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Optimal load forecasting by hybrid the artificial neural network and firefly algorithm

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ABSTRACT

In the smart grid, load forecasting algorithms used for estimating the electricity demand based on the historical data. It helps in generating the accurate electricity and overcoming the two challenges such as shortage of electricity and excess generation cost. In the literature, various traditional load forecasting algorithms proposed for predict the electricity demand but never the accurate results. Therefore, advanced algorithms come in the picture such as artificial intelligence algorithms. In this paper, we have hybrid the Artificial Neural Network (ANN) and firefly algorithm for load prediction. Initially, the ANN algorithm is trained based on the historical data then applied on it. After that, firefly algorithm is used for searching the optimal learning rate for ANN. The experimental results are performed in the MATLAB 2015a. We have measured various performance analysis parameters and compared with the existing results. From the study, we found that the proposed algorithm gives better accuracy as compared to the existing algorithms.

Keywords: *Load Forecasting, Artificial Neural Network, Firefly Algorithm*

1. INTRODUCTION

Load forecasting is a potential prediction of load that plays a key part in control systems related to energy and improved power system planning. Due to its effect on the efficient functioning of power systems and the economy, a significant amount of studies on effective Short Term Load Forecasting (STLF) have been released during last years. It guarantees that the power source is stable and allows the customer to obtain uninterrupted power [1]. The service of power systems can be carried out conveniently by detailed forecast of load, for instance maintenance, scheduling, modification of contract evaluation and tariff rates [2]. Decisions on energy policies may be made on the basis of detailed load forecasts. Several control system decision making can be taken based on detailed load forecasts including activity of the power supply, repair, and planning [3].

Efficient power system planning will save thousands of dollars, and plays a crucial part in a country's economic development. The weather variables have a strong effect on the market for a load like relative humidity, temperature, dew point, wind velocity, dry bulb temp, human body index, and cloud cover. The numerous load used up by citizens often impacts load forecasting considerably. However, all variables that influence the demand of load, such as historical load, respective weather details, and forecast model inputs, need to be optimized for higher forecast performance. A detailed load prediction plays a essential role in the application of the idea of intelligent grids and intelligent structures in this new age of technology [4].

Load forecasts was categorised by the majority of researchers into three groups, although some categorised them into four groups [5]. The load forecast will usually be separated into three distinct groups by time.

- Load forecast based on Long-term (1 year to 10 years ahead)
- Load forecast based on Medium-term (1 month to 1 year ahead)
- Load forecast based on short-term (1 h to 1 day or 1 week ahead).

For long-term energy policy preparation, the potential electricity requirement and energy strategy is the long-term forecast of load. For successful maintenance and support of the power grid, a medium-term load forecast is used. Literature reveals that the emphasis is primarily on forecasting (short-term) for loads in previous years. The significance of short term load forecasting is also critical in ensuring maximum contribution to the unit, management of the spinning reserve and the evaluation of contracts between sales and purchases by different firms.

In this paper, we have designed a load forecasting algorithm by hybrid the artificial neural network and firefly algorithm. The estimation of short-term power usage has a significant effect on the efficiency of the whole electrical grid. The product of

forecasting power load is still a position of study. We have also recommended merging the neural artificial network with the firefly algorithm. First of all, we implement an ANN and firefly algorithm and evaluate network output with ANN parameters respectively. Afterwards the firefly optimization algorithm is used to aim for the optimum ANN learning rate. For the supply of short-range power fee, which can be overcome by ANN, the suggested approach is used.

The next section 2 shows the related work that is done in the arena of load forecasting. Section 3 shows the suggested algorithm. Section 4 illustrates the investigational results for the proposed algorithm. Conclusion is drawn in Section 5.

