APPLICATION OF ARTIFICIAL NEUTRAL NETWORKS FORTIME SERIES DALY ELECTRIC LOAD FORECAST PREDICTION IN MATLAB

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Abstract. *Daily electric load prediction is an important task for the companies that are involved with energy distribution. In this paper are presented results for energy load daily forecasting, when presenting the consumer power load as time series dataset. As predictor the Feedforward Error Backpropagation Neural Networks from the MATLAB Neural Networks Toolbox are used, when changing the resulting Neural Networks structure for best prediction accuracy. Also an comparison with forecasts based on mean average value of the power load data from the previous week with the prediction results when using Neural Networks is also presented.*

Keywords: *time series, electric load, neural networks, function approximation*

1. INTRODUCTION

The prediction of the consumed electric power in the electric power distribution systems is an important task. An essential element of electric utility resource planning is the successful short or long term forecast of the electrical consumption. It is so, because in order the delivery of electric energy to be efficient the operators from the distribution companies will need to know for instance, which are the nodes with higher expected instantaneous load, in which hours of the day are the peak network distribution loads, what is the quality of the supplied electrical energy, what are the effects from power savings and etc.

A definite prerequisite for development of an accurate forecast model is the understanding of the characteristics of the consumers that are going to be analysed. The knowledge about the load behavior can be learned from experience with usage of consumer data and statistical analysis of electrical consumption from the past. Usually electricity consumers are operating in a similar economic and climate environment, and usually we have similar consumer behavior and consumption forecast models developed for a consumer can usually be easily adapted for use with another consumer. Load that is supplied by a power distribution system has a dynamic development and reflects directly the activities and conditions in the environment.

In this paper is presented an approach for adequate forecast of electricity consumption. The forecast is done by usage of artificial neural networks (ANN) based on historical data for several transmission nodes in Bulgaria. It involves the development of several ANN designs and selection of the best network that can produce the best results in terms of its accuracy. Also, a comparison is presented between prediction using mean average of several preceding days and ANN method.

2. INTRODUCTION IN THE NEURAL NETWORK THEORY

The neural networks are parallel processing systems with the capability of storing experimental knowledge. Basically every neural network consists of simple information processing elements named neurons. Every neuron is interconnected with the others and the weights of these connections determine their strength. Every neuron input data is the weighted sum of the signals of the other neurons connected to it, while the neuron output is determined by a transfer function based on the weighted input sum value. The information in one neural network is accumulated in a training process, where the strength of the connections between the various nodes is modeled with weights on the according connections, which are used for information storage.

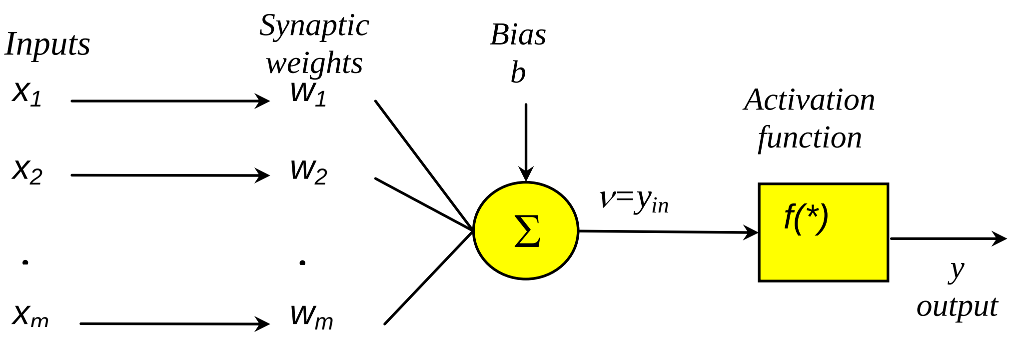


Fig. 1. Single neuron abstract mathematical model

Every neuron have many inputs and one output. Inputs *x1, x2,…,xm* are the signals coming to the neuron and can be external signals or other neuron outputs. Every input is connected with weight w_j, j=1,2,…,m, that models the strength of the transduced signal. The aggregated input signals are modeled with sum unit:

$$v = y_{in} = \sum_{j=1}^{m} w_j x_j + b \tag{1}$$

For convenience, constant signals are modeled with bias b. In most of the cases the activation function is nonlinear and the single neuron output is:

$$y = f(y_{in}) = f\left(\sum_{j=1}^{m} w_j x_j + b\right) \tag{2}$$

Neural networks can be realized in different structures, but the classical structure is with two layers of neurons Feedforward error backpropagation as shown on Fig. 2.

