The Power Load Prediction in GECOL using Artificial Neural Network

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Abstract:
The conducted experiments produce a prediction model to help the company's administrators and technicians make the right and quick decision. A supervised machine learning technique has been adopted and applied for SCADA data. In this study, for the load shedding prediction in general electricity company of Libya, an artificial neural network with multilayer perceptron is used. The energy consumption is used for prediction. For inputs of the neural network, four parameters are used as well. These parameters are power generation, temperature, humidity and wind speed. The collected data from the SCADA database were pre-processed to be prepared in a suitable format to be fed to the Neural Network algorithm. A set of experiments has been conducted on this data to obtain a prediction model. The produced model was evaluated in terms of accuracy and reduction of loss. It can be concluded that the obtained results are promising and encouraging. In this paper for prediction of the power the artificial neural network is used. The 6-K-fold are tested and the best results are obtained. For evaluation of the results four parameter, MSE, RMSE, MAPE and R2 are calculated. The best R2 value is obtained for 1-fold and it was 0.98 for train data and for test data is obtained 0.95 in 5-fold. Also for train data the RMSE value in 1-fold is better than the other Folds and this value was 0.02.

Keywords: Load Shedding Prediction, GECOL, Artificial Neural Network.

1. INTRODUCTION

The issue is tending to emerged from the presence of a colossal measure of information put away in the data set of General Electricity Company of Libya (GECOL) and addressed in the data set of Enterprise Resource Planning (ERP) [1][2]. These days, there exists a ton of data and information that can be dealt with from deals and logical information and data recovery are basically not, at this point enough for dynamic. It is an industrial computer system that monitors and controls a process all of the transmission and distribution elements of electrical utilities, and monitoring substations, transformers and other electrical assets for the company. This technique has been applied for the first time to SCADA data. This data have been recorded from January 2013 until December 2019. They are in the form of historical data every hour throughout the day on the total energy produced from power stations, the total network load and the average temperatures, humidity, weather conditions and wind speed for these historical periods. This technique would additionally predict the expected amount of energy consumed to manage load shedding according to certain hours of the day represented by peak hours, and according to specific periods of the year and weather conditions for that period, to maintain the stability of the electrical network and reduce the cost. Additionally, this can assist the company's decision-makers in taking the appropriate decisions more quickly and maintain the quality of service provided by the company [2][3]. The overall electric organization of Libya GECOL was set up Under Act No. 17 of 1984 AD and is liable for the finishing of the activities for working and adjusting the electric organizations, stations for energy creation and their appropriation and change stations. Likewise, the organization is answerable for the energy transmission lines and their appropriation, the power control focuses and the administration of the activity and adjusting of desalination stations in the entire nation [2]. In Zhou and Wang (2010) an unpleasant set is given to set up the affiliation rules utilized in diagnosing the force transformer. The harsh set can set up profound relationship, the force transformer affiliation rule is won by the unpleasant set. By decreasing the coarse set, the substitute component that influences the reviewing execution is erased. At that point the force transformer affiliation rule is obtained. Exploratory outcomes show that the strategy has awesome outcomes [4]. Predicting the amount of energy consumed and managing electric load shedding status hourly is a basis for strategic information and one of the keys to the stability of the electrical networks in this company, and it also effectively helps in planning and improving the quality of services it provides [5]. Conventional forecasting currently approved is a waste of time and is costly; further, it requires experts, engineers and technicians with experience in the production, distribution and transmission of electric energy, and who are often limited and have a historical archive of this data, not to mention they are prior and expected knowledge of the loads to be provided in the electrical network. Prior and expected knowledge is required according to the peak hours of the day, according to a specific season of the year and according to specific climatic conditions, especially in the presence of a vast amount of readings for the amount of electrical energy produced from power plants, the increasing demand for energy in the produced electrical network and the temperatures recorded at specific times [6]. To cope with these issues, machine learning algorithms have been proposed to support the automated prediction of energy consumed required by the electric network and reduce load shedding or avoid it. Among machine learning algorithms, Neural Networks (NNs)
have been applied to SCADA data set of the electricity company [7]. The problem arose in addressing the presence of a huge amount of data stored in the database of General Electricity Company of Libya (GECOL) and represented in the database of SCADA, where the decision-makers of the electricity company were not taking advantage of this historical data that was recorded in the SCADA database to predict electrical loads. The expected energy required by the electrical network under certain climatic conditions of temperature, humidity, or wind speed can help them in making strategic decisions as quickly as required. Accordingly, the idea of this article is to invest the available digital format data in producing beneficial prediction models of electrical loads for the energy required with better accuracy in terms of load shedding, which in turn can help decision-makers make the right and quick decisions regarding the stability of electricity network in their company. Additionally, the obtained knowledge would provide the engineers and technicians in GECOL with the essential information that can be used to draw up plans for the regulation and management of electrical energy distribution [8]. These days, applied information mining procedures [9] are generally used to find another and complete informational collection. The information mining measure creates a few examples from a given information source. The most notable information mining undertakings are the way toward finding regular thing sets, successive consecutive examples, continuous consecutive principles, and incessant affiliation rules. Various productive calculations have been proposed to play out the above tasks [10]. A program was developed by a well-known software package for data extraction and exportation to external files which is referred to as Visual Studio 2019 and Microsoft Office 2019. These tools are applied to the collected data from the SCADA system, that can be dealt with in this study and configured in a format that is appropriate for this study represented in the artificial neural network. In this paper, a machine learning technique is applied to a vast amount of historical data stored in the database of General Electricity Company of Libya (GECOL) and represented in the database of supervisory control and data acquisition (SCADA).

