

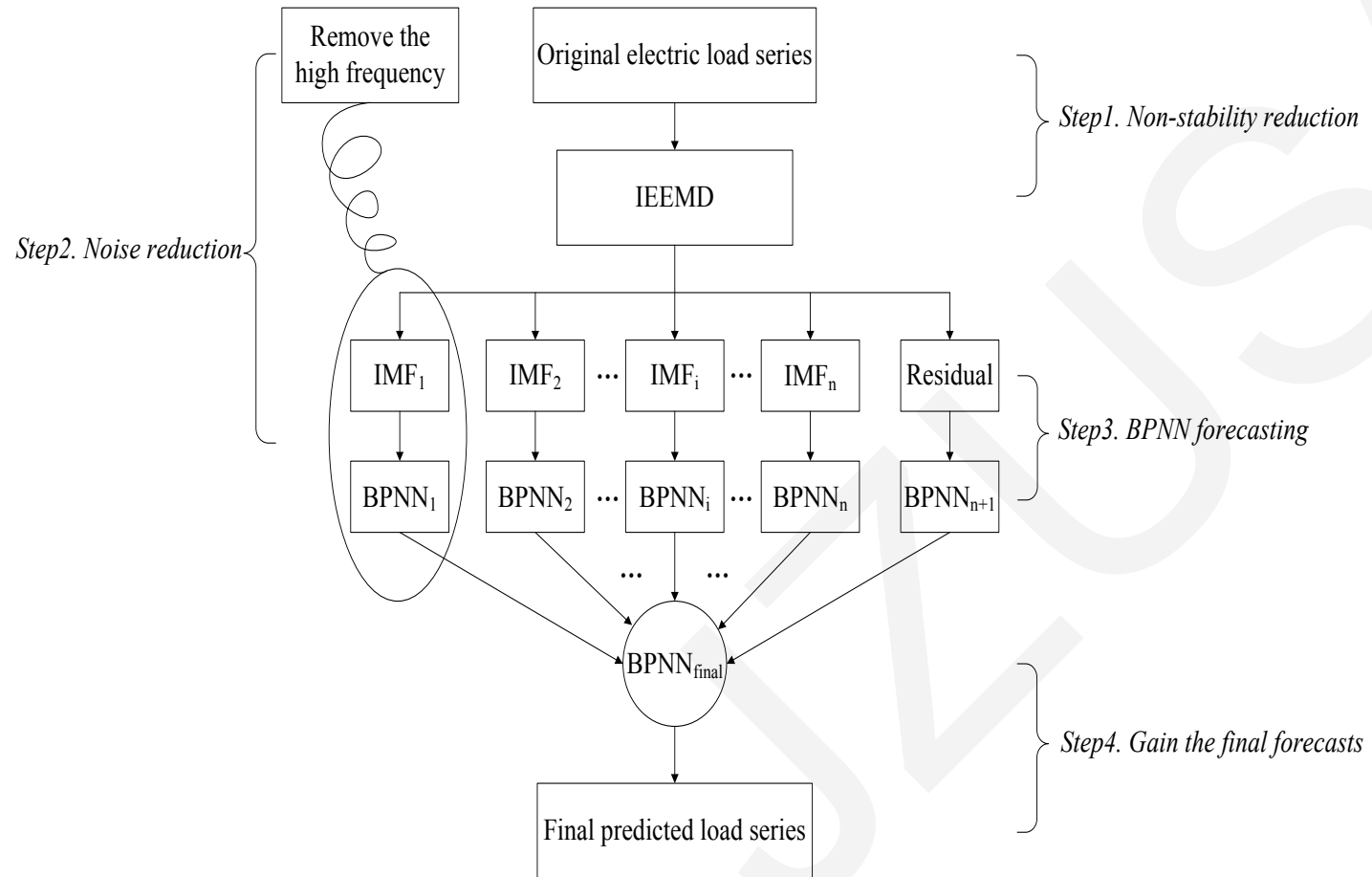
A Hybrid Short-term Load Forecasting Method Based on Improved Ensemble Empirical Mode Decomposition and Back Propagation Neural Network

Keywords: Ensemble empirical mode decomposition, Intrinsic mode functions, Back propagation neural network, Short-term load forecasting

