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A Comparative Study on Condition Monitoring of HVDC Transmission System using Different Artificial Neural Network Techniques

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Abstract - *In the present era of deregulation and competition, demand from every energy supplier is to have good continuity, being trustworthy and reliability. Fault location can play a vital role in achieving this aim. As uninterrupted power supply is the prime demand by all consumers. However, faults in power system will leads to the interruption in power supply and it will make system vulnerable towards system outrage/collapsing and will lead to damage various electrical peripheral of switch gear/ electrical equipment. Here upon all faults are required to be detected and clear as soon as possible to restart power supply to consumer. Emplacement accuracy knowledge of fault location will come very handy in reducing system outrage time and they're by improving continuity and reliability of system. Multifarious researches have been done previously towards finding accurate result. In this paper location detection using various artificial neural network (ANN) techniques is presented. The goal of the work is to prepare a model which can somehow manage to give accurate fault location on HVDC line thus helps in improving the system performance. In this study we are offering a model formed using ANN model for the purpose of fault location presence in HVDC transmission line using the information of sending end and receiving end voltage. This offered work is performed with the help of MATLAB/Simulink environment and simulation using PSCAD software. The results demonstrate the superiority in efficiency and precision of present model in fault location detection using ANN than other tools.*

Key Words: **Fault location Detection, ANN, trainlm, HVDC, MATLAB, PSCAD/EMTDC.**

1. INTRODUCTION

A HVDC Transmission system has very efficient means of transferring power in bulk over long distances due to rapid technical advancement in power electronics. ANN is a mathematical model inspired by biological neural network. It is a powerful in pattern recognition and classification. They possess excellent features such as generalization capability, robustness, noise immunity & fault tolerance. ANN based techniques have been used in power system protection & encouraging results are also obtained. This paper aims to investigate pattern of the over current due to different cases, for instance, load change & fault. The fault taking place on HVDC transmission lines may cause instability of power system & therefore a large economic loss occurs. Artificial Neural Network gives the best results in fault detection and classification.

2. NEED FOR THE STUDY

Basic need is to determine best ANN training algorithm for fault finding and detecting in HVDC transmission system. To propose an HVDC transmission line fault localization algorithm based on ANN with comparison of all types of fault detecting methods. Finding or detecting the faults through different ANN methods

i.e. LM, SCG, and BR algorithmic methods.

3.METHODOLOGY

Following techniques are utilized in present work for the purpose of fault location estimation:

Artificial Neural Networks (ANN):

The evolution of ANN has been dated way back in 1980's with the evolutions of computers. From the very same process of evolution, the term artificial neural network is been derived. The word artificial is basically used to denote the capability of this model to replicate the working of human brain. Usually machines possess a property work according to pre-defined instruction saved in it. However, this is not how human works. The brain of any human has the capacity to take decision based on its experience which we call training in computers language. Hence, it gives capability to brain to take decision that too right in cases which are new to it. Therefore, machine learning is a method by which we inherit this specialty of human biological thinking system and try to replicate same in computer/machine.

Now let's understand how human brain works to form exact algorithm which can give similar outputs. Brain consist of billions of neurons, which are interconnected with each other. These interconnections have a certain strength, which makes our memory storage. Based on these memories we take decision over everything in real time. The strength of these connections depends mainly on signal from various cells/neurons situated in each part of our body. These neurons continuously send signal according to sense organs response to brain in the form of electromagnetic pulses. These pulses are passed to brain through a series of chain of cells linking brain with sense organs. These chains of cells have two responsibility to transfer signal from one part of body to other and second to modify the signal in such a manner that brain will take the decision instantaneously.

Now the objective of formation of neural network is to reproduce the same scenario in computer based upon programming, algorithms, processor and memory, which is discussed in detail in next section.

Levenberg–Marquardt (LM) Algorithm: The algorithm used in this work is Levenberg–Marquardt (LM) Algorithm which a type of back propagation algorithm. The reason behind using this algorithm is due to its exceptional ability to extract information from a nonlinear data with great stability which keeping speed of convergence intractably high. The algorithm is a combination of two different algorithms proposed by two mathematicians Levenberg and Marquardt and hence the named over them. The drawback of prior one is remove by the advancement of second. The equation were derived back in mid-20th century for the sake of 1st order error reduction purpose. However, with the invention of computers and high-level computation problem this algorithm is evolved in to a great tool for time series forecasting. When the performance function has the form of a sum of squares, then the Hessian matrix can be approximated and the gradient can be computers

