Short-Term Electricity Demand Forecasting using Fuzzy Logic-Flower Pollination Algorithm (FL-FPA)

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Short-Term Electricity Demand Forecasting using Fuzzy Logic-Flower Pollination Algorithm (FL-FPA)

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ABSTRACT– This paper proposes an intelligent algorithm for short-term electricity demand forecasting. Hourly electricity demand from January to July 2015 for Makassar city, Indonesia is used in this study. The proposed method is fuzzy logic which the degree of membership is optimized using flower pollination algorithm. Forecasting case for 24 hours ahead (Monday, 6 July 2015) shows fuzzy logic optimized by pollination flower algorithm (FL-FPA) gives better results than non-optimized fuzzy logic (FL). It is seen by obtained MAPE value for FL-FPA (0.000834049%) is smaller than FL approach (0.005915578%).

1. INTRODUCTION

As in many places, load demand in Makassar city, Indonesia has tendency to increase each year. Therefore, it is required a study that can provide a model for load prediction in relation to development of power plant operations. In load forecasting area, intelligent methods have been used by many researchers Ramadhani.A (2015), Dharma. A. et al (2013), A.Kosrafi et al (2011), Firas M. T (2008), G.Gross (1987), H.Mori et al (1996), Castro I.L (2015), K.Song et al (2005), K.H.Kim et al (1995), K.Kim et al (2000), Pandian. S.C.(2006), T.J. Ross (2009). This paper proposes a forecasting method, namely flower pollination algorithm which is used to optimize fuzzy logic membership function (FL-FPA). To examine effectivenes of the proposed method, it is applied for short-term load forecasting (24 hours) in Makassar, Indonesia and its result is compared with fuzzy logic. The used hourly load data is from January to July 2015, and they are taken from electricity state company in Makassar. Previous work which used flower pollination algorithm in their study can be found in Yang X.S (2012).

2. FUZZY LOGIC-FLOWER POLLINATION ALGORITHM (FL-FPA) FOR ELECTRICITY DEMAND FORECASTING

2.1. Preprocessing Data for Electricity Demand in Makassar

Preprocessing data is started firstly by computing some expression and its explanation indicated in Eq.(1) Ramadhani (2015), Dharma. A. et al (2013) In order to quantify the difference between load behavior of special days in this case Monday and that of normal weekdays.

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

Load Differences (LDs) for maximum loads on special days is defined as the difference between the special day and previous four Monday is expressed by Eq. (2), while MaxWD(i) is the average maximum load of previous four Monday which is given on Ramadhani (2015), Dharma. A. et al (2013.

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

Typical LDs (TLDs) is resulted by averaging the LDs of the same Monday in the same Monday of historical data. TLDs is used as a basis to predict the value of maximum load on Monday.

The Variations of LD (VLD) is defined as the amount of difference between the load behavior of Monday and typical behaviors of the same Monday with the same day type. Then the values of VLDMax are calculated simply by subtracting TLDMax from LDMax as shown Eq.(3) Ramadhani (2015), Dharma. A. et al (2013).

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

2.2. Optimization Processing of Fuzzy Logic Membership function using Flower Pollination

In the global pollination step, the first and the third rules are used together to find solution of the next step (xi^{t+1}) using the values from the previous step (step t) defined as xi^{t}. Global pollination is formulated as in Eq. (4).

$$x_i^{t+s1} = x_i + L\,(x^t - g^*) \quad (4)$$

The subscript i represents the i^{th} pollen (or flower) and is applied for the pollen of the flowers Yang X.S (2012). The g* is current best solution. L is the strength of the pollination, which is drawn from a Lévy distribution. The second rule is used for local pollination with the third rule about flower constancy. The new solution is generated with random walks as seen in Eq. (5).

$$x_i^{t+1} = x_i^t + \varepsilon\,(x_j^t - x_k^t) \quad (5)$$

where x_j^t and x_k^t are solutions of different plants. ε is randomized between 0 and 1. According to the fourth rule, a switch probability (p) is used in order to choose the type of pollination which will control the optimization process in iterations. Flower pollination algorithm was first proposed for the optimization problems with a single objective. Then, reference Yang X.S (2012) developed a multi-objective approach for FPA.