Cite this as: Yun-luo Yu, Wei Li, De-ren Sheng, Jian-hong Chen, 2016. A hybrid short-term load forecasting method based on improved ensemble empirical mode decomposition and back propagation neural network. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 17(2):101-114. <http://dx.doi.org/10.1631/jzus.A1500156>



The short-term load forecasting model



Non-stability reduction
IEEMD



Noise reduction
IMF1



BPNN forecasting
BPNN



Gain the final forecasts
BPNN

▪ The short-term load forecasting model ▪



Statistic measures of forecasting performance

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - x_i^*)^2}$$

$$MAE = \frac{1}{N} \sum_{i=1}^N |x_i - x_i^*|$$

$$MAPE = \frac{1}{N} \sum_{i=1}^N \left| \frac{x_i - x_i^*}{x_i} \right| \times 100\%$$

- ◆ RMSE: Root-Mean-square error
MAE: mean absolute error
MAPE: mean absolute percentage error

- ◆ x_i : the actual value

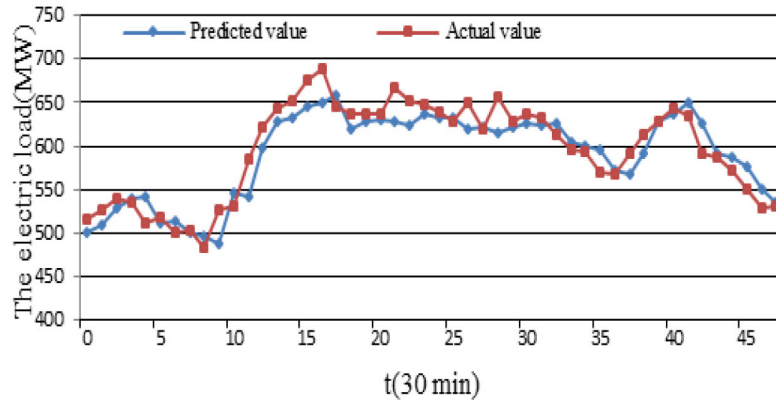
x_i^* : the forecast value

N : the number of test samples

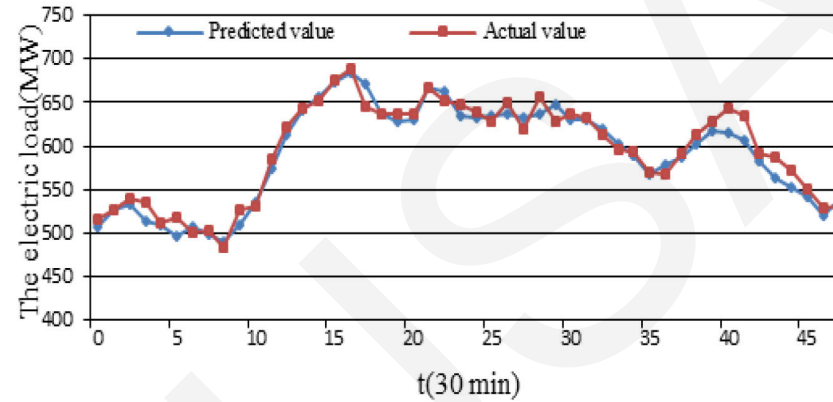
- ◆ The smaller they are, the better the forecasting accuracy is.



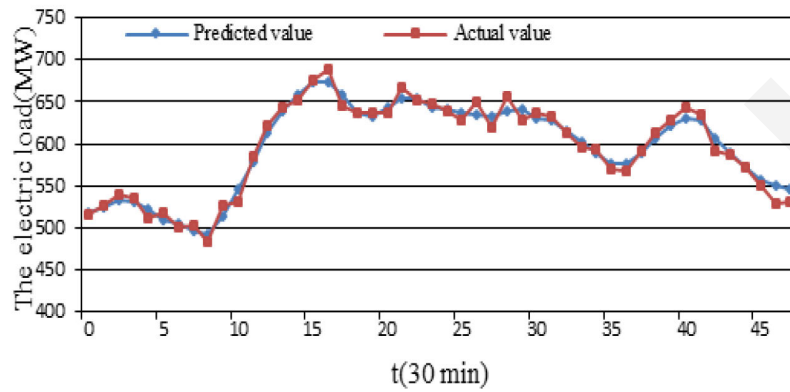
Compared with basic BPNN, EMD-BPNN, EEMD-BPNN



