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Short Term Load Forecasting Using Optimized Neural Network with Harmony Search

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Abstract

This paper presents a neural network based short term load forecasting (STLF) method for Iran national power system (INPS) and its regions. In order to optimized our neural network we used harmony search(HS) that creates the structure of the network based on the inputs. So finding the architecture of network simplified. We used and tested this method for STLF, results show that it can be used instead of common neural networks and has their capability. This method creates a three layers network that the first layer is the input, second layer is main layer and the last layer is for output. In training phase, we used percepteron neural network that is famous for its prediction ability. The short term load forecasting simulator developed so far presents satisfactory and better results for one hour up to a week prediction of INPS loads and region of INPS.

Keywords: Load Forecasting; Neural Network; Harmony Search

1. Introduction

In power system operation, quick and accurate forecasting is so essential. Moreover, it is very important for economic dispatch, hydro-thermal coordination, unit commitment, transaction evaluation, and system security analysis among other functions. These predictions have most benefit for Market operator, transmission owners and generation plants that continuously demand for a more reliable and more robust Short Term Load Forecasting (STLF) technique.

In recent years there has been a growing interest in the study of STLF because of its importance. Many researchers have been proposed diverse techniques to obtain more accurate results. In literatures, statistical methods such as auto-regression and time series have been used broadly for STLF. A lot of models that are based of classical techniques were designed during last decades, such as Box-Jenkins models, ARIMA models, Kalman filtering models, and the spectral expansion techniques-based models. These techniques use complicated mathematical operations for load forecasting and because of that they have a very important defect. Also, Time-consuming for load forecasting, intrinsic inaccuracy and numerical instability are their deficiencies.

In recent years, researchers have been used intelligent techniques for solving engineering problems. Artificial neural network and fuzzy systems are two examples of intelligent algorithms that can be applied approximately in every prediction and modeling problem. It is clear that they have capability of modeling nonlinear systems. Considering this capability, some researchers have created ANN-based short term load forecaster. Contemporary load forecasting techniques, such as Artificial Neural Networks (ANN) [1][1], [3], [4], [5], [6], wavelets [7], have been improved recently, indicating better results than traditional methods.
In computer science and operations research, harmony search (HS) is a phenomenon-mimicking algorithm (also known as metaheuristic algorithm, soft computing algorithm or evolutionary algorithm) inspired by the improvisation process of musicians proposed by Zong Woo Geem in 2001[8].

In this paper we used a special type of Neural networks that has been optimized by harmony search for STLF problem. This network creates its architecture by using the training data automatically as we describe in section 3.

The organization of this paper is as follow. Section 2 outlines the load characteristic. Section 3 derives STLF technique by harmony search optimized neural networks. Section 4 delivers different simulation examples of forecasted loads. Finally, section 5 includes some conclusions and further researches.

2. Input Selection

Selection of proper and optimal number of inputs would result a higher accuracy and convergence speed in neural networks. Most of load forecasting methods use weather information, load power of the days before forecast day, month day and day for input variables. Day type is justified by correlation analysis on the historical load information.

By correlation analysis the load shapes of INPS, and its regions a week is divided into 4 groups: Saturdays (first day of the week), Sundays to Wednesdays (workdays), Thursdays and Fridays (weekends). For each group, most effective lags (load of the previous hours) on hourly load were selected by correlation analysis [9]. Table 1 shows the selected lags for each weekly group. For example first row in table 1 says that for Group “Saturdays” loads of one hour, two hours, and finally 169 hours earlier are used to predict the future load.

Temperature is the most effective weather information on hourly load. In this work, temperature of three cities, representing hot, moderate and cold cities of the region of interest constitute a part of the Neuro-Fuzzy input vector. Instead of using temperatures of all cities in Iran, temperatures of Tabriz, Tehran and Ahvaz were selected, by correlation analysis, as representatives of hot, moderate and cold region temperatures, respectively [9]. The number of month is the last input used.