2.3. Fuzzy Logic (FL)

The fuzzy rules IF-THEN which used in this method for the maximum load is expressed as follows:

IF X is A_i AND Y is B_i THEN Z is C_i

The values of input variable Y are obtained from the neighboring Monday in the year. If the Monday are the days preceding and following Monday, then those values are obtain from the preceding and the following days of the previous Monday.

2.4. Flower Pollination Algorithm (FPA)

In nature, the main purpose of the flowers is reproduction via pollination. Flower pollination is related to the transfer of pollen, which is done by pollinators such as insects, birds, bats, other animals or wind. Some flower types have special pollinators for successful pollination. The four rules of pollination have been formulated based on the inspiration from flowering plants and they form the main updating equations of the flower pollination algorithm Yang X.S (2012).

2.5. Post Processing

In this section forecast load difference is calculated by Eq. (6).

$$Forecast\,LD_{MAX}(i) = Forecast\,VLD_{MAX}(i) + TLD_{MAX}(i) \quad (6)$$

To calculate the peak load forecasted in the year i^{th} (MW) is expressed by Eq. (7).

$$P'_{MAX} = MaxWD(i) + \frac{(ForecastLD_{MAX}(i)\,x\,MaxWD(i))}{100} \quad (7)$$

To find out how far a method to process a particular value when compared with other methods that have been used, or with a value that already exists is successful, one needs to count the difference between values with the calculation method that has real value. This is often called the calculation of the percentage errors in accordance with Eq. (8). :

$$Error\,\% = \left| \frac{P'_{MAX}(i) - MaxSD(i)}{MaxSD(i)} \right| x100 \quad (8)$$

3. RESULT AND ANALYSIS

Optimization of load forecasting using the FL-FPA use load input data on Monday in January to May 2015, and forecasted load is on Monday in June 2015. Flowchart of the forecasting study is shown in Figure 1. Simulation results show MAPE value for FL-FPA method is 0.000834049%, mean while MAPE value using fuzzy logic method is around 0.005915578%.

