A New Approach to Load Shedding Prediction in GECOL Using Deep Learning Neural Network

Ashraf Mohammed Abusida[1] and Aybaba Hançerlioğullari[2]
ashrafbouseda@gmail.com aybaba@kastamonu.edu.tr
[1]Department of Computer Engineering, Kastamonu University, Kastamonu-Turkey,
[2]Art & science faculty, Physics Department, Kastamonu University, Kastamonu-Turkey,

Abstract
The directed tests produce an expectation model to assist the organization's heads and professionals with settling on the right and speedy choice. A directed deep learning strategy has been embraced and applied for SCADA information. In this paper, for the load shedding expectation overall power organization of Libya, a convolutional neural network with multi neurons is utilized. For contributions of the neural organization, eight convolutional layers are utilized. These boundaries are power age, temperature, stickiness and wind speed. The gathered information from the SCADA data set were pre-handled to be ready in a reasonable arrangement to be taken care of to the deep learning. A bunch of analyses has been directed on this information to get a forecast model. The created model was assessed as far as precision and decrease of misfortune. It tends to be presumed that the acquired outcomes are promising and empowering. For assessment of the outcomes four boundary , MSE, RMSE, MAPE and R2 are determined. The best R2 esteem is gotten for 1-overlap and it was 0.98.34 for train information and for test information is acquired 0.96. Additionally for train information the RMSE esteem in 1-overlap is superior to different Folds and this worth was 0.018.

Keywords: *Deep learning, Prediction, GECOL, Load Shedding*

1. Introduction

The general electric company of Libya GECOL was established Under Act No. 17 of 1984 AD and is responsible for the completion of the projects for operating and servicing the electric networks, stations for energy production and their distribution and transformation stations. Also, the company is responsible for the energy transmission lines and their distribution, the electricity control centers and the management of the operation and servicing of desalination stations in the whole country [1].

This brief explains some aspects of GECOL's technical activities, and it was not possible to collect these data and information contained in this study except through the strong and comprehensive support and assistance from GECOL management and employees, and our serious attempt to help them overcome one of major the difficulties facing the company GECOL in providing the necessary energy. And that is by finding the best way to predict the required electrical energy loads through the implementation of machine learning methods techniques, and it becomes one of the most important decision-making tools in GECOL.

The principle and classification of middleware technology are presented. On the basis of both component technology and extensible markup language (XML) technology the middleware technology for database access and its method of application are researched. Applying the database access middleware to the design of the three-layer model for the database system of SCADA and utilizing the database access middleware, the database server of SCADA is connected with foreground application program of clients. The data structure and the design of middleware interface adhere to IEC61970 standard; by means of updating the module of middleware the database system can be expanded and upgraded, thus the database system possesses good compatibility and

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extendibility. In addition, a kind of database system of SCADA based on middleware workstation is designed, the designed system can fully utilize the resources of existing SCADA and share heterogeneous data, so the efficiency of database system can be improved. It is available to use the designed database system in new generation of dispatching automation system [2].

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) [3][1]. 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 [1][4].

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 [1].

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 [5].

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 [6].

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 [7].

To cope with these issues, machine learning algorithms have been proposed to support the automated prediction of load shedding for the electric network. Among machine learning algorithms, Neural Networks (NNs) have been applied to SCADA data set of the electricity company [8].

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 [2].

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

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

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.

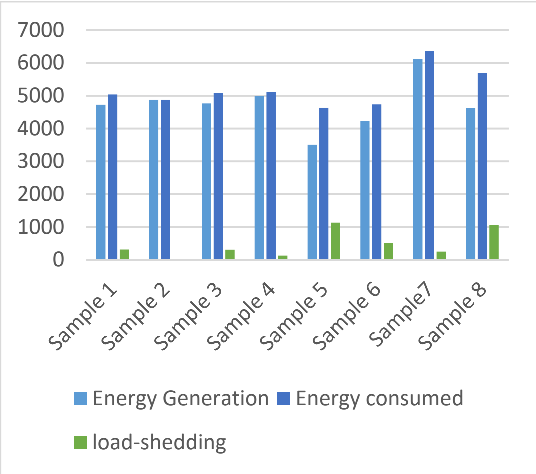

Figure 1. A sample of the data collected

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.