Table 1: SELECTED LOAD LAGS FOR WEEKLY GROUPS

Weekly Group	Selected Load Lags
Saturdays	1, 2, 3, 23, 24, 25, 167, 168, 169
Workdays	1, 2, 3, 23, 24, 25, 47, 48, 49, 147, 148, 149, 167,168, 169
Thursdays	1, 2, 3, 23, 24, 25, 47, 48, 49, 167, 168, 169
Fridays	1, 2, 3, 23, 24, 25, 167, 168, 169, 191, 192, 193, 335, 336, 337

3. Introducing Harmony Search

Introducing back propagation rule in multilayer perceptron neural networks, able researchers to use different kinds of these networks for their purpose. One of the applications of these networks is controlling of different systems by estimating the model of system. However the most important problem of these networks is determining the number of hidden layers, number of neurons in each layer and transfer functions of different layers. Selecting too much neurons and hidden layers for the network, complicates the network structure and also cause the training algorithm to fall in local optimums easily. On the other hand selecting less than needed neurons and hidden layers prevents the training algorithm from being converged.

Harmony Search (HS) is a search heuristic based on the improvisation process of jazz musicians [8]. In jazz music the different musicians try to adjust their pitches, such that the overall harmonies are optimized due to aesthetic objectives. Starting with some harmonies, they attempt to achieve better harmonies by improvisation. This analogy can be used to derive search heuristics, which can be used to optimize a given objective function instead of harmonies. Here the musicians are identified with the decision variables and the harmonies correspond to solutions. Like jazz musicians create new harmonies by improvisation, the HS algorithm creates iteratively new solutions based on past solutions and on random modifications. While this framework leaves a lot of space for interpretation, the basic HS algorithm is always described in the literature in the following way.

A multilayer perceptron structure commonly known as multi-layered feed-forward net is used for simulator. The building block of the developed system is a three-layered perceptron. This network consists of one input layer, one hidden layer and one output layer. For each weekly group, an MLP has been considered separately, the model shown in Fig. 1. Input layer for hourly load forecast of each weekly group, Saturdays, workdays, Thursdays and Fridays, has 13, 19, 16 and 19 neurons respectively (consisting of previous loads and 3 representatives’ forecasted temperatures 1 neuron to indicate month). Hidden layers has 5 and 10 neuron, which had most satisfactory results. Based on HS hidden layers has 5 and 10 neuron, which had most satisfactory results. Output layer has 1 neuron (the load of the forecasted hour).

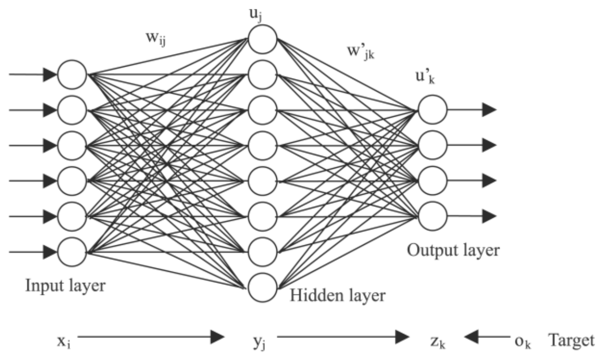

Figure 1. Multi-layered perceptron consists of one input layer, one hidden layer and one output layer

4. Performance

According to Iran Electricity Market Rules, we used three cities Ahvaz, Tabriz and Tehran which have hot, cold and moderate weather respectively. Also, we categorized the first six months of each year in hot months group and the rest in cold months group. From view point of consumed load, daily hours in hot months are considered as follow: 5-8 low load hours, 8-20 ordinary load hours and 20-24 peak load hours. These classifications in cold months are as follow: 0-5 and 21-24 low load hours, 5-17 ordinary load hours and 17-21 peak load hours. According to the new Marketing Rules, forecasting errors for peak, ordinary and low hours should be smaller than 2%, 5% and 10% respectively. So, the designed program (load forecaster) for load forecasting should satisfy all of these goals.

To compare the actual load with forecasted load, we use mean absolute percentage error (MAPE). The MAPE is defined as follows:

$$MAPE(\%) = \frac{1}{N}\sum_{i=1}^{N}\frac{\left|P_A^i - P_F^i\right|}{P_A^i}\times 100 \qquad (1)$$

Where P_A is the actual load, P_F is the forecasted load, and N is the number of predicted hours.
For training the network we used loads for one year (March. 20, 2000 to March. 20, 2002), instead of using more data, as you know this reduces the quality of the neural network answers. But in some cases such as when the system grown very fast, there aren't enough historical data for system.

The performance of the proposed method has been depicted using some examples. Figure 2,3(a-c) shows load forecasting results and their errors for INPS from Aug. 11 to Aug.17, 2002 by compared method and proposed method. The corresponding errors are 3.2% and 1.6% respectively. Figure 4, 5(a-c) shows load forecasting results and their errors for INPS from May. 4 to May. 10, 2002 by compared method and proposed method. Their forecasting errors are 1.8% and 1.7%, respectively. It is clear that the performance of our proposed method is better that the old MLPs.