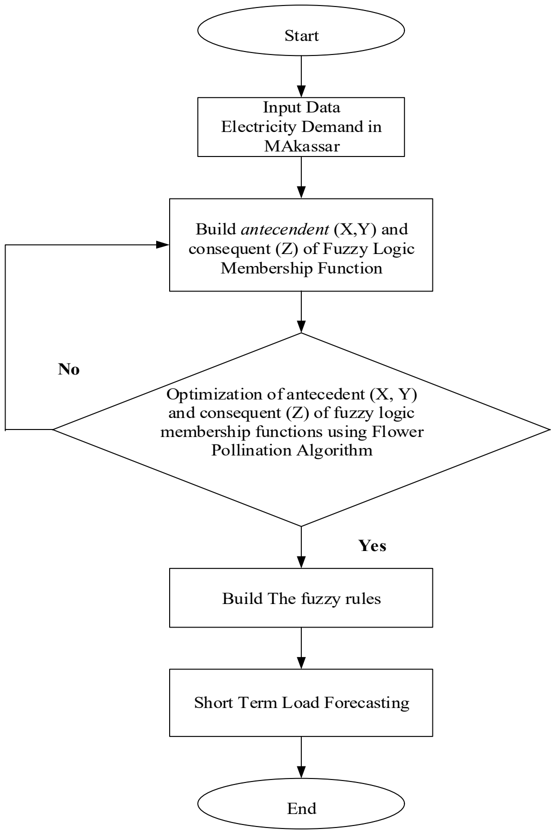


Figure1. Flowchart FL-FPA for forecasting

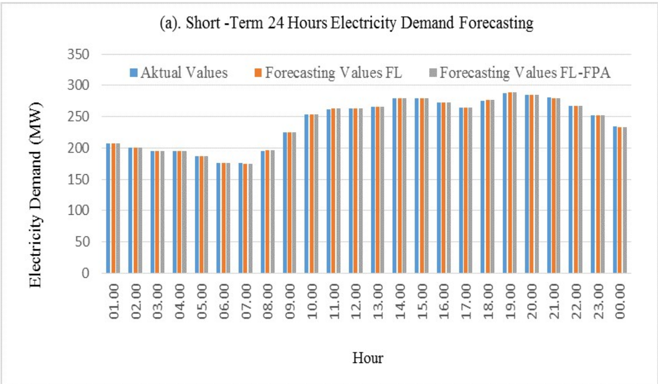
Table 1 shows results of the data processing load and calculate the value for the input fuzzy logic. The analysis process begins by calculating the value of WD Max and LD Max Monday of each month from January to July 2015 using Eq.(1), then calculate the value TLD Max and VLD Max one month before the data is forecasting that the month of June 2015 and VLD Max in forecasting the month in July 2015, using Eqs.(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 Eq. (7) and calculates the error value equation using Eq. (8). Figure 2 shows forecasting results for FL-FPA and FL, and MAPE values.

Table 1. Results of data processing load

Hour	6 July2015			
	WD Max	LD Max	TLDmax	VLDmax
1	216.225	-4.0814	-0.15273	-3.92866
2	205.875	-2.8051	-0.14025	-2.66485
3	202.225	-3.82	-0.40872	-3.41128

4	198.75	-1.93711	0.470607	-2.40771
5	192.15	-2.62816	0.177338	-2.80549
6	186.225	-5.86656	0.7462	-6.61276
7	189.075	-7.28547	-0.00145	-7.28402
8	212.7	-8.27457	-1.3739	-6.90067
9	243.875	-7.65761	0.414671	-8.07228
10	262.65	-3.44565	-1.28741	-2.15824
11	279.225	-6.16886	-1.88961	-4.27925
12	275.4	-4.32099	-1.69046	-2.63053
13	280.325	-5.07447	-1.65405	-3.42041
14	287.4	-2.78358	-1.63104	-1.15254
15	284.75	-1.87884	-2.03409	0.155252
16	279.725	-2.40415	-2.07347	-0.33068
17	268.875	-1.47838	-4.16527	2.686885
18	284.2	-2.92048	-3.02138	0.100905
19	293.55	-1.78845	-4.52865	2.740203
20	289.75	-1.67386	-4.459	2.78514
21	285.05	-1.59621	-5.14814	3.551927
22	270.35	-0.94322	-5.00166	4.058437
23	253.475	-0.4241	-3.9696	3.545497
24	238.95	-2.11341	-4.04843	1.935013



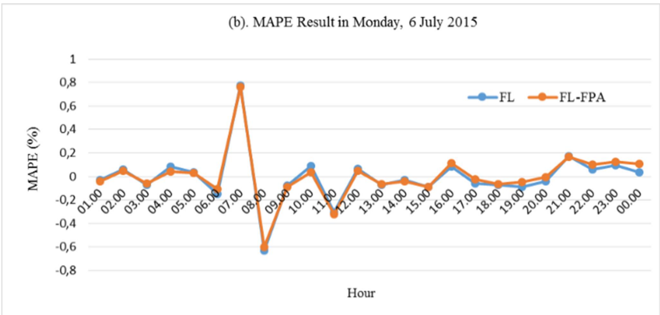


Figure 2 (a)(b).Short-term load forecasting results and MAPE values for FL and FL-FPA methods.

4.CONCLUSION

In this research, fuzzy logic optimized by flower pollination algorith (FL-FPA) method is proposed to forecast electricity demand in Makassar city, Indonesia for 24 hours ahead. Under examined case (Monday, 6 July 2015), results confirm FL-FPA method give better forecasting performance than fuzzy logic (FL) as shown by their MAPE values. The smallest MAPE value using for FL-FPA is 0.000834049% mean while MAPE for FL is around 0.005915578%. Improvement results which make forecasted load values closer to actual load shown the effectivenes of FL-FPA method.

5. ACKNOWLEDMENT

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