010

Figure 11 shown the trend between2 methods and actual data. NN-Fuzzy gives less accuracy in prediction which several days are predicted extremely differ with the actual data. SVM-Fuzzy has slight improvement compare to NN-Fuzzy, not only in better prediction but also in following the actual data trend.

In order to compare the performances of three prediction methods, the prediction accuracy (A) is calculated as following equation.

$$A = \frac{N_p}{N_t} \times 100\% \quad (2)$$

where N_p is the amount of success prediction and N_t is the total number of observations.The results are shown in Table 1, which confirms that theSVM-Fuzzy achieves higheraccuracy than NN-Fuzzy.However, the accuracy is less than 90% due to using the daily data.The accuracy can be improved by using the hourly data.It was our assumption since short term prediction (daily) need a smaller time resolution too.

Table 2.The accuracy of three prediction methods

Prediction method	Accuracy [%]	
	2009	2010
SVM – Fuzzy	75.62	62.47
NN – Fuzzy	73.70	51.78

Two methods are compared in Table 2 in term of percentage of accuracy. Slight improvement by SVM-Fuzzy in 2009 compare to NN-Fuzzy. However, a significant difference is found in 2010. This indicate that SVM-Fuzzy is better in predicting different phenomenon. This is due to the fact that in 2010 rain accoured in the whole year.

V. CONCLUSION

The proposed SVM-Fuzzy method for rainfall prediction was compared to the NN-Fuzzy.The results show that the accuracy of the proposed method is superior than NN-Fuzzy.For example, the accuracy of the SVM-Fuzzy in 2009 and 2010 are 1.92% and 10.69% superior to that of the NN-Fuzzy, respectively. A better prediction in the future research will be expected. Since a new radar was installed at Hasanuddin University and the data sampling resolution (hourly) will gives a much better accuracy.

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