3. Deep Learning Neural Network

Deep learning is a part of machine learning methods that focuses on methods that are based on artificial neural networks. In-depth learning teaches computers to do what is naturally done for humans [11][12][13].

Deep learning is a subset of machine learning that uses algorithms that simulate the human brain. This algorithm is called artificial neural networks. Artificial neural networks are inspired by information processing and communication nodes distributed in biological systems. It can be said that neural networks tend to be static and symbolic .

The concept of deep learning in simple language was first introduced in 1980 as a theoretical argument. But for two main reasons, this concept is now more important and useful than ever. These reasons are:

Deep Learning requires a lot of data. For example, the development of self-driving cars requires millions of images and thousands of hours of video.

Deep learning requires high processing power. Powerful GPU units used in Deep Learning are expensive. If these processors are synchronized with the cloud computing system, development teams can reduce the training time of a deep learning network from a few weeks to a few hours or even less.

When we use the term deep learning, we mean the Deep Neural Network. The difference between deep learning and neural network is that deep learning has a wider scope than neural network and includes reinforcement learning algorithms. Given this difference, we should not confuse the two concepts.

Today, deep learning has achieved a very high level of accuracy in diagnosis. This level of accuracy helps electronics meet user expectations. This level of accuracy is also important in high-sensitivity applications such as self-driving cars. Recent advances in deep learning have reached a level where it works better than humans in tasks such as image categorization.

Deep learning is one of the specialized forms of machine learning. In machine learning, the workflow process begins with its own characteristic, namely the extraction of images manually. These features are then used to create a model that is able to classify objects and objects in images.

But in the deep learning system, with a workflow, related features are automatically extracted from the images. In addition, in the deep learning algorithm, where a raw data network is given, it automatically learns and performs the task of classifying the data.

Another difference is in the scale of the deep learning algorithm with the data. Machine learning is convergent. This type of learning refers to methods that produce a certain level of performance when adding information. One of the positive features of the Deep Learning algorithm is that as the size increases, the data continues to evolve.

In machine learning, you manually select a sorter with its features to sort the images. But in the Deep Learning system, the modeling steps as well as the feature extraction are done automatically.

Figure 2 compares a typical biological and artificial neural network.

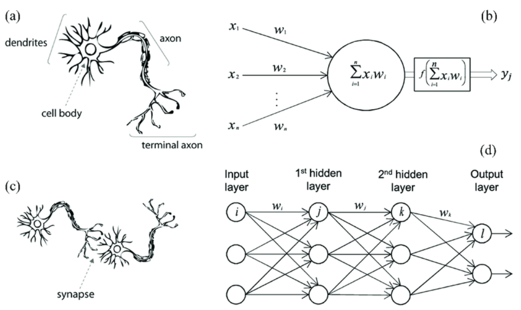

Figure 2. Biological neuron vs ANN, (a) human neuron; (b) fake neuron; (c) organic neurotransmitter; and (d) ANN neurotransmitters [14]

Deep learning network transferred further (outputs 0 or 1), depending on the weighted sum of inputs at a neuron reaches a specific threshold to produce either 0 or 1 [15].

Activation function, is a possible candidate for the activation function, but it is not true. We will take a brief look at some of the popular activation functions which have been used in research work in recent times.

For activation function sigmoid function is define as [16].

$$\sigma(x) = \frac{1}{1+e^{-x}} \quad (1)$$

This shape is shown in figure 3.

