INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 6.078
(Volume 7, Issue 1)
Available online at: https://www.ijariit.com

Hybrid the artificial intelligence and swarm-based optimization algorithm for load forecasting in the smart grid

Kuljeet Singh Sandhu
kuljeetsandhu27@gmail.com
Adesh Institute of Engineering and Technology, Faridkot, Punjab

Puneet Jain
puneetjain988@gmail.com
Adesh Institute of Engineering and Technology, Faridkot, Punjab

ABSTRACT

Electricity load forecasting algorithms are used in the smart grid to predict the electricity demand in the future. Besides that, it helps in reducing the electricity generation cost. In the literature, three types of load forecasting are done such as short-term, medium-term, and long-term. In this paper, short term forecasting is done. The short-term forecasting algorithm predict the electricity demand from few hours to several weeks ahead. Due to the nonlinear, nonstationary and nonseasonal nature of the electric load time series, accurate forecasting is challenging. In this paper, Artificial Intelligence (AI) and swarm optimization algorithm is hybrid in order to improve the prediction of load forecasting. We have considered Artificial Neural Network (ANN) and Binary Particle Swarm Optimization (BPSO) algorithms in our work. The BPSO algorithm used to improve the learning rate in the ANN network. The experimental results were simulated in MATLAB and various performance metrics such as RMSE, MAPE, minimum and maximum error determined. The results show that the proposed algorithms provide better results as compared to the existing algorithms.

Keywords: *Artificial Neural Network, Binary Particle Swarm Optimization, Load Forecasting, Smart Grid*

1. INTRODUCTION

To give electric energy to users in safety as well as cost, an electric industry has various issues related to economic as well as technical while the execution. All these issues scheduling systems, the load flow examination, organizing as well as monitoring of electric energy system is more useful. Load Forecasting is one of the main areas of research for issuing this area for the last few years. It can be stated as the parameter of the correctness of the difference between the correct and hypothesis value of load request. Forecasting the request for electricity will assist in operating the cost of producing electric energy units, and May able to secure the consumption in the design of needed power usages. It may assist to control the execution of the threat, fluctuating request, and request of the spinning reserve as well as various faults. It gives important data for power delivery and organizing. This acts as a crucial play in the management of the energy system.

The power system scheduling system, executions, amount of flow examination, and efficiency are the main interesting area that may be searched through load forecasting [1]. The rough idea of load interest is more important like it will assist the generation as well as the supply of power. The roughly estimating the load request, it has a bad result on request of response. Then, on power established. Also, the outcomes of load are most hard to maintain overload situations. Similarly, the overall idea of influences the foundation and then, the efficiency of the system [2]. For the objective, there are various methods applied at the time of the last few years [1- 6].

Mainly, this method may be classified into two stages like parametric and non-parametric methods. Some main illustrations explain the parametric methods like linear regression, general exponential method, autoregressive moving average (ARMA) method, and stochastic time series method. The limitation of this method is its ability to variation of any kinds of changes like surrounding as well as social. Nevertheless, to reduce, using a non-parametric based method which is due to its potentiality to whole world search. All the non-parametric based methods, ANN has one of the most used methods that have more attention from scientists. The capability to resolve the complex links, adaptive monitor, and making decision and hypothesis structures makes ANN more powerful as compared to the already applied method [7-11]. Therefore, there are various variants of ANN that is the hybridization of neural networks with various methods like GA, PS0, BFO, etc are suggested by some scientists.

The main aim of this article to improve the prediction of load forecasting by hybrid the ANN and Binary PSO. In the proposed algorithm, the binary PSO algorithm is to improve the learning rate of ANN. The experimental results were performed on the

standard dataset and found that the proposed algorithm gives better results than which are already used algorithms in terms of RMSE and Mean Absolute Percentage Error. Thus, the proposed algorithm can be used for load forecasting in the smart grid.
The rest of the paper as follows. Section 2 provides an overview of ANN and Binary PSO. Further, section 3 illustrates the algorithm. Section 4 indicates the experimental results performed for the proposed method. In the last, section 5 provides the conclusion.

2. RELATED WORK

In this section, an overview of the Artificial Neural Network and Binary Particle Swarm Optimization (BPSO) algorithm is given.

2.1 Artificial Neural Network (ANN)

The ANN is based on the biological neural network. The ANN is internally connected to nodes as well as analogous to neurons. Each network has three main important parts: node character, network topology, and learning rules. The first find how signals are executed through the node, like the number of inputs and outputs connected with the node as well as the weight associated with data, and the activation function. Network topology analysis of the nodes of the way are planned and interconnected. The third one is how the weights are started as well as adjusted [13].

2.2 Binary Particle Swarm Optimization (BPSO)

The PSO is the most concept as well as the computational method that are used to optimize several continuous nonlinear methods [13]. The population is started randomly with particles and then analyzed to calculate fitness function by detecting the best value and global best. Startlingly, with the fixed dimensions and fitness value, each individual determines its particle best. The best value among the particle best population, on the other hand, the global best is examined and then the loop initiates to converge to an optimum solution. In the loop, these are examined to upgrade the position and velocity of each particle. The analysis is executed and to calculate the fitness of the swarm. It is ended with an ending criterion already founded. It is simulated with new ways to produce binary code called BPSO. In the BPSO method, the equation remains not changed, without that Xid and p bested are integer in [0,1] [14-15].