Neuron number in the input layer is determined by the input data dimensions, and the same is valid for the output layer.For this structure by a rule of thumb defined by Oja the optimal neuron number in the hidden layer can be determined. If with Z is denoted the hidden layer neuron number, with P number of samples in the training dataset, m is input numbers and n is the output layer dimension, then:

$$Z = \frac{P}{5(m+n)} \tag{3}$$

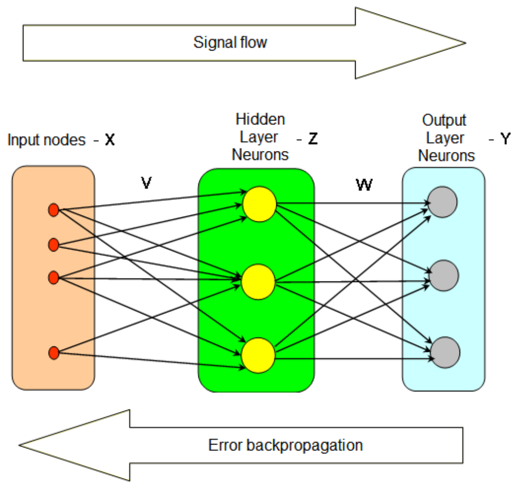


Fig. 2. Two layer Feedforward neural network architecture

3. SIMULATION MODELING AND RESULTS

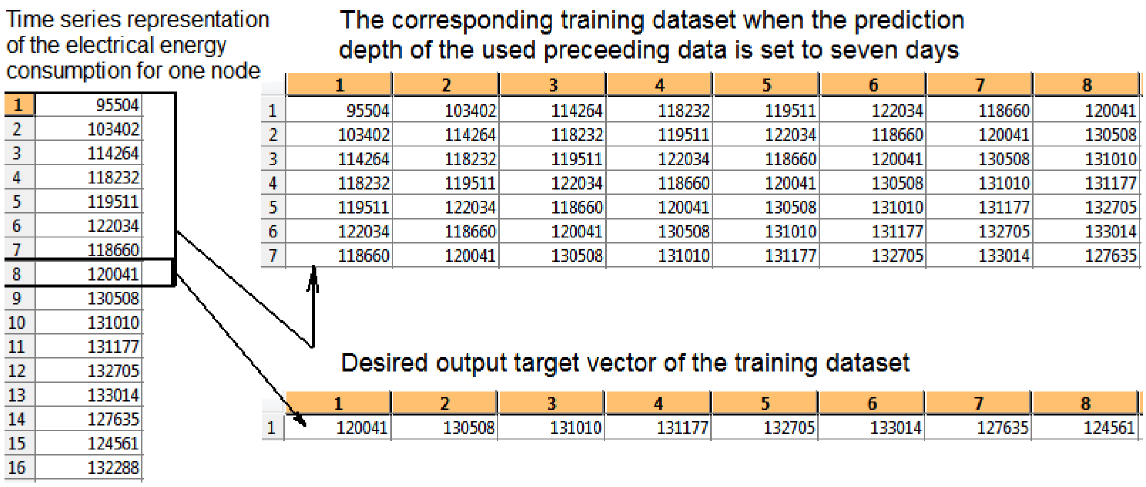
The forecasting results are based on data from preceding time intervals. For training the neural network we have the daily data of consumption in 24 high voltage nodes for year 2006 and the data from year 2007 is used for testing and validation. This data we have was in the for as shown on Table 1.

Table 1. Data from 24 high voltage nodes

Year	Month	Day	Node 1	Node 2	Node 3	Node 4	***	Node 22	Node 23	Node 24	P daily summed
2006	1	1	4293	4186	4026	3877	***	4301	4346	4335	29364
2006	1	2	4030	3823	3678	3571	***	4806	4809	4684	29401
2006	1	3	4307	4045	3897	3811	***	5017	5044	4868	30989
2006	1	4	4568	4319	4119	4024	***	5136	5229	4990	32385
2006	1	5	4625	4289	4128	4088	***	5248	5281	5045	32704
2006	1	6	4741	4412	4268	4183	***	5379	5389	5310	33682
2006	1	7	4872	4612	4445	4362	***	5107	5213	5147	33758
2006	1	8	4915	4614	4421	4282	***	5514	5631	5343	34720
2006	1	9	4936	4538	4494	4379	***	5609	5800	5512	35268
2006	1	10	5116	4775	4646	4589	***	5688	5806	5574	36194
2006	1	11	5139	4749	4652	4514	***	5801	5879	5593	36327

From this data that we have the training dataset is formed by packing every n number of days consecutive sequence as input sample and the next following sample as desired output. One example for the time series training dataset formation for forecast based on 7 preceding days and 8-th day used for desired output is shown on Fig. 3.

