Forecasting Indonesian Weather through Evolving Neural Network (ENN) based on Genetic Algorithm

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ABSTRACT

The research was motivated by the extremely altered weather condition of Indonesia within the last two decades. In forecasting the country's weather, recently, we have been built an improvement system of back propagation performance by using Conjugate Gradient (CG) on forecasting of air temperature and humidity in Indonesia using Artificial Neural Network (ANN). The research used weather data taken from the Indonesian Agency for Meteorology Climatology and Geophysics (BMKG). The data included air temperature, rainfall, air humidity, length of sun radiation, air pressure, and wind speed in Kemayoran Jakarta within five years from 2007 to 2012. Through this piece of research, ENN (Evolving Neural Network) algorithm was compared to ANN optimalized with CG (ANN-CG) in order to discover the accuracy of weather forecasting performance between them. Genetic Algorithm was utilized with ENN to discover the ANN's optimal weight and architecture. The result revealed that ENN could forecast rainfall with 61,18 percents of accuracy or 38,82 percents of MAPE while ANN-CG was not able to predict the rainfall in the research location for its excessive MAPE.

KEYWORDS

ENN, ANN, Conjugate Gradient, Weather, Kemayoran Jakarta

1. INTRODUCTION

Radical weather alternation, recently, has affected Indonesia in wide areas. One of the affected area is agriculture. As an agrarian country, Indonesia relies on rainfall in order to know the period of planting and harvesting. For the radical change, it is getting hard to predict precisely those periods with the calender of planting period. This phenomenon also attracted the advocate of Indonesian Farmer Harmony Association (HKTI) to admit that many of Indonesian farmers are in difficulty because of this radical change of weather. For this reason, the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) were expected to be able to forecast the country's weather accurately.

Weather is one of the important aspects in life aspects of nations. Weather alternation therefore frequently becomes a barrier especially in agricultural and flight areas. Focused on these areas, the research was conducted in Kemayoran

Jakarta Indonesia by referring to its weather data during the period of 2007 to 2012 from BMKG.

In the previous research, the accuracy of ANN, optimalized with CG (ANN-CG) was found not able to predict the weather in all around. On the other words, this forecasting system was only able to predict air temperature, air humidity, and air pressure. Therefore, its rainfall accuracy prediction was low [1,2]. Besides, Hybrid Fuzzy and Genetic Algorithm were also developed as the weather prediction [3]. By implementing ENN Algorithm, therefore, the optimalized structure and weight of ANN using Genetic Algorithm were expected to make more accurate weather prediction than what ANN-CG could make. Along with the weather, the ENN Algorithm was also implemented to rate the accuracy of rainfall prediction. Furthermore, the result of the ENN Algorithm experiment would be taken for the purpose of the sake of society.

In this piece research, data were taken from the weather history of Kemayoran Jakarta Indonesia from 1 January of 2007 to 29 February of 2012. The parameter used was its temperature (C), air humidity (%), and the length of solar radiation (lpm), rainfall (milimeter), wind speed (knots), and air pressure (Milibar).

ENN Algorithm was hybrid algorithm derived from Genetic Algorithm (GA) and Artificial Neural Network (ANN). GA and ANN had strength and weakness. One of the ANN weakness for example was the difficulty in optimally finding its architecture and weight. The architecture of ANN difficultly discovered was its total input, hidden layer, neuron in the hidden layer, as well as its connection in every neuron. In order to improve ANN, GA was used to optimalize the ANN architecture and weight [4,5].

Furthermore, for the matter of the research focus, the study was limited into Multi Layer Perceptron (MLP) architecture in ANN which connects its neurons one another.

2. DESIGN OF FORECASTING SYSTEM

The forecasting system designed was a system which was able to predict the weather parameter in the next day (Day+1) or (D+1). The prediction made was adderesed to temperature, rainfall, air humidity, and air pressure. Figure 1 described diagram block from the developed prediction system.

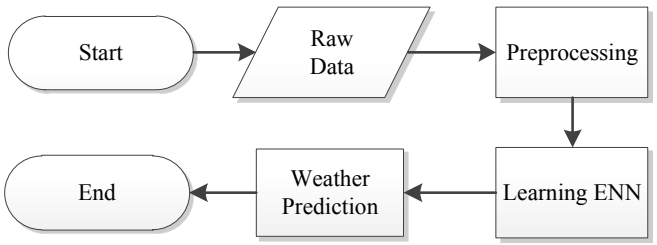

Fig. 1. Block diagram of System

In the figure 1, the raw data was processed in advance in the stage of pre-processing data. The data taken had missing values in the rainfall data, so that 0 mark was given for those values. 0 mark mean that rain did not fall on that day.

After pre-processing stage, the data was processed into ENN learning process. The detail ENN learning process was described in the Figure 2. The ENN learning process would result best individual which was the number of hidden layer, hidden neuron, and the weight. The best individual

would be a model of weather prediction in the next day.

