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Towards An Effective Power Outage Planning: Ann Approach

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Abstract

Utility companies in developing nations are battling the problem of incessant power outages without giving prior warning to the consumers. This has caused questions to be raised as touching the integrity of the so called utility companies. Inability to give precise forecast is another problem that confronts these companies. Most forecast data are purely statistical which could be enhanced by the use of artificial intelligence tool like Artificial Neural Network. Outage planning could therefore be well analyzed making both the utility company and consumers schedule their activities without untold damage to machine, equipment, and minimization of economic losses.
Keywords: utility, outage, predictability, ANN, trainoss

1. Introduction

Developing nations are daily seeking effective ways of bringing stable electricity to their citizenry. Construction of more power generating stations, spring up all across developing nations without appreciable improvements in the power available at the consumer end. Several works by researchers have been aimed at forecasting power generation and load demands [1]. This trend has been ongoing for sometimes now [2]. Countries like South Africa, Ghana, and Libya have experienced remarkable improvement in terms of stability of power. Nigeria, the focus of this work, is struggling even in the attainment of 5,000MW of power. Recently, the power has dropped to a disappointing level. Therefore, there is a difficulty in forecasting power that would be generated or available in the national grid due to factors ranging from gas pipeline vandalisation, unstable operational policy, political undertone, nepotism and so on.

In the last five years, several companies have closed shops in Nigeria due to severe power outages experienced which is not good for the survival of any business outfit. For instance, Dunlop PLC closed shop in 2011, Michelin in 2007 while Unilever PLC, PZ Cussons Nigeria, Afprint Nigeria Limited have considered relocating to other neighbouring countries that have stable power supply for their productions.

From the above discussions, the place of proper power outage planning cannot be overemphasized. Proper power outage planning would be helpful to industries, parastatals, small businesses and individuals to plan their activities ahead without much emergency situations.

Artificial neural network has played a significant role in the forecast and predictability of load demand in power sector [3, 4, 5]. The backpropagation training algorithm is adopted with "trainoss" being the drive vehicle. This algorithm is settled for since its implementation is made possible by inherent parallelism in the network architecture due to repeated use of simple neuron processing element [6]. ANN's characteristics of learning information by example, ability to generalize to new inputs, robustness to noisy data that occurs in real world applications, and fault tolerance make it an important tool to use for this work. The rest of this paper examines types of outages, outage planning, model of artificial neuron, methodology, results and discussions, and conclusion.

2. Types of Outages

i. Forced outages
ii. Planned outages
iii. Urgent outages
iv. Emergency outages

2.1 Outage Planning

Utility company in Nigeria requires a comprehensive outage forecast details from all power generating stations across the country. Downtimes, strictly arisen from equipment breakdown, schedule maintenance periods as well as grid integrity and security are factors generally considered in forecasting periods of power outages likely to be experienced in a given year.

The National Control Centre's data of outages released in 2009 was used in the training of ANN, testing, and validation of the results generated. Outage planning is therefore a key component in the overall operation of the utility company.

The transmission lines considered are 330kV line and 132kV line for different types of outages experienced in 2008 and 2009 [7].

2.2 Model of Artificial Neuron

The most common model of artificial neuron was proposed by McCulloch and Pitts in 1943. The model has each neuron input, x_i, and corresponding weight, w_i. An offset or better still, a bias with a constant input of 1 weighted by the value, w_o. Output is given as y which is obtained by summing the weighted inputs to the neuron and passing the result through a non-linear activation function, f [8].