5. Conclusions

One of the most successful applications of MLP to real-world problems has been electrical load forecasting. In this paper, proposed method program developed for INPS and its region was presented, which is based on an optimized neural network with harmony search. The proposed method has fast convergence, due to assigning the network weights based on training data.

To improve the accuracy of the program for special conditions such as holidays' loads, time changing, and also for sudden load changes caused by weather front and etc. fuzzy expert systems and reshaping the load shapes by charging the peak load can address for future work.

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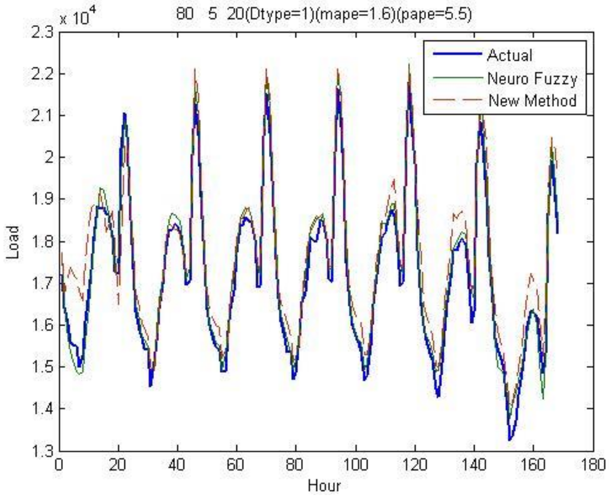

Figure 2. (a) Actual,, compared method(MAPE = 3.2) and new method(MAPE = 1.6) forecasted hourly loads of INPS from Aug. 11 to Aug.17, 2002.

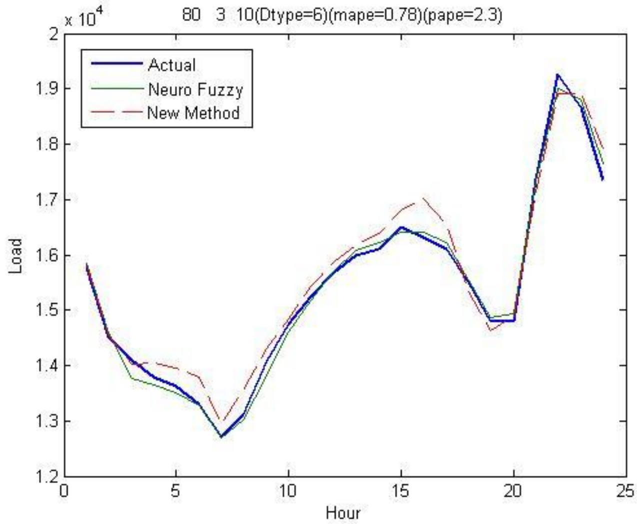

Figure 3. (a) Actual, compared method(MAPE = 1.7) and new method(MAPE = 0.78) forecasted hourly of INPS for May. 31, 2002.

