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Procedia Computer Science 48 (2015) 121 – 125

Procedia Computer Science

International Conference on Intelligent Computing, Communication & Convergence

(ICCC-2015)

Conference Organized by Interscience Institute of Management and Technology,

Bhubaneswar, Odisha, India

A Review of Short Term Load Forecasting using Artificial Neural Network Models

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Abstract

The electrical short term load forecasting has been emerged as one of the most essential field of research for efficient and reliable operation of power system in last few decades. It plays very significant role in the field of scheduling, contingency analysis, load flow analysis, planning and maintenance of power system. This paper addresses a review on recently published research work on different variants of artificial neural network in the field of short term load forecasting. In particular, the hybrid networks which is a combination of neural network with stochastic learning techniques such as genetic algorithm(GA), particle swarm optimization (PSO) etc. which has been successfully applied for short term load forecasting (STLF) is discussed thoroughly.

Peer-review under responsibility of scientific committee of International Conference on Computer, Communication and Convergence (ICCC 2015)

Keywords: Short term load forecasting (STLF), Artificial Neural Network (ANN), Particle Swarm Optimization (PSO),Back Propagation algorithm(BP),Genetic Algorithm

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Peer-review under responsibility of scientific committee of International Conference on Computer, Communication and Convergence (ICCC 2015)
doi:10.1016/j.procs.2015.04.160

1. Introduction

In order to supply electric energy to the customer in a secure and economic manner, an electric company faces many economical and technical challenges in operation. Among these challenges scheduling, load flow analysis, planning and control of electric energy system are most prominent. Load Forecasting is also one of the most emerging field of research for this important and challenging field in last few years. Load forecasting may be defined as the measure of exactness of the difference between the actual and predicted value of future load demand. Forecasting of electricity demand will help in optimizing the start up cost of generating units, and can also able to save the investment in the construction of required number of power facilities. It can also help to check the risky operation, fluctuating demand, demand of spinning reserve and vulnerability to failures. Load forecasting provides the most important information for power delivery and planning. It also plays an important role in energy management system.

Power system scheduling, load flow analysis, day to day operation and efficiency are some of very interesting field that can be explored by load forecasting [1]. The estimation of load demand is very significant as it will help the production and distribution of electric power. By under-estimating the load demand, it has a negative consequence on demand response and hence on power installation. Also, this under-estimation of load results difficulty to manage the overload conditions. Similarly, the over-estimation affects the installation and hence the efficiency of system [2]. For the purpose of load forecasting, several techniques have already been applied during the last few decades [1- 6].

Broadly, the load forecasting techniques can be divided into two categories such as parametric or non parametric techniques. The linear regression, auto regressive moving average (ARMA), general exponential technique and stochastic time series techniques are some examples of parametric (statistical) technique. The main drawback of this technique is its capability in abrupt change of any types of environment or social changes. However, this shortcoming is overcome by applying non- parametric (artificial intelligence) based technique because of its potentiality to global search. Among these artificial intelligence based methodology, artificial neural network has emerged as one of the most prominent technique that receive much more attention of researchers. The ability to solve the complex relationships, adaptive control, image denoising, decision making under uncertainty and prediction patterns makes ANN a powerful performer than previously implemented techniques [7-11]. Hence, several variants of ANN which is generally hybridization of neural network with some learning techniques such as GA, PS0, BFO etc are proposed by several researchers. Similarly, ANN in hybridization with fuzzy logic, AIS (Artificial Immune System), LMA (Levenberg Marquardt Algorithm) etc have also shown improved performance in terms of accuracy, computational cost and time requirement. In sec 2, a brief discussion on ANN has been done. In section 3, different variants of ANN, that includes the conventional and hybrid neural network techniques that have successfully applied to STLF is described. Finally, the conclusion of the present review work has been presented in section 4.