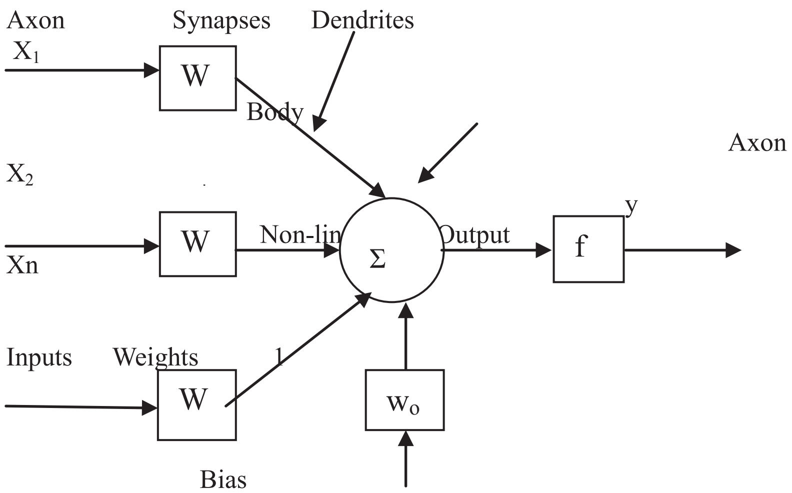

Figure 1: McCulloch-Pitts neuron model

3. Methodology

Backpropagation algorithm is used for this work. This algorithm is derived following the simple gradient principle with a start point containing a typical weight w_{pq} which is updated as follows:

$$w_{pq}(t+1)=w_{pq}(t)-\eta\frac{\partial E}{\partial w_{pq}} \quad (1)$$

η= the learning rate

$E=\frac{1}{2}(y^d(t)-y(t))^2$ is the error function to be minimized.

The implementation is realized with these steps:

1. Initialize the weights to small random values
2. Choose a pattern x_k; k=1, 2, ..., n and apply it to the input layer.
3. Propagate the signal forwards through the network using

$$s_j=\sum_{k=1}^{n}W_{jk}x_k \quad (2)$$

$$v_j=f(s_j)_{j=1,2,\ldots,h} \quad (3)$$

$$q_i=\sum_{j=1}^{h}w_{ij}v_j \quad (4)$$

$$y_i=f(q_i); i=1,2,\ldots,m \quad (5)$$

4. Compute the deltas for the output layer

$$\delta_i=f(q_i)(y_i^d-y_i) \quad (6)$$

5. Compute the deltas for the hidden layers by propagating the errors backwards

$$\Delta_j=f(s_j)\sum_{i=1}^{n}w_{ij}\delta_i \quad (7)$$

6. Use

$$w_{ij}(t+1)=w_{ij}(t)+\eta\delta_i v_j \quad (8)$$

$$W_{jk}(t+1)=W_{jk}(t)+\eta\Delta_j x_k \quad (9)$$

to update all connections.

