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Application Fuzzy Logic - Cuckoo Search Algorithm for Load Forecasting in 150 kV Sulselrabar Electric Power System

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ABSTRACT- Load forecasting for 150 kV Sulselrabar electric power system in Indonesia using artificial intelligence method is presented in this paper. The proposed method is fuzzy Logic which degree of membership is optimized by using Cuckoo Search Algorithm. From results, it is concluded that forecasting performance using Fuzzy Logic optimized by Cuckoo Search Algorithm (FL-CSA) is better than non-optimized Fuzzy Logic (FL) under tested scenario (input data is June of 2011-2015, and forecasted load is 30 days within June 2016). It is confirmed by the value of mean absolute percentage error (MAPE) for FL-CSA which is smaller than FL method, namely 0.283564552% and 0.28535111%, respectively.

1. INTRODUCTION

Knowing future electricity load is valuable for power utilities in relation to manage operation of power systems. Thus, load forecasting study is important to be done. Normally it is conducted by providing load demand model using a method. In relation to selected methods, intelligent methods have been applied by previous researchers for electricity load forecasting (A. Khosravi et al. 2011, Dharma.A. et al. 2013,2006, K.Kim et al. 2000, K.Song et al. 2005, Nurohmah.H et al 2015), but for optimized fuzzy logic is still not so many and optimal. Therefore we propose a method is based on the cuckoo search algorithm as optimization for fuzzy logic membership function. Next, the proposed method is used to forecast the load of 150 kV Sulserabar electric power system in June 2016 (30 days) and assesed using MAPE value. Load data particularly in June from Year 2011 to Year 2016 is obtained from power utility in Makassar, PT. PLN (Persero). References Djalal.M.R et al (2015) are some previous works which used cuckoo search algorithm to solve problems in power systems.

2. LOAD FORECASTING USING FUZZY LOGIC – CUCKOO SEARCH ALGORITHM

2.1. Preprocessing Load Data of Sulselrabar Electric Power System

The first is to calculate data preprocessing MaxWD(i) a maximum load of an average of four days before the day is obtained from the following equation Nurohmah.H (2015), Dharma.A. et al. (2013,2006) :

$$MaxWD_{(i)} = \frac{WD_{(i)h-4} + WD_{(i)h-3} + WD_{(i)h-2} + WD_{(i)h-1}}{4} \quad (1)$$

Load Differences (LDs) for the maximum load on the load of the day is obtained from the difference between MaxSD and MaxWD.

$$LD_{MAX}(i) = \frac{MaxSD(i) - MaxWD(i)}{MaxWD(i)} x100 \quad (2)$$

Typical Load Differences (TLDs) obtained from averaging the typical load on the same type of day from the historical load data. TLDs are used as a basis for forecasting the maximum load.

Variation of Load Differences (VLDs) is defined as the difference between the behavior of the burden of the day with the type of load behavior of the day on the same type of day VLDs calculated using the following equation Nurohmah.H (2015), Dharma.A. et al. (2013,2006) :

$$VLD_{max}(i) = LD_{max}(i) - TLD_{max}(i) \quad (3)$$

2.2. Optimization Processing of Fuzzy Logic Membership Function using Cuckoo Search Algorithm

Design of fuzzification of inputs X and Y using IT1MF Editor, where there are 2 trapezoidal membership functions and 9 triangular membership functions with a range between -12 and 12 for input and output, then there are 11 models of triangular membership functions are used to output Z. All values input X, Y and output Z is value of $VLDMAX_{(i)}$ where the value of X is a day that is the same in the year before the year forecasting, Y is a day before (near) the type of day that same year forecasting and Z is a day of forecast.

2.3. Fuzzy Logic (Membership Function & Rules)

Fuzzy IF-THEN rules used for forecasting the maximum load. In this paper input from membership functions (antecedents), namely X, Y and output membership function (consequent) is Z for short-term load forecasting follow the equation below Nurohmah.H (2015), Dharma.A. et al. (2013,2006) :

$$IF\ X\ is\ A_i\ AND\ Y\ is\ B_i\ THEN\ Z\ is\ C_i \quad (4)$$

Fuzzy set A_i, B_i, and C_i have eleven membership functions, that is *Negative Very Big (NVB), Negative Big (NB), Negative Medium (NM), Negative Small (NS), Negative Very Small (NVS), Zero (ZE), Positive Very Small (PVS), Positive Small (PS), Positive Medium (PM), Positive Big (PB), Positive Very Big (PVB).*