(1) $H = J_x{}^T$

(2) $g = J_x$

Where J_k is the Jacobian matrix for k[th] input, which contains first order derivatives of the network errors with appreciate to the weights and biases, *e* is a vector of network mistakes. The Jacobian matrix can be computed through a well-known back propagation method that is a good deal less complex than computing the Hessian matrix. [11]

The Levenberg –Marquardt algorithm is actually a blend of the steepest descent method and the Gauss–Newton algorithm. . The following is the relation for LM algorithm computation,

$$W_{k+1} = W_k - [J_K{}^T J_k + \mu I]^{-1} J_K{}^T e_k$$

It tries to combine the advantages of both the methods hence it inherits the speed of the Gauss–Newton algorithm and the stability of the steepest descent method. The combination coefficient μ is multiplied by some factor (β) whenever a step would result in an increased e_{k+1} and when a step reduces $e_{k+1,}$ μ is divided by β. In this study, we used β=l0. When μ is large the algorithm becomes steepest descent while for small μ the algorithm becomes Gauss-Newton. [11]

The Neural Network in present study consists of three layers. The primary one is input layer (consist of four Neutrons for 4 enter detail) from where inputs are feed to model for further computation. Then comes 2nd layer referred to as Hidden Layer (consist of 10 Neurons), that is wherein activation characteristic is used to restrict price of output Neuron.At last we have output layer (1 Neuron) form which we take output result for comparison with actual result to calculate error and the feeding it back to model to vary weight accordingly for improving performance.

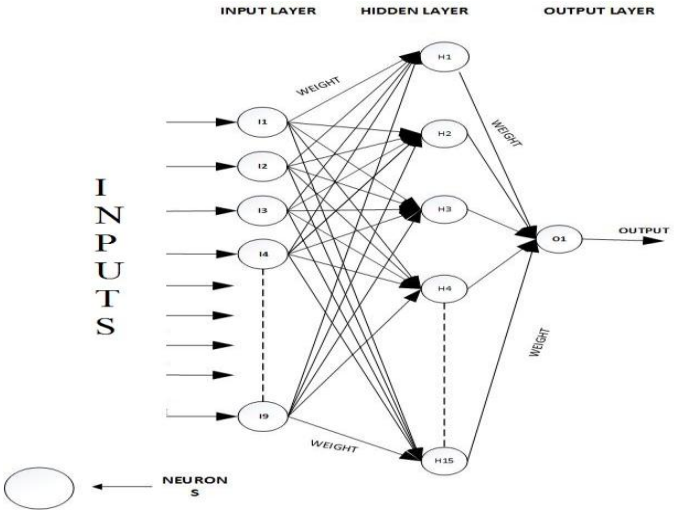

Fig.1: Working model of an ANN

4.STAGES FOLLOWED IN FAULT LOCATION ESTIMATION

Following stages are followed in same order as mentioned estimating fault location.

Stage 1: Data Collection Stage

First stage of present work is to collect data for neural network training and testing. For this a bipolar HVDC transmission line is simulated for fault at a step of 1 km in PSCAD/EMTDC software and data of both sending end and receiving end is collected. This data is input data for Neural Network. In the present study a line of DC voltage of ±500kV 816 km is taken. This line is a prototype of India first bipolar line i.e. Rihand-Dadri HVDC line. A case study is done for same line in present work. Fault location value is target data for neural network. Hence all data is collected using multiple simulations and presented to neural network.

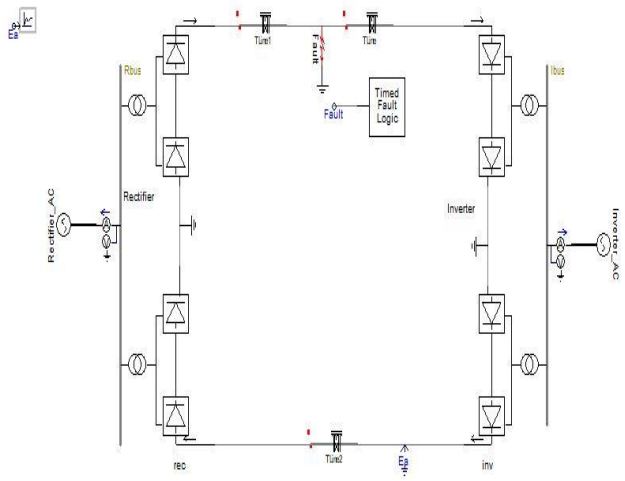

Fig.2: ±500kV HVDC Bipolar line model in PSCAD.

