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Check the Stability of Smart Grid Using Deep Learning Technique

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ABSTRACT

The smart grid stability process starts with collecting consumer information, then estimating this information against performance specifications, and finally sending the pricing information to consumers as consumption reports. This process takes long time and should therefore predict the stability of smart networks using artificial neural network (ANN). Current improvements in NN accuracy have provided effective solutions for solving prediction problems of smart grid stability, but there is still a need to enhance high-performance NN that offer higher accuracy. Deep Learning (DL) technique is suggested to predict intelligent grid stability for smart grids in this paper. Neural network is utilized to a dataset collected from network stability simulations to predict the network stability as stable and unstable. The efficiency of the proposed technique guarantees high efficiency with a test accuracy of 97.3 %. This article shows that DL models provide new insights into the simulated system. A quick adjustment generally enhance system stability as depicted in this paper.

Keyword: Prediction, Smart Grid, Classification, Optimization Techniques.

1.Introduction

Artificial Intelligence (AI) techniques were suggested to predict electrical loads for a smart grid in [1-4]. The authors focus on utilizing different deep learning purposes for smart grid load prediction.Wood introduced a mathematical model for smart grid Control systems to show smart grid demand control by correlating electricity costs with grid frequency changes based on small-second timing metrics in [5].Chen et al, suggested a ML technique with a principal ingredient analysis process [6-8] to decrease the data size utilized to increase the stability of smart grids in [9]. Arzamazow et al suggested a classification and regression tree algorithm to predict the stability of smart grids. A four-node star model for simulating smart grid system have been utilized by authorsIn [10],alsothey obtained an overall accuracy of 80%. Aghamohammadiet al in [11] [12] suggested a decision tree model with a sufficiently simple hierarchy to predict the stability of smart grids. This pattern was utilized in a 39 bus power system. Six patterns from the data set were utilized and an overall accuracy of 90.3% was gained.The essential contribution of the paper is utilizing ANN to predict the stability of a smart grid whether stable or unstable.

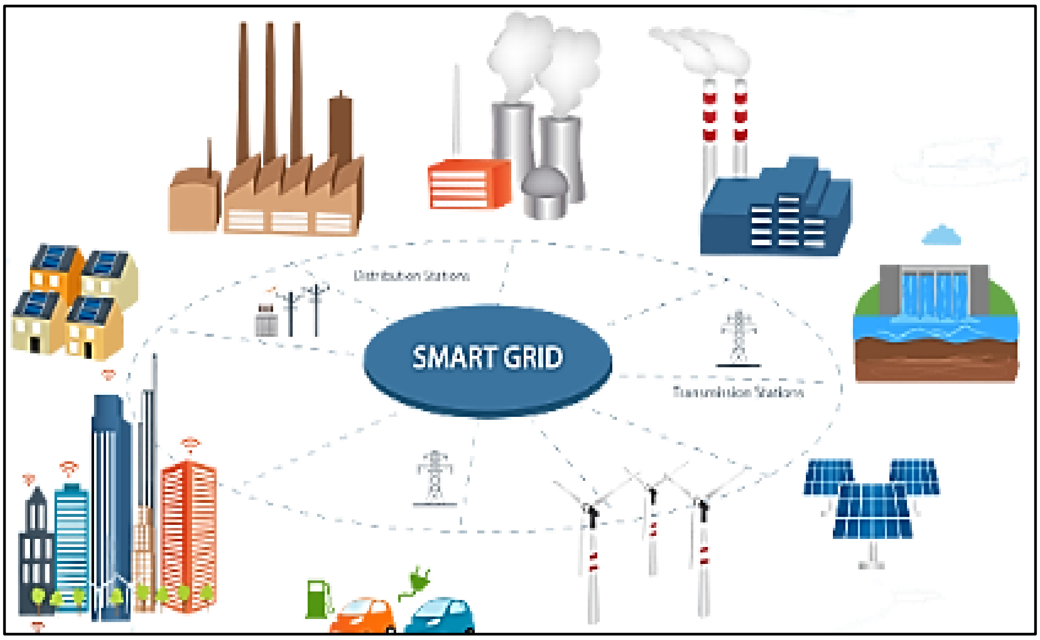

Fig1. The structure of smart grid

2.Suggested Artificial Neural Network (SANN)

The proposed architecture of NN consists of an input layer, five hidden layers, and an output layer. The input layer has 256 neurons with 12 features. Firstly, a hidden layer is utilized for all features of input data; this layer utilizes a ReLU activation function to hold data features. The hidden layer has 128 neurons, followed by another hidden layer with 64 neurons, and 16 neurons with a ReLU function, then followed by a final hidden layer that has a configuration of 8 neurons and also uses a ReLU function. Finally, the output layer has one single neuron, and uses a sigmoid activation function to minimize the output for two classes [13].This NN is built using the Keras framework. An Adam optimizer algorithm is used in this NN [14]. This technique, which defined the optimum weights for this NN, minimizes errors and also maximizes training accuracy [15]. A loss function is utilized to measure the error between the prediction and the true values [16]. This NN is trained based on a batch size of 64 and training epochs of 200. This NN has total trainable parameters of 47,233.