2. LITERATURE REVIEW

Since its emergence, various studies have been performed on load forecasting. Various classifications are suggested in literature over a given time depending on the length of the forecasting and prediction processes. The load forecasting techniques are classified in three key categories according to the different styles of studies discussed past researches [6-7]:

2.1 Traditional methodology for forecasting

In traditional methods of load forecasting, the method of Regression and Exponential smoothing is normally used. these are described below:

a) Method of Regression: It is the most popular and simple to apply statistical strategies. Regression models are typically used to model the consumption of load relation and additional variables like temperature, day categories and segments of customer. This strategy suggests that the load may be split into a normal load pattern and a pattern that is linearly depending on some load conditions. The mathematical model of regression can be written as:

$$L(t) = Ln(t) + \sum a_i x_i(t) + e(t)$$

In the above equation, Ln(t) describes the standard or normal load at any time t. a_i represents the calculated coefficients that vary slowly. $x_i(t)$ represents the influencing factors that are independent like the effect of weather, e(t) shows the component of white noise and n represents the number of samples.

b) Exponential Smoothing: This technique is also used for load forecasting. In this technique, first the previous/past data is used to prepare a load forecast model and then this model is used to predict the load for future demands. The method of Winter's is one of the traditional exponential smoothing method that has the capacity to examine the time series of seasonal data directly. This method is normally based on three constants of smoothing that are seasonality, stationary, and trend.

2.2 Modified traditional technique and

The conventional prediction models have been improved so that in evolving environmental circumstances they will immediately correct the previous model's parameters. These techniques are:

a) **Adaptive Demand Forecasting:** The model parameters for demand forecasting are automatically corrected to track evolving charging conditions. This implies that demand forecasts are variable in nature and can therefore be used in the service system as an online software kit. Using present forecast errors and established weather data processing programmes, the next vector is predicted. Complete historical data collection review shall evaluate the State vector. In that mode, it is possible to switch between multiple analyses and adaptive regression.

b) **Stochastic Time Series:** One of the most common methods for STLF appears to be the Time Series process. Time series approaches are expected to have an intrinsic framework including autocorrelation, pattern or seasonal variance. In the time Series methodologies, the first impetus of the process is the precise compilation of the available data to follow the trend and then the predicted time value utilising the defined model.

2.3 Soft computing technology

It is a reality that each structure is ubiquitous, unpredictable, and challenging to model. A scalable methodology called the soft technique has been built in the research scenario to solve these models efficiently and efficiently. In recent decades it has been commonly used.

a) ANN Algorithm: A highly linked sequence of elementary processors, called neurons, can be classified as artificial neural networks that can be represented as a complete description. Its structure is similar to the human brain, which is linked in an extremely dynamic nonlinear and extremely massively parallel network by huge numbers of neurons. A multi-layer perceptron is an artificial neural network with input neurons, one or even more secret layers and one output layer. The layers each comprise of multiple neurons, and the adjacent weight layer is bound to each neuron. The ANN network can be trained by reducing the function of cost [10].

b) Firefly Algorithm: This algorithm is an evolutionary technique of optimization that is based on the behaviour of fireflies and its random population. This algorithm considers three basic assumptions to work on the problem. First is that all the fireflies are unisex due to which they can be attracted with each other. Second is the brighter firefly attract the firefly has is less bright. Third is if there are no remaining firefly in the search space that is brighter than other firefly then that firefly is in motion randomly in the search space [8].

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.