3. PROPOSED ALGORITHM

The proposed algorithm provides a minimum error to predict the load demand based on historical data. The flowchart of the proposed algorithm is shown in Figure 1.

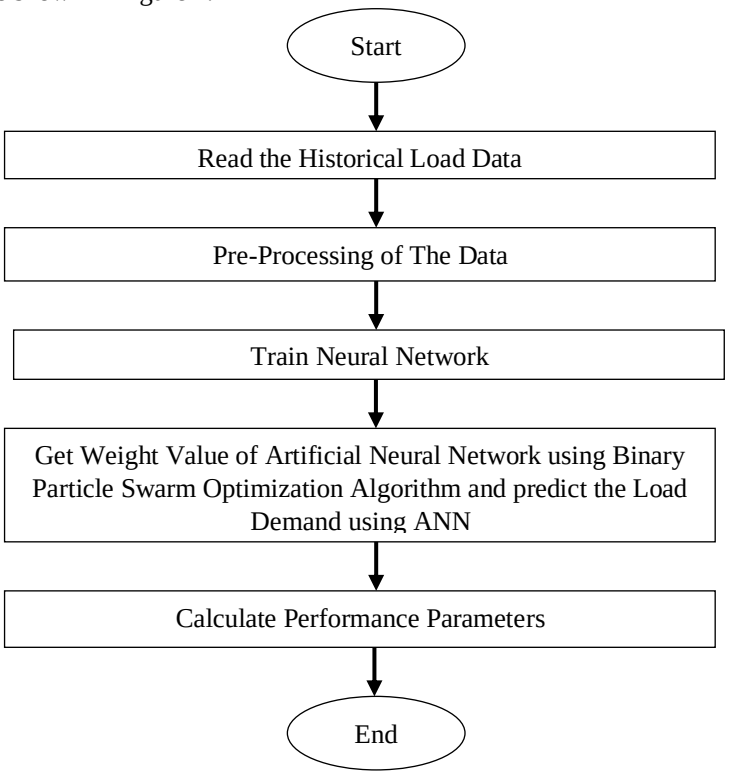

Fig. 1: Flowchart of the Proposed Algorithm for Load Forecasting

Next, the proposed methodology is explained for the proposed algorithm.

- In first step, we read excel file in MATLAB to access the historically data of load to train the classifier for forecasting of load.
- In the second step, of pre-processing data to extract meaningful information for create training and testing data for neural network.
- In third step, initialize the neural network for training with historical load data to forecast the short-term load.
- In the fourth step, training get weight values of ANN to improve the prediction efficiency of ANN. In this section update weight values of ANN with binary particle swarm optimization algorithm.
- In the last step, calculate performance parameter of proposed system like Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE), maximum and minimum error etc.

4. EXPERIMENTAL RESULTS

The experimental results were performed for the proposed algorithm is shown in this section. The standard dataset was downloaded [15]. The dataset contains 24 hours power consumption along with weather, minimum and maximum temperature, and holiday details. To analysis the execution of a forecasting method, forecasting error is analysed. The lower value of the forecasting error makes the higher the execution of this method. The error is the difference between the correct values with the hypothesis value. There are various error that are supposed for computing the forecasting error and contrast with already used methods [16].

Root Mean Square Error (RMSE): The RMSE displays the normal variance of the sample between the predicted and observed current values. The low value represents the minimum variance between predicted and observed values that gives higher accuracy. It is calculated using Eq. (1).

$$RMSE = \sqrt{MSE} \qquad (1)$$

Whereas, MSE denotes the mean square error and it is calculated using Equation (2).

$$MSE = \frac{1}{n}\sum_{t=1}^{n} e_t^2 \qquad (2)$$

Whereas, e_t is the residual at some time t, n is the total number of the period. Table 1 shows the comparative analysis of RMSE value with the existing algorithm. The results show that the proposed algorithm provides lesser RMSE as compared to the existing algorithms.

Table 1: Comparative Analysis based on the RMSE with the Existing Algorithms [15]

Model	PSO-ENN	ENN	GRNN	Proposed Algorithm
RMSE	0.1951	0.2636	0.4328	0.1808

Mean Absolute Percentage Error (MAPE): MAPE is used to find out the prediction accuracy. The lower value represents the better prediction accuracy. It is calculated using Eq. (3).

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} \frac{|e_t|}{y_t} 100\% \qquad (3)$$

Where, y_t is the actual value at some time t; n is the total number of the period, e_t is the residual at the time t.

Table 2: Comparative Analysis based on the MAPE with the Existing Algorithms [15]

Model	PSO-ENN	ENN	GRNN	Proposed Algorithm
MAPE	1.1708%	1.6171%	2.7157%	0.95%

Table 2 shows the comparative analysis of MAPE value with the existing algorithm. The results show that the proposed algorithm provides lesser MAPE as compared to the existing algorithms.