2. MATERIAL

The dataset used for experiments in this paper was historical data on the total electrical energy produced per hour, the temperature recorded at the same time, humidity, and wind speed within a specified period from January 2013 until December 2019 are specified as shown in Table 1.

Table 1. GECOL Dataset Properties

<table>
<thead>
<tr>
<th>Variables</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Date time</td>
<td>Represent of Date of day</td>
</tr>
<tr>
<td>Time</td>
<td>Time</td>
<td>Represent the time in the day</td>
</tr>
<tr>
<td>Energy Generation</td>
<td>Numeric</td>
<td>Represent The amount of electrical energy produced by (MW)</td>
</tr>
<tr>
<td>Temperature</td>
<td>Numeric</td>
<td>Represent Temperature</td>
</tr>
<tr>
<td>Humidity</td>
<td>Numeric</td>
<td>Represent a percentage of Humidity</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>Numeric</td>
<td>Represent The wind speed by km/h</td>
</tr>
</tbody>
</table>

As a sample of the collected data used in this study, Figure 1 illustrates in a simplified way to represent the data, which includes the value of the energy produced, the value of energy consumed, the value of load-shedding in a specific hour of the day and different periods of the year and under different climatic conditions.

The obtained knowledge would provide the decision-makers with the essential information that can be used to draw up plans and to ensure continuity and quality of service. The rest of the paper is organized as follows: Section 2 reviews artificial neural
network concepts, Section 3 provides information on the prediction algorithm and the experimental result, and finally, Section 4 presents conclusions.

3. ARTIFICIAL NEURAL NETWORK

An artificial neural network is a model for the processing of information inspired by the study of bioelectric networks in the brains of people and animals, produced by neurons and their synapses [11]. The mathematical analogue of the biological neural network is a set of interconnected simple computational elements (neurons). Each neuron receives signals from the others (in the form of numbers), sums them up, as the sum goes through an activation function, and thus determines its activation (excitation degree), which is transmitted through the output connections to the other neurons. Each connection has a weight which, multiplying by the signal, determines its significance (strength). The weights of the connections are analogous to the strength of the synaptic impulses transmitted between biological neurons. A negative value of weight corresponds to a suppressive impulse and a positive value to an excitatory one [12]. The neuron model shown in simplified form in Figure 2 can also be considered as a threshold volume

Threshold (θ) unit, which collects the output and hazel Harmandir only produces an output exceeds the sum of the internal threshold of the entrance as a threshold neuron unit receives signals from the synapse and collects all the signals that are generated by multiplying the appropriate weight. You will now sign up to the power of the threshold gathered strong sign stimulus is transmitted along the axon and dendrites of other neurons. Intersecting compared with all the signs of internal threshold gated neurons with dendrites and synapses from the axons sign spreads threshold is exceeded. Output depending on whether the result of the sum function value is above or below the threshold activation functions are formed by the normalizing. ANN, connecting these simple nodes and the unit is obtained by conversion to a network. ANN block diagram is shown in Figure 3.
To set the threshold value of the signal entering the activation function at this point bias (\(\theta\)) is called a fixed input value applied to the input neurons, this allows the threshold to be changed to receive the expected outputs. ANN as a basic, simple structure and versatile. Each node cells called the nth degree and a non-linear transfer. Processing elements called nodes and links therebetween. Each connection is involved in the transmission of one-way mark delay. An unlimited number of processing element inputs and a single output connection. However, if this needs to be copied and used in many cells of a single output power supply, the output of the processing element may be any desired mathematical type. Indicate the function of the output of the processing element \(x\) input value, \(y\) output value, \(\Psi\) transfer function, \(f(x)\) collecting function, \(w_{kj}\) is the connection weights, \(0_k\) for sequential neurons, including neurons sequential threshold for \(k\) can be expressed as follows [13].