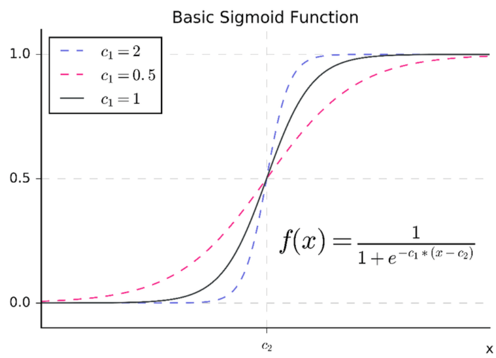

Figure 3. Basic Sigmoid function [17]

We have used ReLU as activation function in both ANN and CNN models. Figure 4 represents the rectified linear unit graph. The expression for ReLU is as follows [18].

$$y = x^+ = \max(0, x) \quad (2)$$

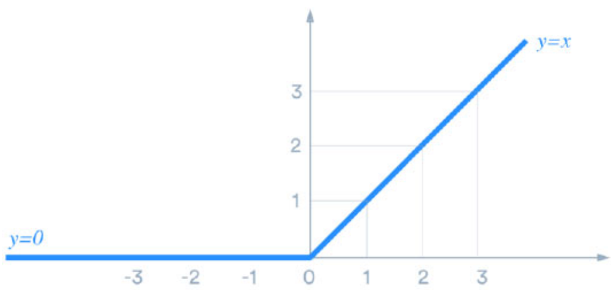

Figure 4. Rectified linear unit [19].

The other activation function is the hyperbolic tangent that define as [20].

$$f(x) = \frac{(e^x - e^{-x})}{(e^x + e^{-x})} \quad (3)$$

Hyperbolic tangent (tanh) is shown in figure 5.

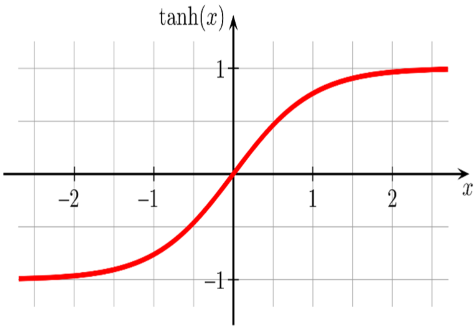

Figure 5: Hyperbolic tangent (tanh)

Softmax has been used as an activation function for our model's final layers [20].

$$softmax(x)_j = \frac{e^{x_j}}{\sum_m e^{x_m}} \quad (4)$$

The cost function is define as:

$$E(W, b) = \frac{1}{N}\sum_{n=1}^{N} E(W, b;\ x_n, y_n) \quad (5)$$

The sum of squared error is define as:

$$SSE\ (y, \hat{y}) = \sum (y_n - \hat{y}_n)^2 \quad (6)$$

we will cover it in the upcoming paragraphs:

$$CE(y, \hat{y}) = -\frac{1}{N}\sum_{n=1}^{N}\sum_{k=1}^{K} -y_n^k \log(\hat{y}_n^{(k)}) \quad (7)$$

We can summaries the above function is:

$$CE(y, \hat{y}) = -\frac{1}{N}\sum_{n=1}^{N} y_n.\log(\hat{y}_n) + (1 - y_n).\log(1 - \hat{y}_n) \quad (8)$$

The Gradient Descent is define as:

$$\Delta w_i(\tau + 1) = -\alpha \frac{\partial E}{\partial w_i} \quad (9)$$

$$w_i(\tau + 1) = w_i(\tau) + \Delta w_i(\tau + 1) \quad (10)$$

Where $\Delta w_i(\tau + 1)$ is the weight update.

It also is, high variance or sometimes slow convergence which might lead to a fluctuating loss function during parameter updates.

4. Results and Discussion

The basic idea behind the Load Shedding Prediction in GECOL data is to predict the likelihood of value of the load shedding according to their test results. MSE and MAPE analysis, are used to determine the real truth. The Training progress of the deep learning is shown in figure 6.