2.4. Cuckoo Search Algorithm

Inspired by this cuckoo bird behavior, so that became the inspiration for Xin-She Yang and Deb in discovering new methods in the world of optimization. In addition, because the bird has a uniqueness that is not possessed by other birds. Levy flight is a random walk long stride meet Levy distribution. Levy distribution itself has a density function as follows, μ> 0 minimum steps Djalal.M.R et al (2015) :

$$L(s,\gamma,\mu)=\begin{cases}\sqrt{\frac{\gamma}{2\pi}}\exp\left[-\frac{\gamma}{2(s-\mu)^{3/2}}\right]\frac{1}{(s-\mu)^{3/2}}, 0<\mu<s<\infty\\ 0\end{cases} \quad (5)$$

Random Walks

Random walks is a random process that consists of a series of successive random steps Djalal.M.R et al (2015) :

$$Y_N=\sum_{i=1}^{N}K_i=K_1+\ldots+K_N=\sum_{i=1}^{N-1}K_i+K_N=Y_{N-1}+K_N \quad (6)$$

2.5. POST PROCESSING

After getting Forecast VLD_{MAX} we then look for Load Forecast Difference as follows Djalal.M.R et al (2015) :

$$Forecast\,LD_{MAX}(i)=Forecast\,VLD_{MAX}(i)+TLD_{MAX}(i) \quad (7)$$

Peak Load Forecasting (MW) can be calculated using the following equation Djalal.M.R et al (2015) :

$$P'_{MAX}=MaxWD(i)+\frac{(ForecastLD_{MAX}(i)\,x\,MaxWD(i))}{100} \quad (8)$$

The percentage of error between forecasting value and actual value can be calculated by the following equation Djalal.M.R et al (2015) :

$$Error\,\%=\left|\frac{P'_{MAX}(i)-MaxSD(i)}{MaxSD(i)}\right|x100 \quad (9)$$

3. RESULT AND ANALYSIS

Load forecasting optimization using FL-CSA use load data input in June from Year 2011-2015 and as the comparison of actual data used in June 2016. Simulation results show obtained mean absolute

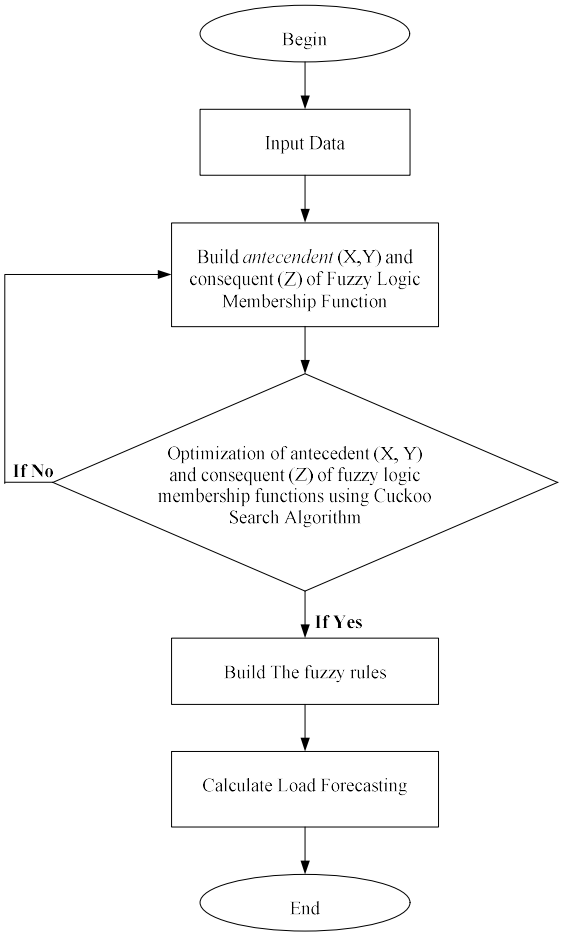

Figure 1. Research flowchart

percentage error (MAPE) value is smaller using FL-CSA, that is equal to 0.283564552%. While MAPE using FL method is 0.28535111%.

Table 1 shows the results of data processing load and calculate the value for the input fuzzy logic. The analysis process begins by calculating the value of MaxWD and MaxLD years 2011-2016 using Equation 1, then calculate the value MaxTLD and MaxVLD one year before the data is forecasting that 2015 and MaxVLD year forecast that by 2016, using Equations 2 and 3.

Next to optimize the fuzzy logic membership functions for calculating the forecast value VLD, and the results are then calculate the load forecasting using Equation 8 and calculates forecasting error value using Equation 9.