2.1. Dataset

The dataset used for the classification is from the Kaggle website [17]. It has 1000 patterns of two grid classes: stable and unstable. The dataset has results that are aggregated from grid stability simulations carried out in a five-node star network hierarchy. The hierarchy has an artificial nature. It consists of a power source and a localized production node that powers three receiving nodes.The dataset contains twelve features related to network stability as shown in table 1:

Table 1. Details used in the dataset for smart grid

Features	Name	Values
From P1 to P4	Nominal power	-2 to -0.5
From tau1to tau4	Reaction time of each network	0.5 to 10
g1, g2, g3, g4	Energy price elasticity coefficient	0.05 to 1
g1	Supplier node	
g2 to tau4	Consumer node	
stab	Positive value (system linearly unstable) Negative value (system linearly stable)	
stabf	Binary label (stable or unstable)	

2.2. Performance Metrics

The performance metrics are used to test the performance of the suggested NN utilizing the different metrics [18–20] after the training process. These metrics contain accuracy, recall, precision, and F1-score. These metrics are based on true negative (TN), false positive (FP), true positive (TP), and false negative (FN). Note: (0 indicates smart grid stability, 1 indicates smart grid instability).

Table 2:Performance metric equations

Parameters	Formula
Precision	$TP/(TP + FP)$
Sensitivity	$TP/(TP + FN)$
Accuracy	$(TP + TN)/(TP + TN + FP + FN)$
F1-score	$2*[\frac{(Precision * Recall)}{(Precision + Recall)}]$

Table 3:Layers summary of suggested neural network

No of layer	type	Output neurons	Parameters for training
1	input	256	3328
2	hidden	128	32896
3	hidden	64	8256
4	hidden	32	2080
5	hidden	16	528
6	hidden	8	136
7	output	1	9

3. Results and discussion

The suggested NN is experimentally implemented in the Google Colab Notebook environment by utilizing the programming language Python. The accuracy of the NN is depicted in figure 2. The curve with a blue color is training accuracy, which continuously changes and extends to a maximum value of 97.3% after 35 epochs.

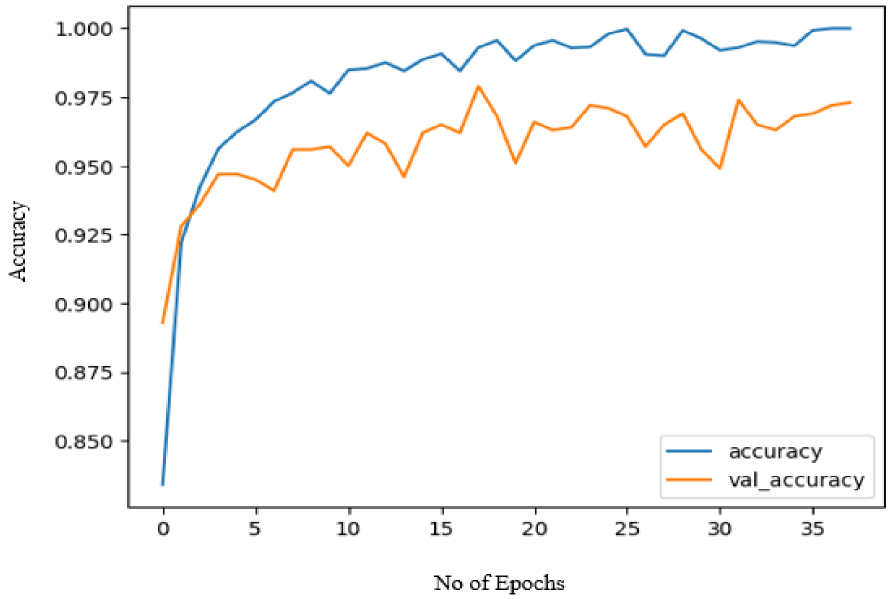

Fig2.Proposed neural network accuracy curves

The confusion matrix gained from the suggested ANN has been shown in Figure 3. Here, the matrix identifies 349 and 624 as true positives for the two classes: unstable grid and stable grid, respectively.