\[
\begin{align*}
fx &= w_{k1}x_1 + w_{k2}x_2 + \ldots + w_{kn}x_n + \theta = \sum_{j=0}^{n} w_{kj}x_j \theta = 0_k x_0 \\
y &= \psi(fx) = \psi(\sum_{j=1}^{n} w_{kj}x_j) \\
f_kx &= wk0 \cdot wk2 \cdot wk3 \ldots wkn \cdot x_0 \cdot x_1 \cdot x_n = w_kTx
\end{align*}
\]

Expressed in the form of a neuron matrix are as follows.

\[
fx = wk0 \cdot wk2 \cdot wk3 \ldots wkn \cdot x_1 \cdot x_n = w_kTx
\]

Inputs are information that enters the cell from other cells or the external environment. The information enters the cell via links on weight and weights, will determine the effect on the corresponding input cell [14]. The architecture of the proposed neural network with backpropagation algorithm is illustrated in figure 4.

**Figure 4. Architecture of proposed MLP with backpropagation algorithm**

As shown in figure this figure, four inputs are used. for the output the energy consumption is used. The levenberg Marquardt [15] is used for the training algorithm. In this algorithm, for the estimation of the error, the mean square error is used for the reducing of the error.

4. EXPERIMENTAL RESULT

For the implementation of the proposed method, the Matlab 2019a with 4GB Ram, Core i7, 8th generation laptop is used. about 10 times the method was run and the result saved in table 1. The proposed ANN-MLP is shown in figure 5.

**Figure 5. the proposed ANN-MLP**
The result of the train data and output neural network is shown in figure 6. The red-coloured result shows the target real data (energy consumption), and the blue-coloured result shows the ANN result for train data. The MSE value for this scenario is 151344.4585.

![Figure 6](image1)

Figure 6. Result for target train data and output of the neural network

The result of the test data and the output neural network is shown in figure 7. The red-coloured result shows the target real data (energy consumption), and the blue-coloured result shows the ANN result. The MSE value for this scenario is 155927.63.

![Figure 7](image2)

Figure 7. Result for target test data and output of the neural network
The performance analyzing of this scenario is shown in figure 8.

![Best Training Performance is 0.010325 at epoch 1000](image)

Figure 8. performance analyzing for 1000 iteration

As shown in this figure the best MSE is 0.010325 and this value obtained after 20 iterations.

The training state of the model is shown in figure 9.

![Gradient = 2.675e-05, at epoch 1000](image)

![Mu = 1e-12, at epoch 1000](image)

![Validation Checks = 0, at epoch 1000](image)

Figure 9. training state of the proposed model

As shown in this figure the gradient value in each iteration depends on this model. The best gradient value is 2.67e-5 and this value obtained after 1000 iteration. For the \( \mu \) the best value obtained after 1000 iteration and this value is 1e-12. This parameter is the training rate. Finally, the validation fail is 0 for each iteration in the training state. The regression analyzing of the proposed model is shown in figure 10.
In this figure, the regression is obtained 0.9234, normally this value should be near to 1, but the data used in the proposed model is nonlinear. The Mean Square Error for training and testing data is shown in figure 11. The number of neurons that used for the model are 5, 8, 10, 12 and 16. For each scenario, the result is illustrated as well.

As seen in this figure when the number of the neurons are increasing the MSE value is decreasing. So for the best model, the number of neurons must increase. With the low number of the neuron, we cannot get a good result.

The Mean Absolute Percentage Error (MAPE) and R2 score for training data and testing data are shown in figure 12.
The Root Mean Square value for training and testing data is shown in figure 13.

Figure 13. Root Mean Square value for training and testing data

The simulation results for the 1 number of hidden layer and 5 number of hidden layer is illustrated. In this figure the train data and test data results are shown. For 6 K-fold the model is tested. In each fold the results obtained and illustrated in each figure. For criteria parameter are tested. These parameters are MSE, RMSE, MAPE and R2.
Figure 14. simulation result, a) train data with 1 number of hidden layer, b) test data with 1 number of hidden layer, c) train data with 5 number of hidden layer, d) test data with 5 number of hidden layer, b)

For different Folds the train and test results are shown in figure 15 and figure 16 respectively.
5. CONCLUSION

In this study for the prediction of the energy consumption, multilayer perceptron with one hidden layer and multi neuron numbers are used. Simulation results show that the proposed method has good accuracy for the prediction of energy consumption. The accuracy of the prediction is 95%, and this value is getting after running ten times. For the input, four parameters are used. The obtained result shows that this system can be used instead of the real system. This paper directed a bunch of examinations to assemble a model as far as prescient guidelines, and the acquired prescient model has been assessed. The got prescient model is valuable, it helps analysts, designers, architects, and professionals in every area to remove the key and important data. It additionally helps viably in arranging and improving administrations. It tends to be reasoned that the got prescient model is an establishment for GECOL key data. What's more, it very well may be utilized to help mindful workers make their right, appropriate, essential, and speedy choices appropriately and unquestionably.

6. REFERENCES