Generation of ANNs in MATLAB with the Neural Network Toolbox function newff for creation of multilayer feedforward networks was used. Then, after forming the training dataset a training is performed on the created structures. For the example when using prediction depth n=7 days for only next day forecast window, this results in 7 ANN inputs representing the preceding day 1, day 2, …, day 7 and one output neuron for day 8. The number of neurons in the hidden layer can be determined with (3), which in this particular case gives 9 neurons forming the hidden layer.



Time series representation of the electrical energy consumption for one node

1	95504
2	103402
3	114264
4	118232
5	119511
6	122034
7	118660
8	120041
9	130508
10	131010
11	131177
12	132705
13	133014
14	127635
15	124561
16	132288

The corresponding training dataset when the prediction depth of the used preceeding data is set to seven days

	1	2	3	4	5	6	7	8
1	95504	103402	114264	118232	119511	122034	118660	120041
2	103402	114264	118232	119511	122034	118660	120041	130508
3	114264	118232	119511	122034	118660	120041	130508	131010
4	118232	119511	122034	118660	120041	130508	131010	131177
5	119511	122034	118660	120041	130508	131010	131177	132705
6	122034	118660	120041	130508	131010	131177	132705	133014
7	118660	120041	130508	131010	131177	132705	133014	127635

Desired output target vector of the training dataset

	1	2	3	4	5	6	7	8
1	120041	130508	131010	131177	132705	133014	127635	124561

Fig. 3. Training dataset formation

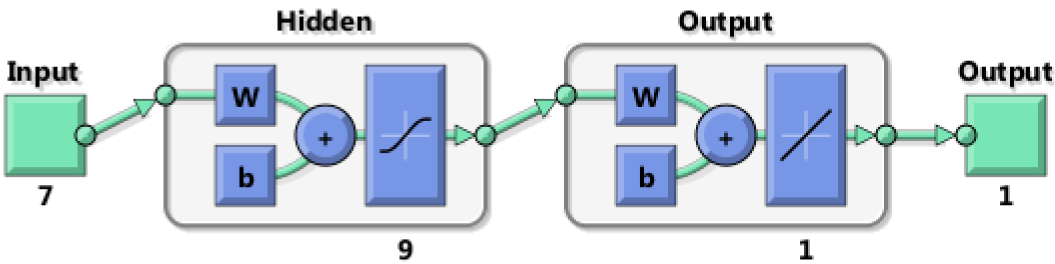


Fig. 4. ANN for daily forecast based on data from the preceding week

After training the ANN with data from year 2006 for testing the adequateness we used the data from 2007. On Fig. 5 is shown an result comparison between actual and predicted value for the energy consumption. From the graph easily is seen that the ANN approximates very well the data and that there are no big differences between predicted and actual data.

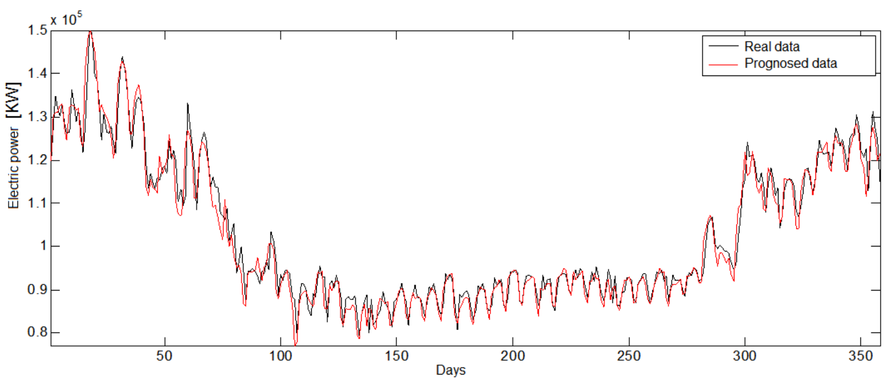


Fig. 5. Comparison of daily consumption between real and prognosed data in one node for one year