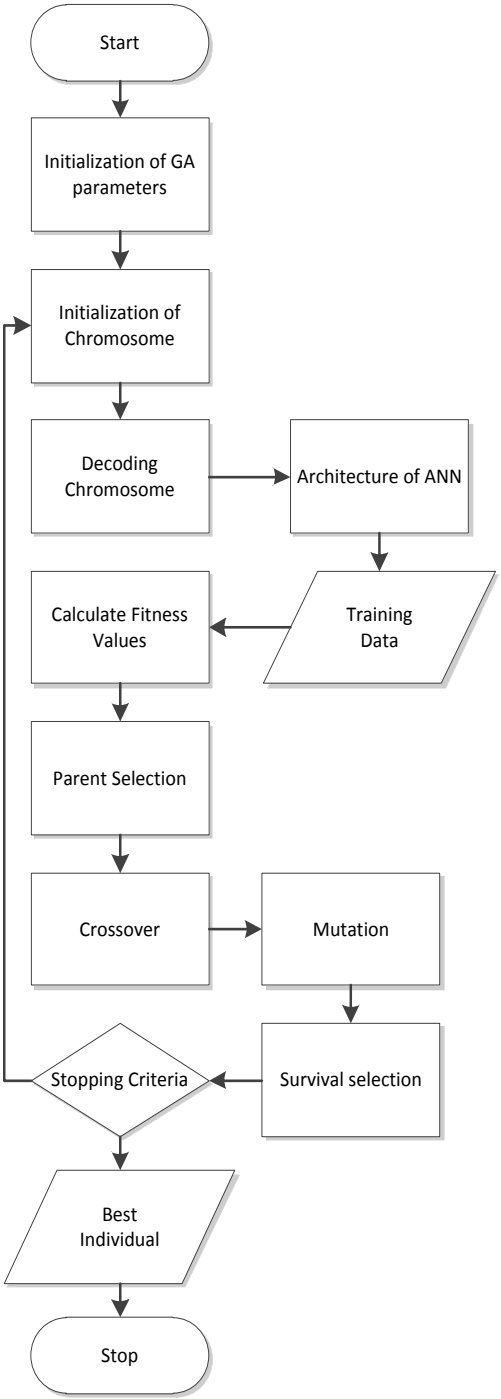

Fig. 2. ENN Learning Process

In the figure 2, the learning process of ENN began by determinating GA parameter. The observation for the parameter could be seen in the following table.

TABLE I. GA PARAMETER

Maximum evaluated individuals	5000
Population Size	[5 50 100]
Crossover Probability	[0.1 0.3 0.5 0.7 0.9]
Mutation Probability	[0.05 0.1 0.2 0.3 0.4]

In addition to the learning process of ENN, chromosome design used in the intialization of chromosome was described in the Figure 3. Chromosome design for individual was vital because that chromosome would be a solution from ENN that is ANN architecture and weight. Following is the chromosome design on GA in ENN.

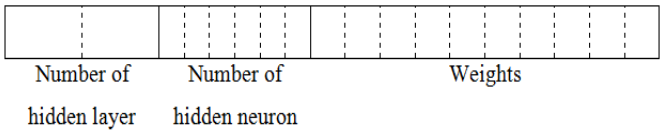

Fig. 3. GA Chromosome Design in ENN

The optimalized architecture in the figure 3 was the total of hidden layer and the total of hidden neuron. The hidden layer was limited with the minimum total of hidden layer = 1 and its maximum total=3 while the minimum total of neuron in the hidden layer = 1 and the maximum= 30.

The learning process of ENN would discontinue if the number of evaluated individual reached 5000 already. The result of the learning process was the best individual or the most prominent chromosome that had optimal ANN architecture and weight. These optimal architecure and weight then would be considered for the weather prediction process in the next day (D+1).

3. RESULTS OF EXPERIMENT

In the research, a couple of experiments were conducted to predict four weather parameter, including rainfall, air humidity, air pressure, and temperature. The learning process of ENN resulted the best chromosome which was an optimal architecture and weight.

Table 2 described error rate counted based on MAPE (Mean Absolute Percentage Error). The research was compared the prediction result of ANN-CG [1] with ENN Algorithm.

TABLE II. ERROR RATE OF EXPERIMENT RESULT

Technique	Absolute Error (%)			
	Tempera-ture	Air Humi-dity	Air pressure	Rain-Fall
ANN + CG + Brent's Line Search [1]	2,07	7,53	0,08	210,9
ANN + CG + Cha-ralambous' Line Search [1]	2,17	5,88	0,08	167,1
ANN + CG + Golden Section Line Search [1]	1,90	8,29	0,07	133,4
ANN + CG + Hybrid Bisection-Cubic Line Search [1]	2,03	7,96	0,08	157,7
ENN algorithm	2,14	5,82	1,14	38,82

In table 2, the variety of Line Search Techniques in ANN-CG used were explored. In the table 2, it was described that the techniques were not able to predict the parameter of rainfall. ENN could predict the rainfall with error rate 38,82 percents or with 61,18 percents of accuracy. This result for other parameters made the error rate between Line search in ANN-CG and ENN was not far different. On the other words, ENN still could accurately predict 94,18 percents and could give fewer errors for the air humidity parameter, compared to ANN-CG result. In addition, ENN also gave a better accurate result for air pressure parameter with 98,86 percents of accuracy. Table III pictured the best architecture taken from the best ENN chromosome.

TABLE III. BEST CHOROMOSOME

Parameter	Number of hidden layer	Number of hidden neuron
Temperature	2	30
Air Humidity	1	29
Air pressure	1	1
Rainfall	2	1

Based on the table 3, it was clear that total of the best hidden layer was not similar in each parameter, along with the number of hidden neuron. In order to predict temperature and air humidity, more number of hidden neuron was required than to predict air pressure and rainfall. In order to predict the air pressure, 1 hidden layer and 1 hidden neuron were required. This small number of layer and neuron resulted higher accuracy of prediction reaching 98,86 percents. In contrast, hidden neuron having the same total as air pressure could only reveal far different error rate. Missing values in the rainfall data was assumed to be one of the causes.

4. CONCLUSIONS

As the result of the experiment conducted, ENN was found to be able to predict data with more missing values than ANN-CG. For the marks in its element, ENN was able to predict maximally 5,82 percents of MAPE otherwise the 94,18 percents of accuracy. On the other hand, ANN with CG was found that it did not predict rainfall reffered to its MAPE higher than ENN able to predict 38,82 percents of MAPE or 61,18 percents of accuracy.

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