2. A Brief Introduction to Artificial Neural Network (ANN) for STFT.

ANN can be defined as a highly connected array of elementary processors called neurons and a complete description of it may be found in [12], [13]. It resembles its origin from human brain that has large number of neurons interconnected in a highly complex, non linear and forming highly massive parallel network. A artificial neural network (ANN) with input layer, one or more hidden layer and one output layer is known as multilayer perceptron (MLP). Each layer consists of several neurons and each neuron in a layer is connected to adjacent layer with some weights known as synaptic weights. The training of the neural network is done by minimizing the cost function, usually a quadratic function of output error. A network having no hidden layer is called as SLNN (Single Layer Neural Network). The least mean squares (LMS) and back propagation (BP) algorithm are generally applied to train single layer and multilayer neural network respectively. It has been successfully applied to many emerging field such as control, image, videos etc[7-13].

3. Related work

Hybridization of different techniques with ANN that has been successfully applied to short term load forecasting is described in this section.

3.1 ANN with Back Propagation (BP) Algorithm

From the previous research work published, a back propagation algorithm has always been considered as the conventional training of neural network for load forecasting problems. Yu-Jun He et al. have used similarity degree parameter to identify the appropriate historical load data as training set of neural network [14]. A neural network with back propagation momentum training algorithm was also proposed in the aforementioned paper for load forecasting in order to reduce training time and to improve convergence speed. M.B. Abdul Hamid and T.K. Abdul Rahman presented an Artificial Neural Network (ANN) trained by the Artificial Immune System (AIS) learning algorithm for short term load forecasting model [15]. This algorithm has specific benefits such as accuracy, speed of convergence, economic and historical data requirement for training etc. The major benefit of this algorithm over back propagation algorithm is in terms of improvement in mean average percentage error (MAPE).

3.2 *ANN with Fuzzy Logic*

To classify a large input data set, for the prediction of load demand, a fuzzy logic load forecasting model ANN is generally developed. Kuihe Yang et al. have proposed a method to simplify system structure and enhance forecasting precision [16]. Lingling Zhao et al. showed that if the membership functions are constructed on the characteristics of short term load and if the modification of load heft is realized, the load forecasting result can be enhanced up to a certain extent [17]. Jain, A. et al. presented a forecasting method based on similar day approach [18]. In the aforementioned paper, the effect of temperature and humidity with weight factors for the selection of similar days was taken into account. Khosravi et al. proposed the application of Interval Type-2 Fuzzy Logic Systems (IT2 FLSs) for STLF [19]. IT2 FLSs, with extra degrees of freedom, are proved to be an excellent tool for handling different spurious uncertainties and for improving the prediction accuracy.

3.3 *ANN with Genetic Algorithm (GA*)

The genetic algorithm is a heuristic search technique, that is widely used to find the optimal solution. While the GA is hybridized with ANN, it is used to globally optimize the number of input neurons and the number of neurons in the hidden layer of the neural network architecture. Genetic algorithms (GAs), that solve optimization problems using the method of evolution and survival of the fittest, also optimizes the weights between neurons of ANN. Chaturvedi et al. have also demonstrated how to train the artificial neural network using improved Genetic algorithm [20]. The genetic algorithm with the combination of some other such as PSO,fuzzy logic etc. to reduce the error in the prediction of load demand [21-23].

3.3 *ANN with Particle Swarm Optimization (PSO*)

Particle swarm optimization is a population based derivative free algorithm developed by Kennedy and Eberhart in 1995 [24]. This stochastic search based algorithm is successfully applied to some real time optimization problem in different emerging fields [25, 26]. Tian Shu et al. have developed a new training method of radial basis function (RBF) neural network, based on quantum behaved PSO [27]. Ning Lu et.al have proposed the PSO based RBF neural network model for load forecasting [28]. Yang Shang Dong et al. proposed a new PSO algorithm with adaptive inertia weight factor and incorporated Chaos with PSO [29]. They showed that the proposed PSO enhances the searching efficiency and greatly improves the searching quality for efficient load forecasting.

4. Conclusion

In this paper, we have presented the recent published work on different hybrid neural networks that has been successfully applied to short term load forecasting. From the work reported by different researchers, it can be concluded that the artificial intelligence based forecasting algorithms are proved to be potential techniques for this challenging job of non linear time series prediction. Different random search techniques such as GA, PSO, BFO,

AIS which are capable of global learning capabilities had also been highlighted in combination with ANN for this challenging and interesting problem. The discussed techniques show their ability in forecasting of electrical load which ultimately reduced the operational cost of power system and increases the efficiency of operation.

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