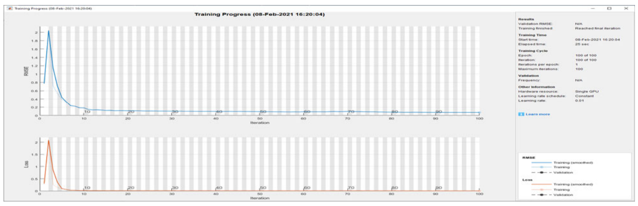

Figure 6. Training progress of the deep learning

The Deep learning neural network analyzing is shown in figure 7.

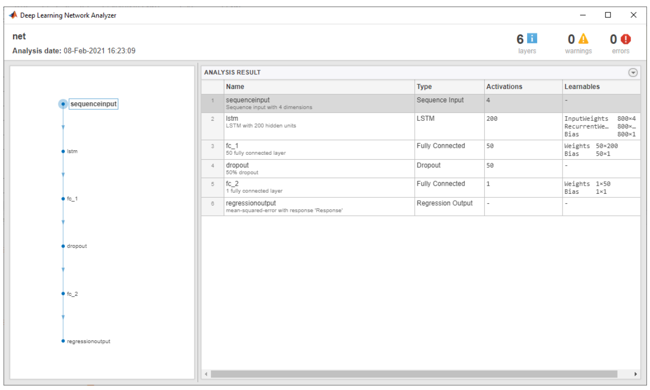

Figure 7. Deep learning neural network analyzing

The information of the layer of the deep learning neural network is shown in table 1.

Table 1. information of the layer of the deep learning neural network

1	'sequenceinput'	Sequence Input	Sequence input with 4 dimensions
2	'lstm'	LSTM	LSTM with 200 hidden units
3	'fc_1'	Fully Connected	50 fully connected layer
4	'dropout'	Dropout	50% dropout
5	'fc_2'	Fully Connected	1 fully connected layer
6	'regressionoutput'	Regression Output	mean-squared-error with response 'Response'

The simulation result for training data is shown in figure 8.

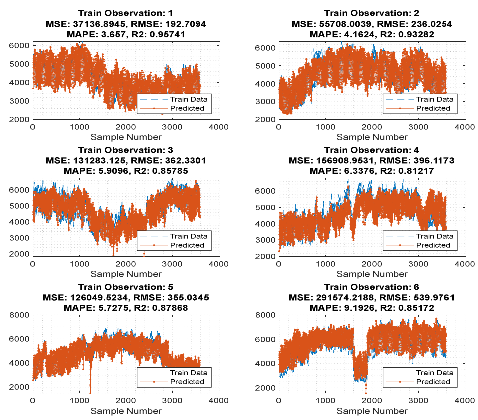

Figure 8. Simulation result for training data

The simulation result for testing data is shown in figure 9.

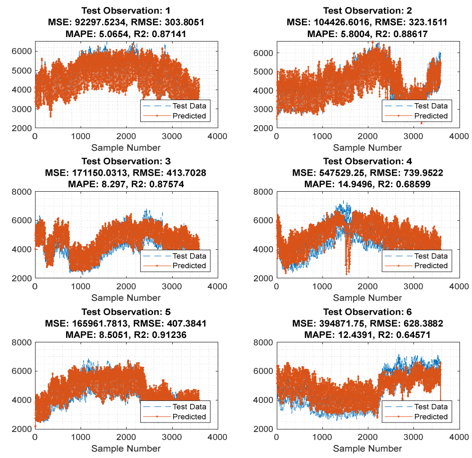

Figure 9. Simulation result for testing data

The comparison of the result for MSE, RMSE, MAPE and R2 for training data is shown in figure 10.