Table 1. Results of calculation value

Date	June 2016 (30 Days)			
	WD Max	LD Max	TLDmax	VLDmax

1	923.1	1.332467	-0.22257	1.555034
2	934.65	0.069545	-3.56835	3.637891
3	934.8	-4.01155	0.365104	-4.37666
4	918.125	-2.45337	1.901545	-4.35491
5	915.9	1.091822	1.774991	-0.68317
6	913.525	3.423552	1.022699	2.400853
7	915.9	5.655639	-2.23614	7.891778
8	933.5	3.38511	-1.1977	4.58281
9	950.875	-4.72985	0.072912	-4.80277
10	945.875	-1.86864	-1.568	-0.30064
11	941.725	-4.95102	-1.07989	-3.87113
12	923.575	0.533254	3.551144	-3.01789
13	914.425	-2.64921	0.413313	-3.06252
14	910.5	1.372872	0.158021	1.214851
15	909.2	-0.46194	-1.77468	1.312736
16	911.675	0.2989	-1.39192	1.690825
17	908.15	-1.82239	1.917444	-3.73983
18	908.5	-3.62135	1.115168	-4.73652
19	896.65	-1.87922	1.401288	-3.2805
20	890.35	1.083843	-1.83587	2.91971
21	886.75	5.328447	-0.37344	5.701883
22	897.35	1.097676	-0.64086	1.738535
23	905.25	0.34797	0.280109	0.067861
24	912.4	-4.83341	0.555071	-5.38848
25	904.475	-2.65071	0.50692	-3.15763
26	891.1	2.401526	1.403176	0.998351
27	892.425	-2.78175	0.789675	-3.57142
28	882.225	-4.34413	-1.59097	-2.75316
29	876.125	0.156941	-1.35801	1.514953
30	875.375	1.168071	-1.02815	2.196218

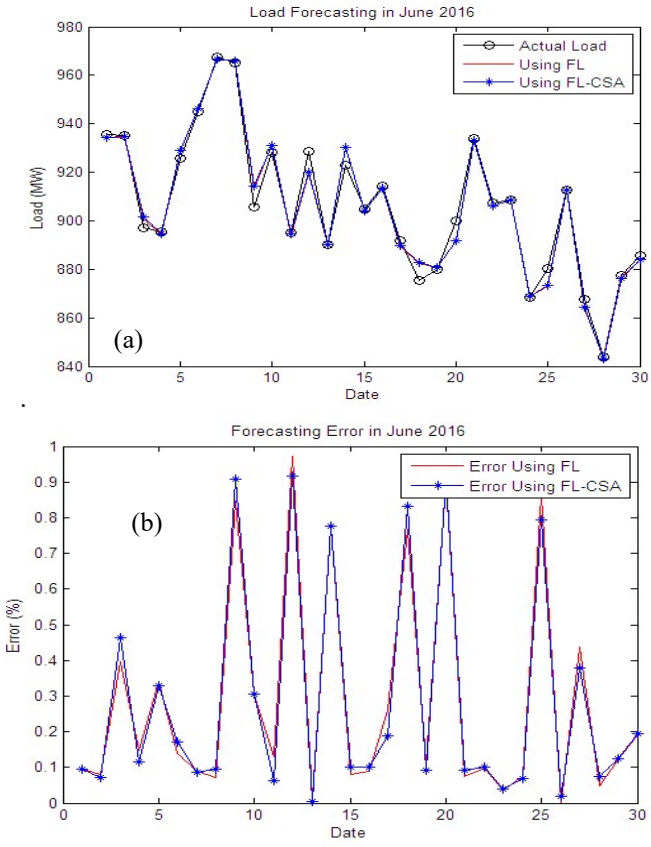

Figure 2 (a)(b). The comparison of load forecasting results in June 2016 using FL and FL-CSA method, and error value (MAPE)

4. CONCLUSION

Optimization Fuzzy Logic using Cuckoo Search Algorithm for load forecasting in June 2016 in 150 kV Sulselrabar electric power system shows obtained MAPE value for Fuzzy Logic optimized by Cuckoo Algorithm (FL-CSA) is smaller than Fuzzy Logic method without optimizations (FL). The smallest MAPE value using the FL-CSA of 0.283564552%. Meanwhile MAPE value using FL is 0.28535111%. MAPE value is still below the allowable limit of tolerance values. It can be concluded that proposed method namely FL-CSA give better results which can optimize electricity load forecasting.

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