Maximum Error: This parameter measures the maximum error generated between input and output data. It is measured in MWh. Table 3 shows the comparative analysis of maximum error value with the existing algorithm. The results show that the proposed algorithm provides lesser error as compared to the existing algorithms.

Table 3: Comparative Analysis based on the Maximum Error with the Existing Algorithms [15]

Model	PSO-ENN	ENN	GRNN	Proposed Algorithm
MaxError (MWh)	16.3622	17.6066	26.7637	15.6500

Minimum Error: This parameter measures the minimum error generated between input and output data. It is measured in MWh. Table 4 shows the comparative analysis of minimum error value with the existing algorithm. The results show that the proposed algorithm provides lesser error as compared to the existing algorithms.

Table 4: Comparative Analysis based on the Minimum Error with the Existing Algorithms [15]

Model	PSO-ENN	ENN	GRNN	Proposed Algorithm
MinError (MWh)	2.3032	1.3180	5.4496	1.6500

5. CONCLUSION

An electric load forecasting means the load forecasting that time units are the hour, day, month, or years. In this paper, initially, load forecasting overview and its popular algorithms studied. Based on the study, found that Artificial Neural Network (ANN) is the most preferred algorithm and hybrid with the other algorithms in order to enhance the prediction. In this paper, we have hybrid the ANN and Binary Particle Swarm Optimization (BPSO) Algorithm are hybrid. The BPSO algorithm enhance the learning layer of ANN algorithm. The experimental results performance on the standard dataset and various error metrics are measured. The results show that the proposed algorithm provides better results as compared to the existing PSO-ENN, ENN, and GRNN algorithm [15].

6. REFERENCES

[1] S. Ruzic, A. Vuckovic, and N. Nikolic. Weather sensitive method for short term load forecasting in electric power utility of Serbia, IEEE Trans. Power System; 2003.vol. 18, no. 4, p. 1581-1586.
[2] C. Ying, et al., Short-Term Load Forecasting: Similar Day-Based Wavelet Neural Networks, IEEE Trans. Power System; 2010.vol. 25, p. 322- 330.
[3] S. J. Huang and K. R. Shih. Short-term load forecasting via ARMA model identification, including non-Gaussian process considerations, IEEE Trans. Power Syst; 2003.vol. 18, no. 2, p. 673-679.
[4] A. Khosravi, et al., Construction of Optimal Prediction Intervals for Load Forecasting Problems, Power Systems, IEEE Transactions on; 2010. vol. 25, p. 1496-1503
[5] S.Rahman and O. Hazim. A generalized knowledge-based short-term Load-forecasting technique, IEEE Trans. Power Syst.; 1993. vol. 8, no. 2, p. 508-514.
[6] J. W. Taylor and R.Buizza. Neural network load forecasting with weather ensemble predictions, IEEE Trans.Power Syst.; 2002. vol. 17, no.3, p. 626-632.
[7] Sudhansu Kumar Mishra,Ganapati Panda, SukadevMeher "Chebyshev Functional Link Artificial Neural Networks for Denoising of Image Corrupted by Salt and Pepper Noise" International Journal of Recent Trends in Engineering,Academy publisher, Finland, ISSN: 1797-9617. Vol. 1, No. 1, pp 413-417, June 2009.
[8] T. W. S. Chow and C. T. Leung. Neural networks based short-term Load forecasting using weather compensation, IEEE Trans. Power Syst.; Nov. 1996. vol. II, no. 4, p. 1736-1742,.
[9] W. L. Gorr, Research prospective on neural network forecasting, Int. J. Forecast; 1994. vol. 10, p. 1–4
[10] T. Hill, L. Marquez, M. O'Connor and W. Remus. Artificial neural network models for forecasting and decision making, Int. J. Forecast; 1994.vol. 10, p. 5–15
[11] G. Zhang, B. E. Patuwo and M.Y. Hu. Forecasting with artificial neural networks: The state of the art, Int. J. Forecast.; 1998. vol. 14, p. 35– 62.
[12] Zou, J., Han, Y., & So, S. S. (2008). Overview of artificial neural networks. In *Artificial Neural Networks* (pp. 14-22). Humana Press.
[13] Hannan MA, Abdolrasol MG, Faisal M, Ker PJ, Begum RA, Hussain A. Binary particle swarm optimization for scheduling MG integrated virtual power plant toward energy saving. IEEE Access. 2019 Aug 5;7:107937-51.
[14] Mathur YP, Kumar R, Pawde A. A binary particle swarm optimisation for generating optimal schedule of lateral canals. The IES Journal Part A: Civil & Structural Engineering. 2010 May 1;3(2):111-8.
[15] Xie K, Yi H, Hu G, Li L, Fan Z. Short-term power load forecasting based on Elman neural network with particle swarm optimization. Neurocomputing. 2020 Nov 27;416:136-42.
[16] Maralloo MN, Koushki AR, Lucas C, Kalhor A. Long term electrical load forecasting via a neurofuzzy model. In2009 14th International CSI Computer Conference 2009 Oct 20 (pp. 35-40). IEEE.