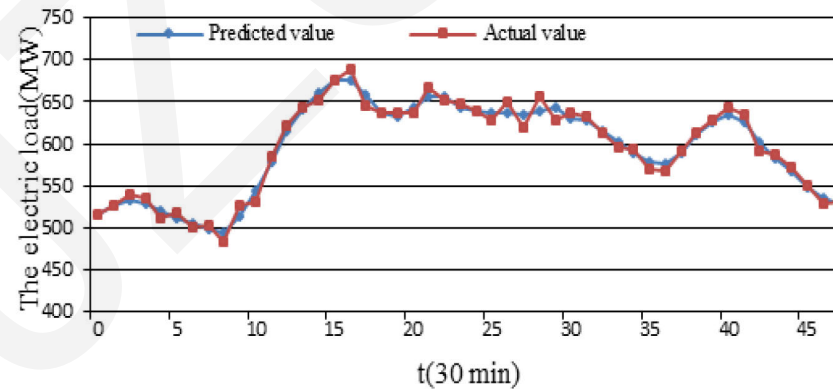
(a) The actual and predicted load data obtained by basic BPNN



(b) The actual and predicted load data obtained by EMD-BPNN



(c) The actual and predicted load data obtained by EEMD-BPNN



(d) The actual and predicted load data obtained by IEEMD-BPNN

The IEEMD-BPNN results are more consistent with the actual load than the other the basic BPNN, EMD-BPNN, EEMD-BPNN methods.



Compared with basic BPNN, EMD-BPNN, EEMD-BPNN

Compared with basic BPNN, EMD-BPNN, EEMD-BPNN:

Date	RMSE of (MW)				MAE of (MW)				MAPE of (%)			
	BPNN	EMD-BPNN	EEMD-BPNN	IEEMD-BPNN	BPNN	EMD-BPNN	EEMD-BPNN	IEEMD-BPNN	BPNN	EMD-BPNN	EEMD-BPNN	IEEMD-BPNN
20 th	20.38	9.41	12.40	8.08	16.76	7.87	9.93	6.73	2.81	1.34	1.67	1.13
21 th	26.48	9.12	9.42	8.33	18.07	7.61	7.05	6.81	3.13	1.30	1.19	1.15
22 th	18.25	8.18	7.21	7.01	13.97	6.64	6.04	5.57	2.48	1.19	1.07	0.99
23 th	18.02	27.98	24.79	8.63	12.76	22.78	22.57	6.44	2.33	4.35	4.14	1.17
24 th	20.36	29.12	13.67	9.94	16.71	24.25	10.49	7.97	3.09	4.53	1.92	1.46
25 th	21.09	14.02	13.49	8.27	15.53	9.44	10.90	7.05	3.01	1.84	2.11	1.36
26 th	25.57	11.78	10.01	6.68	21.13	8.28	7.29	5.26	4.43	1.71	1.50	1.09
Average value	21.45	15.66	13.00	8.13	16.42	12.41	10.61	6.55	3.04	2.32	1.94	1.19