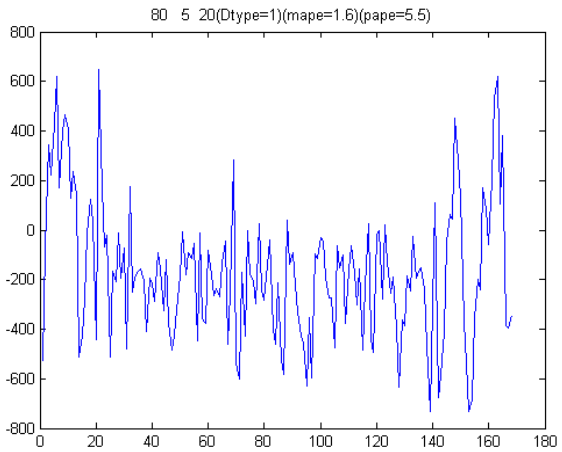

Figure 2. (b) Corresponding error of new method

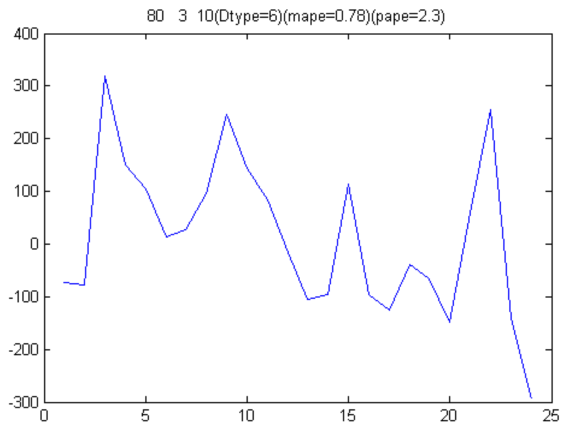

Figure 3. (b) Corresponding error of new method

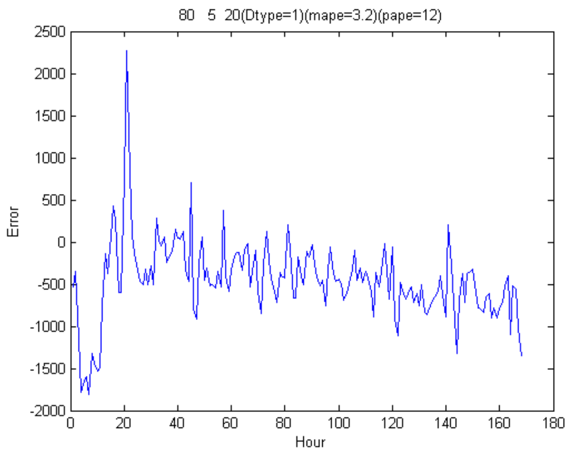

Figure 2. (c) Corresponding error of new method

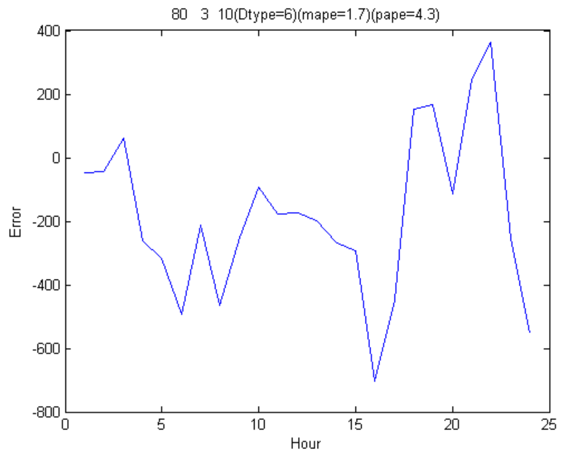

Figure 3. (c) Corresponding error of new method

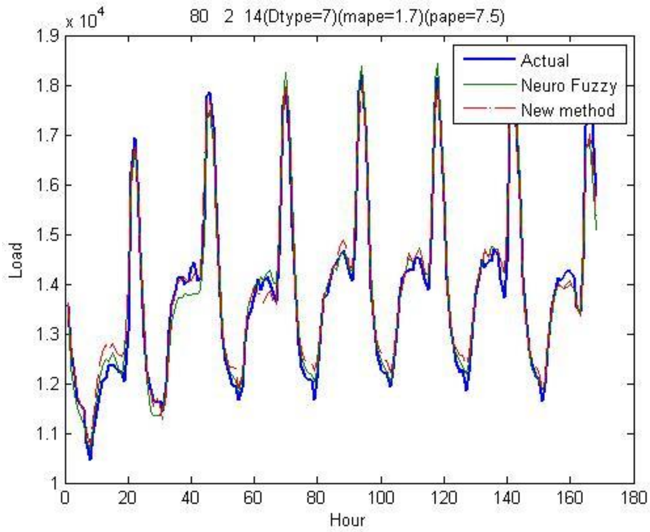

Figure 4. (a) Actual compared method(MAPE = 1.8) and new method(MAPE = 1.7) forecasted hourly loads of INPS from May. 4 to May. 10, 2001.