7. Go back to step 2 and repeat for the next pattern.

4. Results and Discussions

4.1 Results

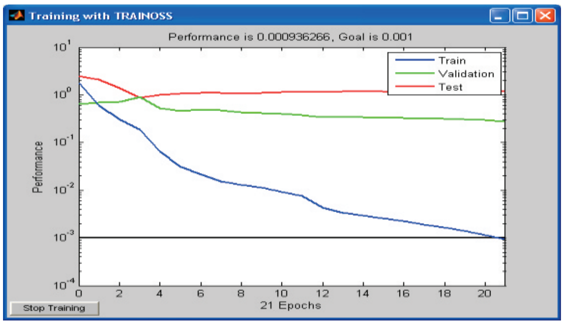

Figure 2: Performance training curve

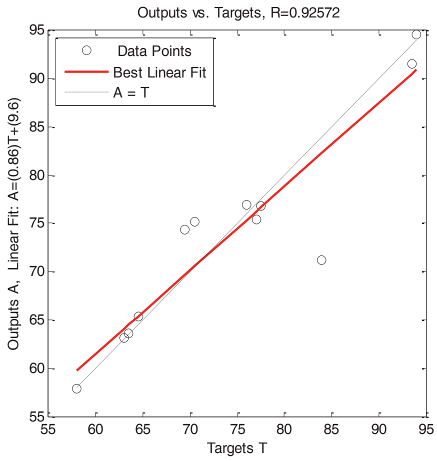

Figure 3: Regression curve of the training parameters

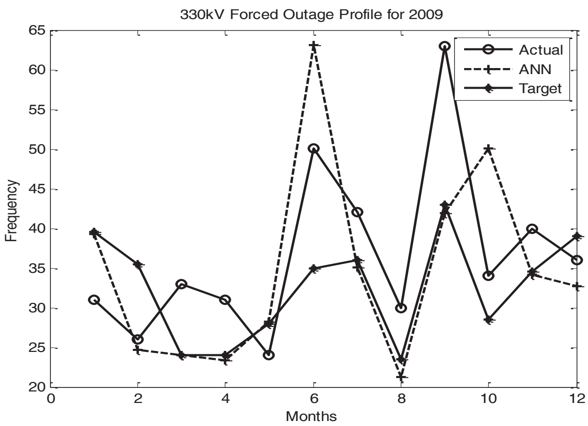

Figure 4: 330kV forced outage profile for 2009

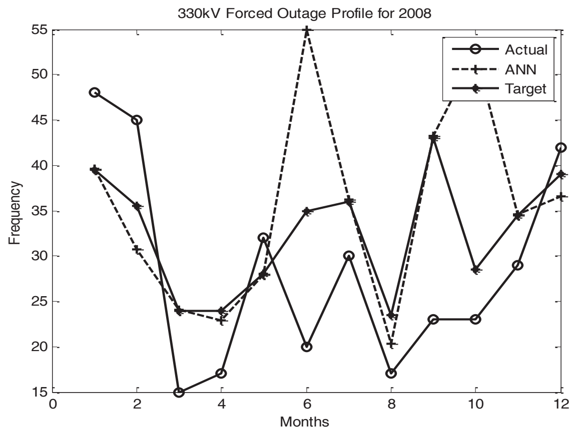

Figure 5: 330kV forced outage profile for 2008

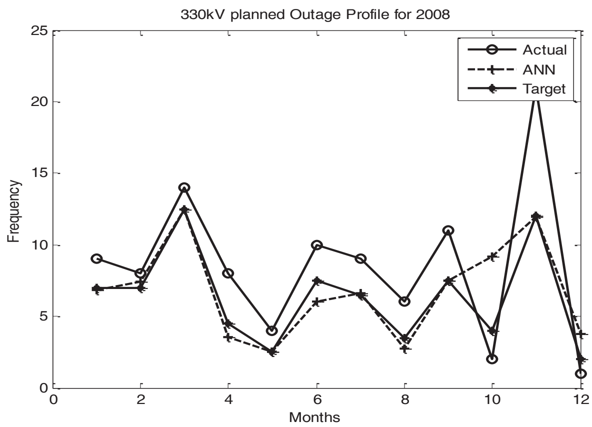

Figure 6: 330kV planned outage profile for 2008

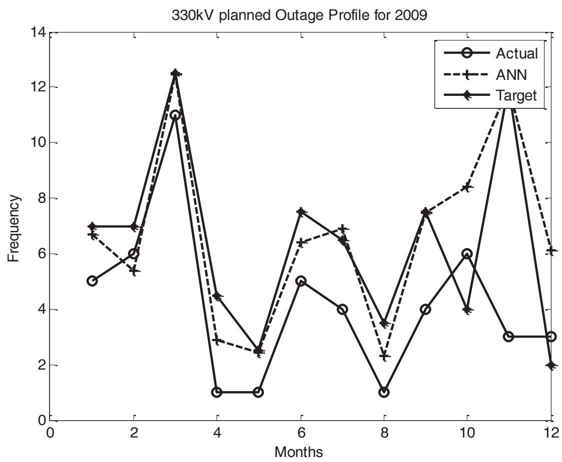

Figure 7: 330kV planned outage profile for 2009

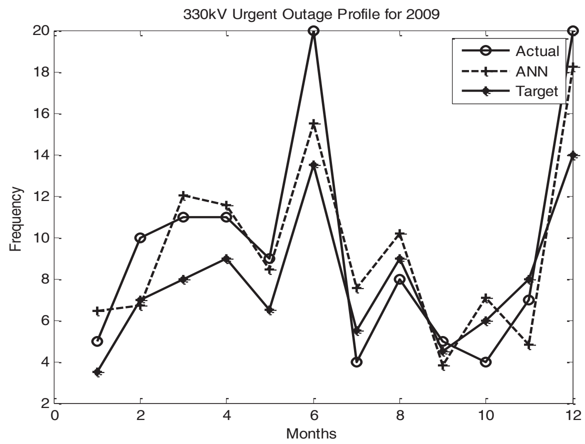

Figure 8: 330kV urgent outage profile for 2009

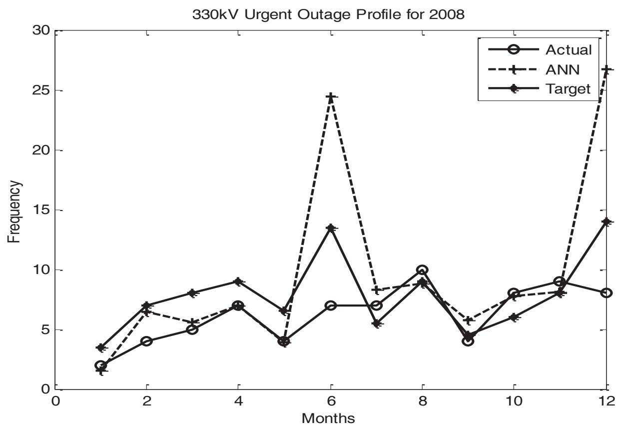

Figure 9: 330kV urgent outage profile for 2008

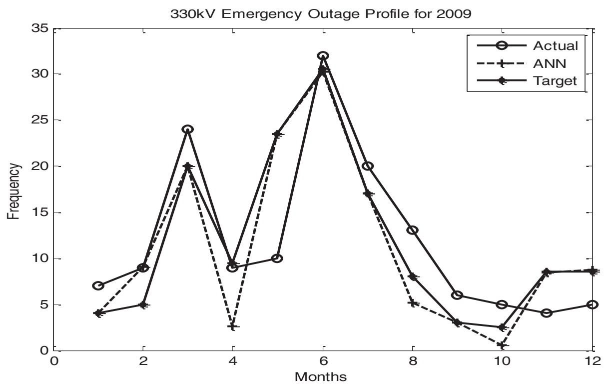

Figure 10: 330kV emergency outage profile for 2009

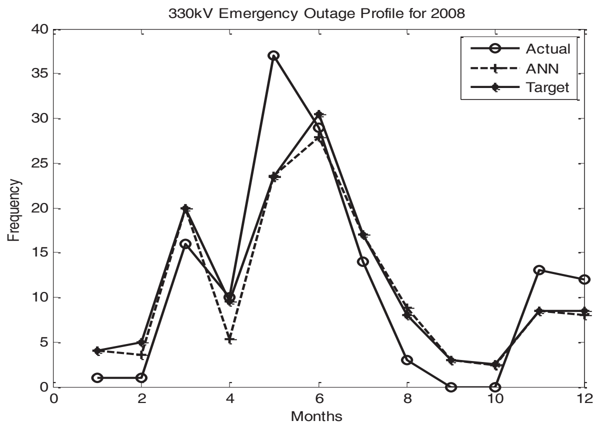