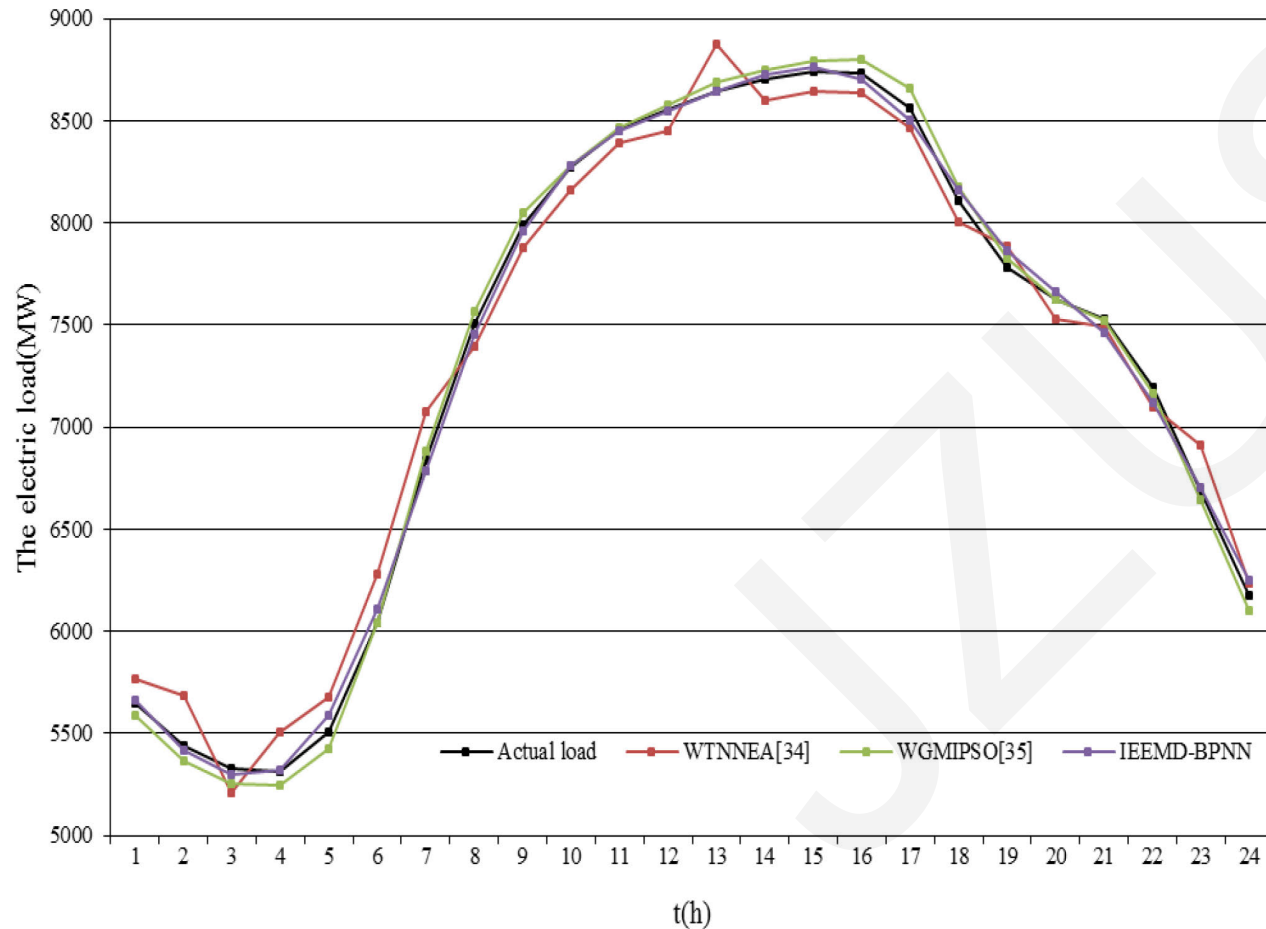
➤ Basic BPNN has the worst performance.

➤ EMD-BPNN and EEMD-BPNN both performed better than basic BPNN.

➤ IEEMD-BPNN outperforms other 3 methods in terms of all the 3 standard statistical indicators.



Compared with methods published in other studies



The same load data used in other 2 studies were used to predict the same day load through IEEMD-BPNN.

The IEEMD-BPNN results are more consistent with the actual load than the other 2 methods.

Compared with methods published in other studies

Compared with methods published in other studies:

	MAPE (%)	MAE (MW)	RMSE (MW)	Maximum error (MW)	Minimum error (MW)	Maximum absolute error (MW)	Minimum absolute error (MW)
WTNNEA method (Amjady and Keynia, 2009)	1.931	132.11	145.19	114.45	-242.63	242.63	36.921
WGMIPSO method (Bahrami <i>et al.</i> , 2014)	0.682	46.625	53.711	81.79	-93.77	93.77	1.96
IEEMD–BPNN method	0.533	37.225	45.78	83.761	-71.747	83.761	0.751

The proposed method outperforms other methods both mentioned in this article and published in other studies in terms of all the three standard statistical indicators considered in this study.