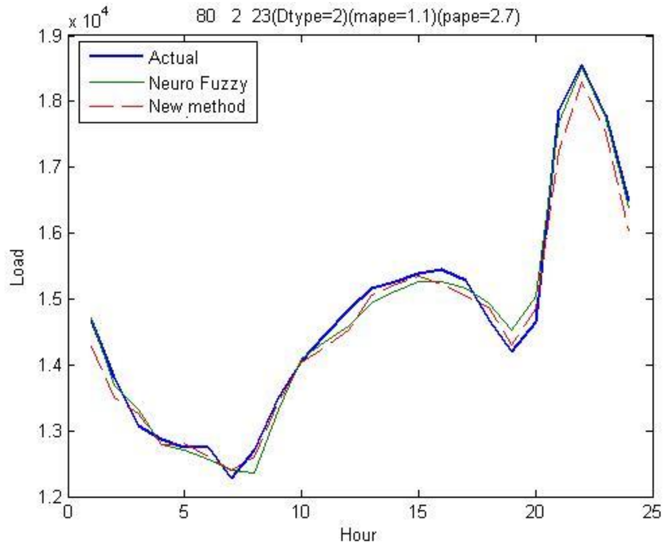

Figure 5 (a) Actual, compared method(MAPE = 1.3) and new method(MAPE = 1.1) forecasted hourly loads of INPS for May. 13, 2001.

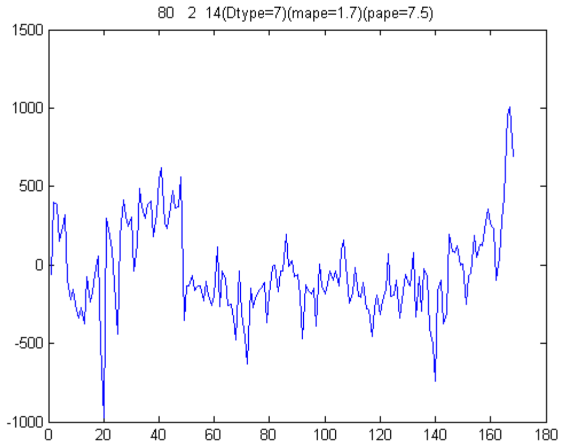

Figure 4. (b) Corresponding error of new method

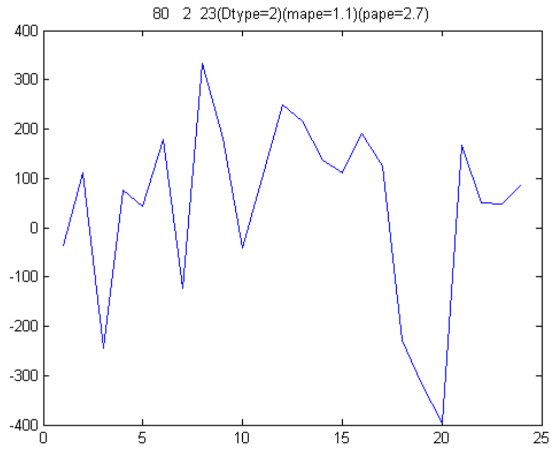

Figure 5. (b) Corresponding error of new method

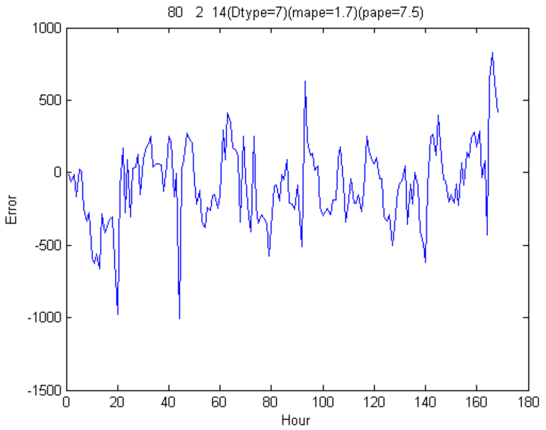

Figure 4. (c) Corresponding error of new method

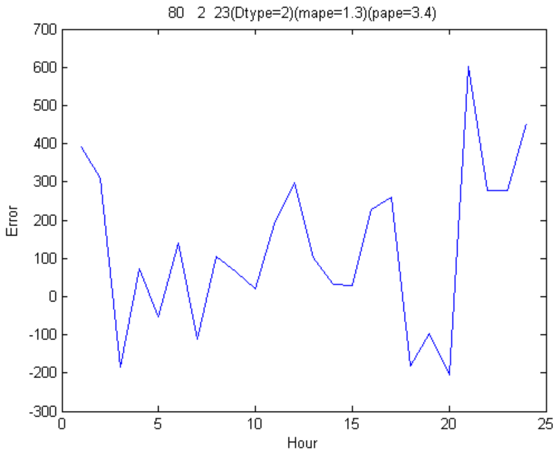

Figure 5. (c) Corresponding error of new method