Figure 11: 330kV emergency outage profile for 2008

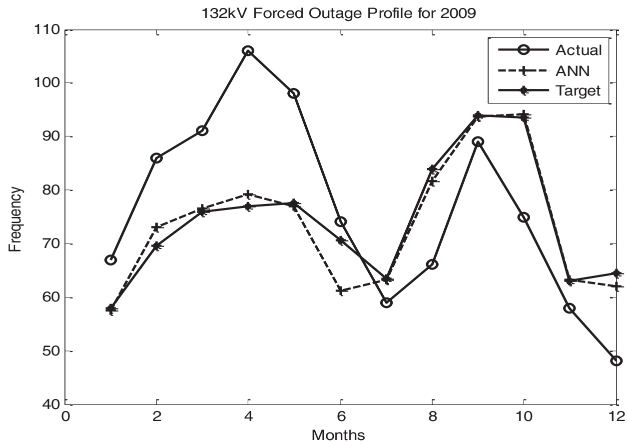

Figure 12: 132kV forced outage profile for 2009

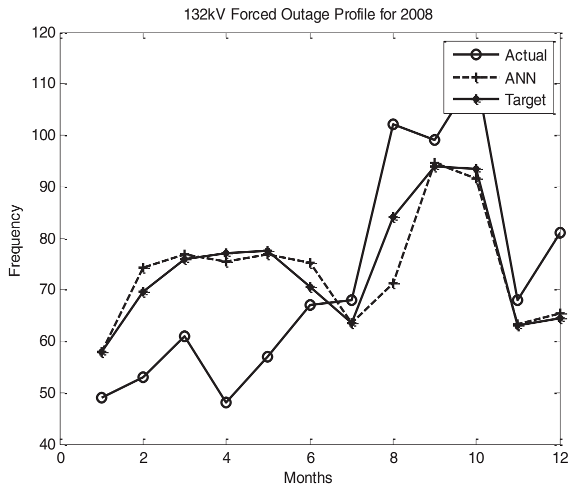

Figure 13: 132kV forced outage profile for 2008

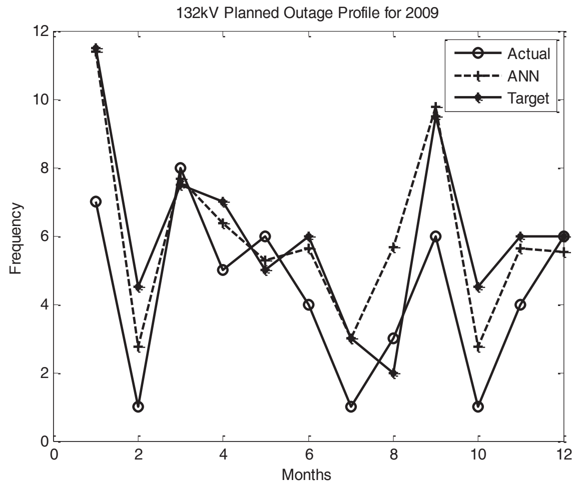

Figure 14: 132kV planned outage profile for 2009

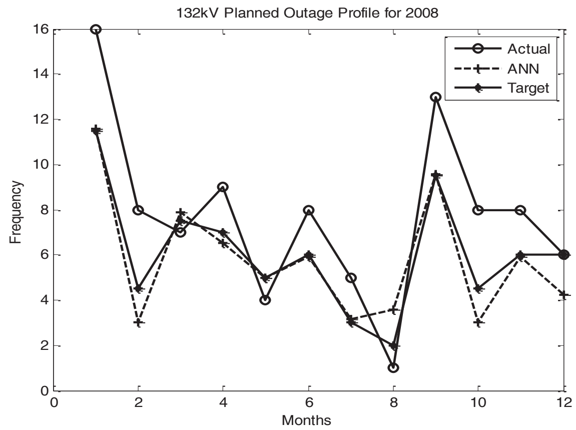

Figure 15: 132kV planned outage profile for 2008

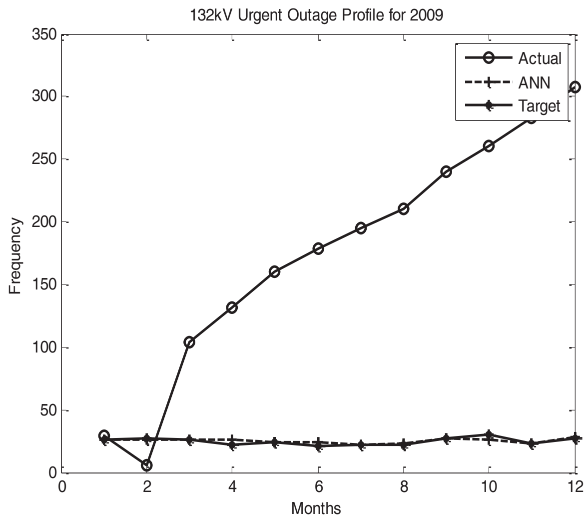

Figure 16: 132kV urgent outage profile for 2009

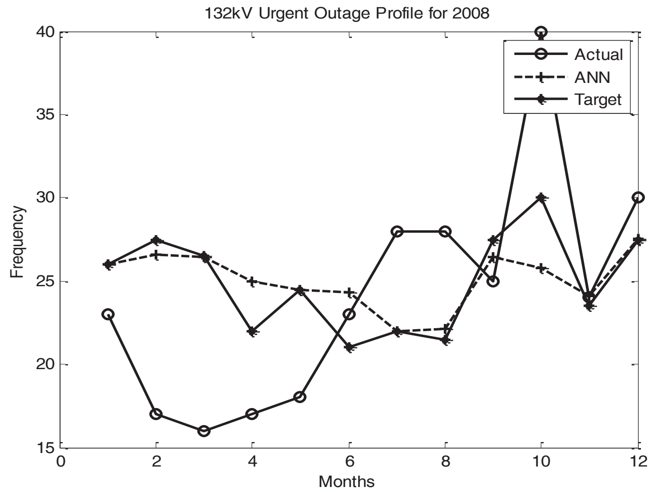

Figure 17: 132kV urgent outage profile for 2008

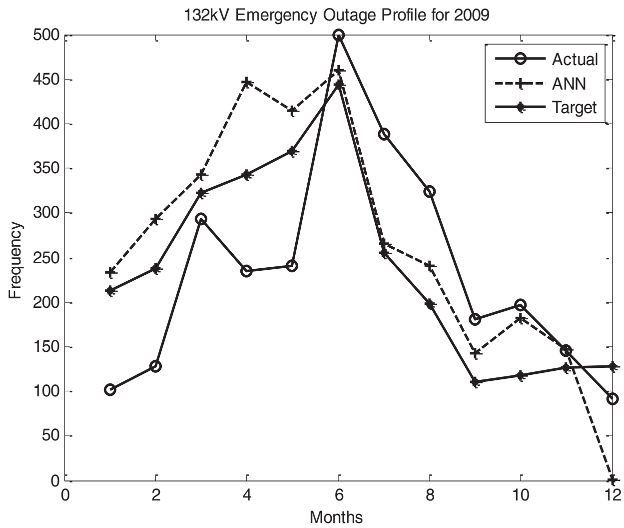

Figure 18: 132kV emergency outage profile for 2009

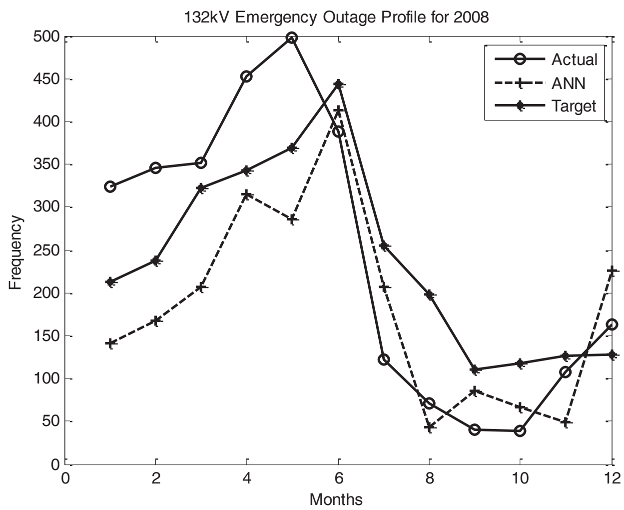

Figure 19: 132kV emergency outage profile for 2008

4.2 Discussion