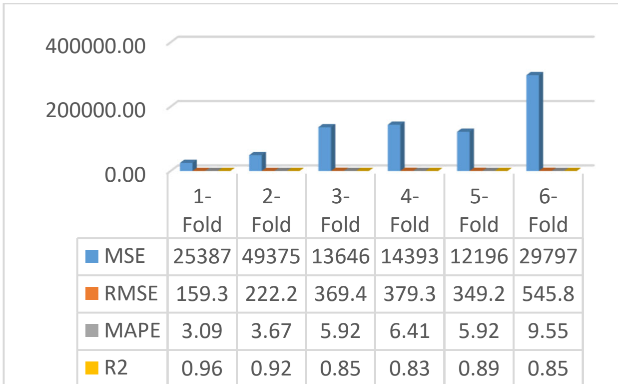

Figure 10. comparison of the result for MSE, RMSE, MAPE and R2 for training data

The comparison of the result for MSE, RMSE, MAPE and R2 for testing data is shown in figure 11.

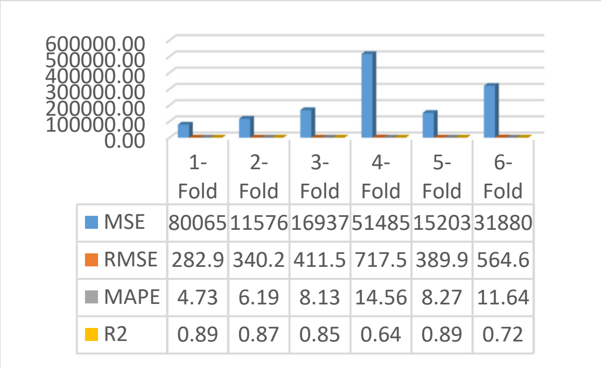

Figure 11 comparison of the result for MSE, RMSE, MAPE and R2 for testing data

The statistical analyzing of the deep learning neural network is shown in table 2.

Table 2. The statistical analyzing of the CNN result

	Criteria	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Fold 6
Train	MSE	25387.13	49375.17	136466.73	143933.56	121966.68	297978.9
	MAPE	3.09	3.67	5.92	6.41	5.92	9.55
	R2	0.96	0.92	0.85	0.83	0.89	0.85
	RMSE	159.33	222.21	369.41	379.39	349.24	545.87
Test	MSE	80065.49	115766.98	169371.47	514854.97	152037.02	318804.4
	MAPE	4.73	6.19	8.13	14.56	8.27	11.64
	R2	0.89	0.87	0.85	0.64	0.89	0.72
	RMSE	282.96	340.25	411.55	717.53	389.92	564.63

5. Conclusion

In this paper for the expectation of the energy utilization, Deep learning neural network with multi neuron numbers are utilized. The results show that the proposed technique has great precision for the expectation of energy utilization. The precision of the expectation is 96.66%, and this worth is getting subsequent to running multiple times. For the information, four boundaries are utilized. The result shows that this framework can be utilized rather than the genuine framework. This study guided a lot of assessments to gather a model similar to insightful rules, and the procured perceptive model has been evaluated. The got insightful model is significant, it helps experts, designers, and experts in each space to eliminate the key and significant information. It moreover helps feasibly in orchestrating and further developing organizations. It will in general be contemplated that the got perceptive model is a foundation for GECOL key information. Also, it might be used to assist careful laborers with making their right, suitable, fundamental, and fast decisions fittingly and certainly.

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Ashraf Mohammed Abusida A native of Libya received his Bachelor degree in Computer Science in 1996 from the Faculty of Science, University of Tripoli, and Tripoli, Libya. From 1998 to 2018, he worked as a software developer for General Electricity Company of Libya (GECOL). Until he became head of the company's developers team. In 2010, he started a Master study of Computer Science in Libyan Academy, Tripoli, Libya. In 2019, he enrolled in a PhD program in Computer Engineering, at the Department of Computer Engineering, University of Kastamonu, Turkey.

Aybaba Hançerlioğullari Graduated BSc in physics Engineering department from Hacettepe University/Turkey in 1992.Msc from Gazi University Institute of science Nuclear Research in 1996. PhD from Gazi University institute of science Nuclear Research/Turkey in 2003. He is currently working as Professor at Institute of Science Physics department, Kastamonu University..