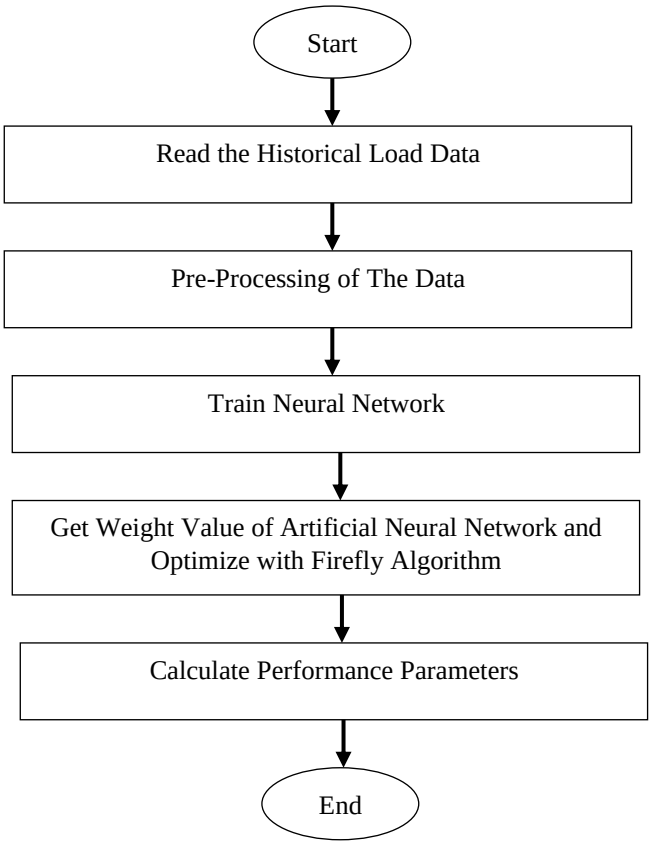

Fig. 1: Flowchart of the Proposed Algorithm for Load Forecasting

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 firefly optimization algorithm.
- In the last step, calculate performance parameter of proposed system like accuracy, Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE), etc.

4. EXPERIMENTAL RESULTS

In this section, the experimental results are shown for the proposed algorithm. The algorithm is written and simulated in MATLAB. Further, we have calculated the various parameters, as explained below [9].

- **RMSE - Root Mean Square Error:** The RMSE displays the normal sample variance between the values expected and current values observed. The lesser the RMSE value the greater is the accuracy of the prediction. 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, n represents the total number of the period; e_t represents the residual at some time t;

- **MAPE - Mean Absolute Percentage Error:** As it tests relative efficiency, it is the most effective way to evaluate predictions for numerous things or goods. It is an accuracy measure widely used in quantitative prediction methods [ref]. If MAPE's value measured is below 10%, it is regarded as an outstanding specific projection, decent provision of 10–20%, good predictions of 20–50%, and bad predictions of over 50%. It is calculated using Eq. (3).
-

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

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

- **Maximum Error:** It measures the maximum error generated between the predicted load and historical data.

- **Minimum Error:** This parameter measures the minimum error generated between the predicted load and historical data.
- **Accuracy:** Accuracy is one of the most sensitive and vital measures of system performance and it is defined as a ratio of observations that are predicted correctly to the sum of total observations.

4.1 Comparative Analysis

The proposed algorithm is contrasted with the current algorithms in this section. The findings indicate that stronger results are achieved in the suggested algorithm than the existing techniques [10].

Table 4.1 Comparative Analysis with the Existing Algorithms [10]

Model	PSO-ANN	ANN	GRNN	BPNN	Proposed Algorithm
RMSE	0.1951	0.2636	0.4328	0.5445	0.1195
MAPE	1.1708 %	1.6171 %	2.7157 %	2.7297 %	0.6358 %
MaxError(MWh)	16.3622	17.6066	76.7637	60.0381	14.4535
MinError(MWh)	2.3032	1.3180	5.4496	1.0479	1.5285

Next, we have compared the accuracy of ANN algorithm with the proposed algorithm and found that the proposed algorithm gives 6% better accuracy.

Table 4.2 Comparative Analysis with the Existing ANN Algorithm in terms of Accuracy

S no.	Technique	Accuracy (%)	Improvement (%)
1	ANN	77.96	--
2	FA-ANN	83.05	6 %

5. CONCLUSION

In this paper, forecasting of load is done by hybrid the two algorithms known as Artificial Neural Network and firefly algorithm. The ANN network is trained based on the historical data and firefly algorithm is used for searching the optimal learning rate for it. Next, we have measured various performance parameters for it and found that the proposed algorithm gives less RMSE, MAPE, maximum error, and minimum error as compared to the existing algorithms. In the last, we have compared the accuracy of proposed algorithm with the ANN algorithm and found that the proposed algorithm gives better accuracy.

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