The results obtained for the outage periods shows that ANN could be used to predict the power outage periods in the country as attested to by the regression curve value of 0.9 obtained. This would enable adequate plans to be made and the consumers should be provided with such data in order to plan their activities.

The training performance goal is met with one of the fastest training algorithms other than the 'trainlm', that is, 'trainoss' as shown on the matlab window below:

TRAINOSS-srchbac-calcgrad, Epoch 0/300, MSE 1.76984/0.001, Gradient 5.33559/1e-006
TRAINOSS-srchbac-calcgrad, Epoch 21/300, MSE 0.000936266/0.001, Gradient 0.0469698/1e-006
TRAINOSS, Performance goal met.

The "trainoss" stands for one step secant (OSS) method and is an attempt to bridge the gap between the conjugate gradient algorithms and the quasi-Newton (secant) algorithms. This algorithm does not store the complete Hessian matrix. It assumes that at each iteration the previous Hessian was the identity matrix. This has the additional advantage that the new search direction can be calculated without computing a matrix inverse. It therefore requires less storage space and computational time.

5. Conclusion

Power outage forecasting helps to evaluate grid system outage times and serve in some way to represent or show the pattern of the present and future grid downtime. It also enhances adequate planning on both consumer side as well as the supply authority side. Furthermore, improvement as regards ways to lessen outage periods of whatever type could be fashioned since research activities would have shown the causes of such outages before they occur. The result obtained from this research work shows the efficiency of neural network and the accuracy of short term method to forecast outage periods. The Network was able to determine the nonlinear relationships that exist between the historical outages experienced that is presented to it during training phase.

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