In the industry practice one simple method for electricity load consumption prediction is used with having the forecast being mean average of n preceding days:

$$P_{prognosed} = \frac{\sum_{day=1}^{n} P_{day}}{n} \tag{4}$$

A comparison with this technique showing the results on Fig.6 and Fig.7 was made. As it can be seen the ANN method is better as it yields more adequate and correct data forecast prediction. We also created a variation of the number of neurons in the hidden layer ranging them from -2 to +2 from the Oja rule (3) and variation on the prediction depth from 4 to 9 days. The results from the tested data and the corresponding percentage error are presented in Table 2 and they don't vary much.

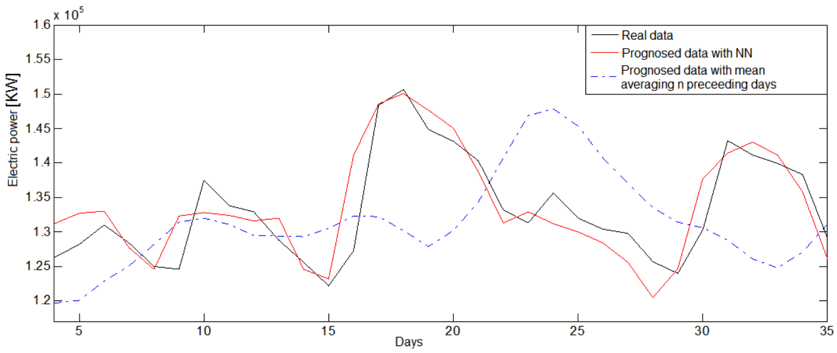


Fig. 6. Prediction methods comparison for n=4 days

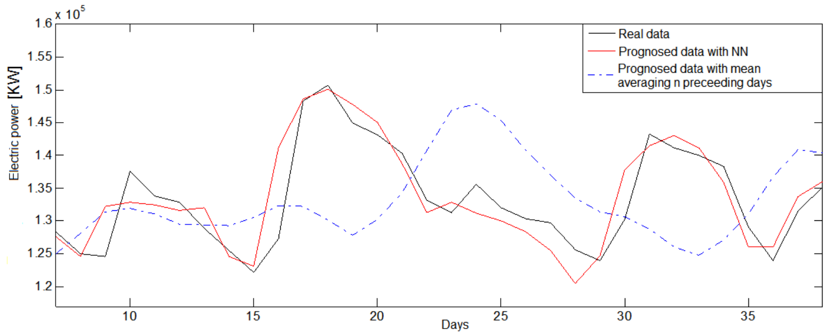
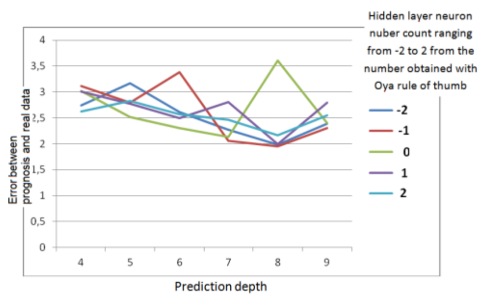


Fig. 7. Prediction methods comparison for n=7 days

Table 2. Percent error between forecast and actual data for ANN hidden layer neuron and prediction depth variation

Prediction depth

Hidden layer neuron nuber count ranging from -2 to 2 from the number obtained with Oja rule of thumb		4	5	6	7	8	9
	-2	2,74%	3,17%	2,61%	2,27%	1,98%	2,39%
	-1	3,12%	2,8%	3,38%	2,06%	1,95%	2,3%
	0	3,02%	2,52%	2,3%	2,13%	3,61%	2,4%
	1	3,01%	2,77%	2,5%	2,81%	1,99%	2,79%
	2	2,62%	2,83%	2,57%	2,46%	2,16%	2,55%



4. CONCLUSION

After making comparison with forecasting on the electricity consumption based on mean average of preceding days samples or with neural networks shows that the prognosis with neural networks are more accurate than the classical approach with mean average of several preceding days. The developed neural network model yield very satisfactory results and this leads to the conclusion that, the range of electricity consumption can be successfully predicted when needed.

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