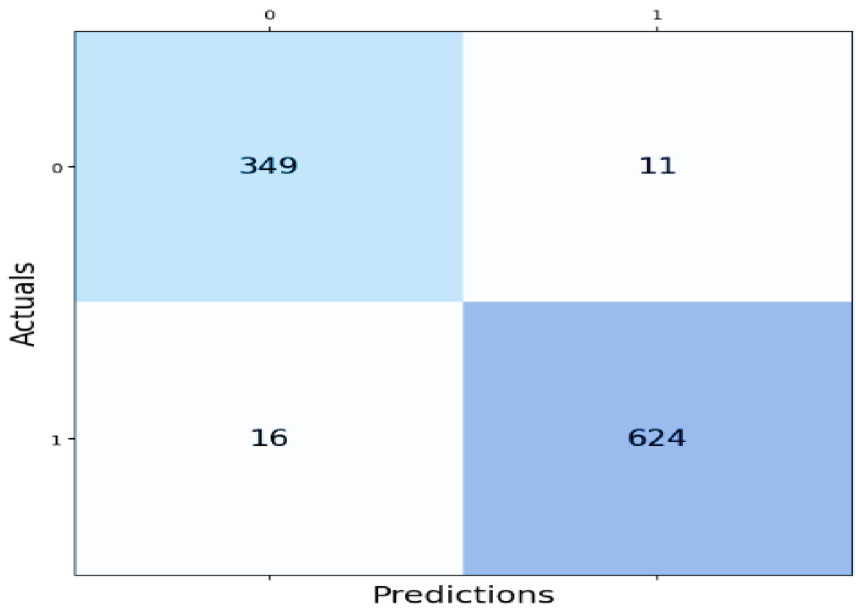

Fig3. Suggested neural network confusion matrix

The obtained dataset information can be depicted in Figure 4. Illustrates the relationship between the selected dependent parameter "stabf" and the numeric characteristics. Also, it is easy to view the average relationship between the generated power "p1" and reaching to p4".

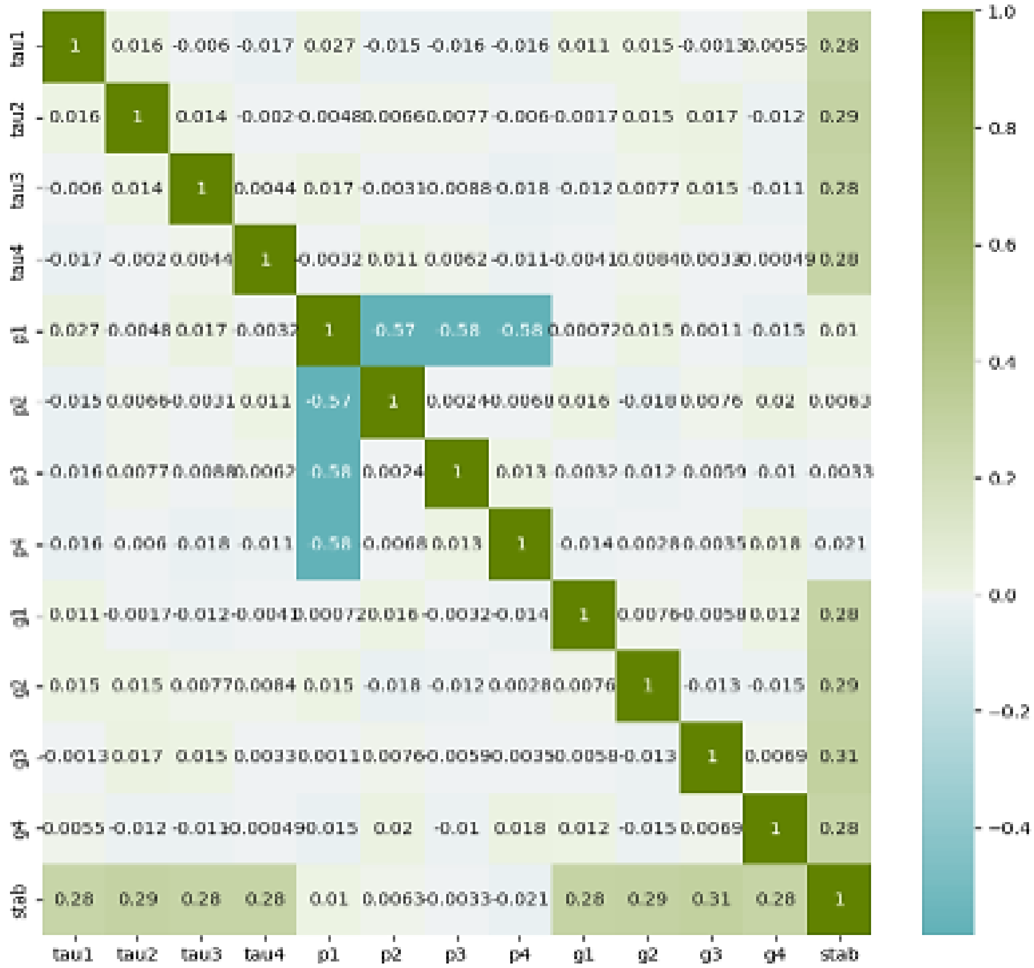

Fig4.Correlation matrix for information on the dataset

4.Conclusion

The article proposes the implementation of a neural network to predict the stability of a smart grid. The data set used comes from a simulation of DSGC systems. Experiments to verify the accuracy of the suggested neural network achieved a test accuracy of 97.3%. A confusion matrix is described that allows for an assessment of the performance of neural networks. In the future, it will also be possible to construct a new neural network to increase accuracy in predicting network stability. The suggested neural network can be constructed with multiple dataset patterns.

Data Availability

Data is available on request from the authors

Conflict of Interest

I do not have any conflict of interest.

Funding Source

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Authors' Contributions

Nada Mohamed Sallam is corresponded author; she researched literature and conceived the study, put the protocol for the manuscript, and wrote the first draft of the manuscript. reviewed and edited the manuscript and approved the final version of the manuscript.

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