Stage 2: Data pre-processing stage

In this stage, all the data extracted in previous stage are organized and pre-processed for further stages. In this stage first all the data is copied in single ms excel sheet, with each column representing value of each input parameter. A search is to be performed to check for empty data cells in sheet for better performance. This data is than inserted in Mat lab workspace using drag and drop method for using in developing model. This data is then divided in to input and target data. This two are further divided in to two parts one for training and other for testing. Approximate to 3:1 is kept for dividing data for training and testing.

Stage 3: Neural Network Training Stage

In this stage we will feed input data to input layer of present designed model and target is fitted to output layer. We have used LM and BR training algorithm for training. It is this stage in which model is prepared and value of weights is optimized for better performance according to input and target data samples.

Stage 4: Neural Network Testing and validation stage

At this stage, the second part of dataset is used. Although only inputs are provided to already train neural network and output is calculated from neural networks. These are then compared to original target fault distance to observe the closeness between the two.

The below figure shows a training GUI of neural network, which will give all details of related to training. We have taken 10 hidden layer neurons 4 input layer neurons and 1 output layer neuron

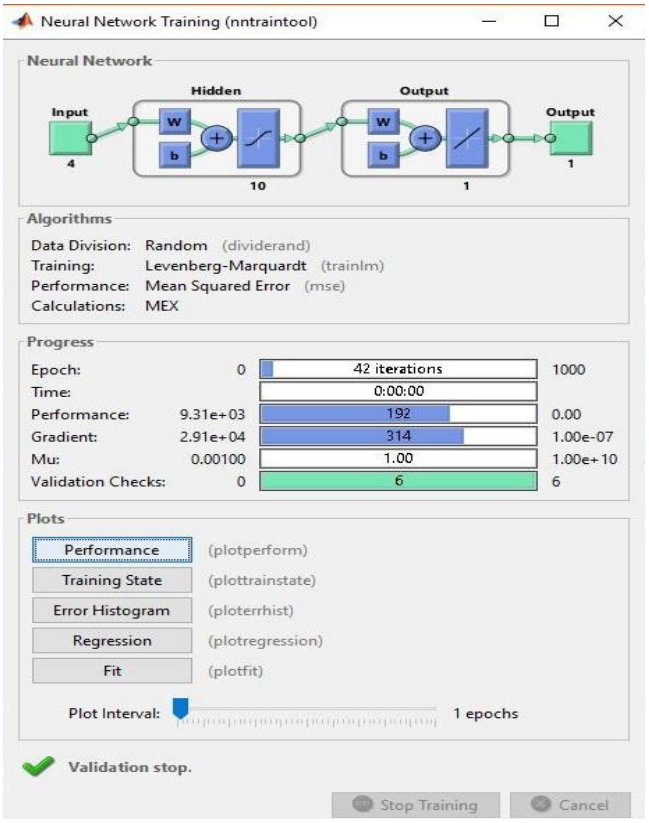

Fig.3: GUI of ANN during training.

5. RESULTS

With trainlm >>

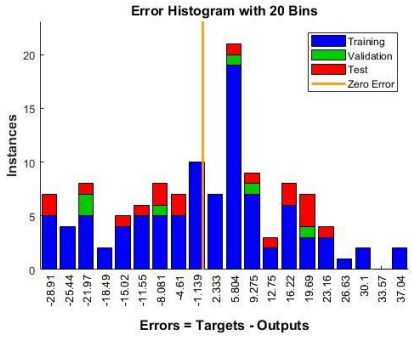

Fig.4: Error histogram employing the proposed model using LM training.

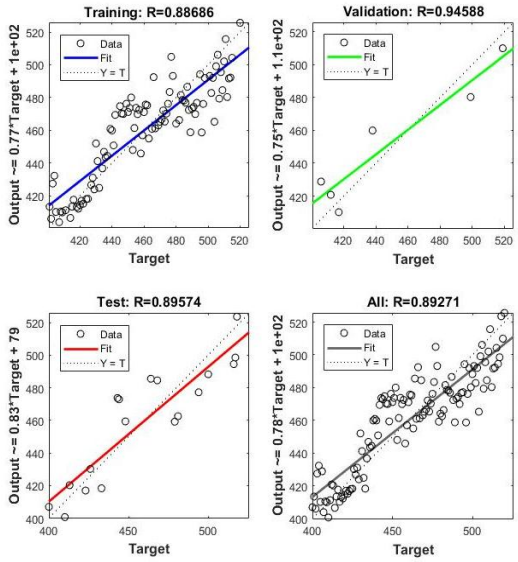

Fig.5: Regression plot during training, testing & validation for Proposed LM training algorithm.

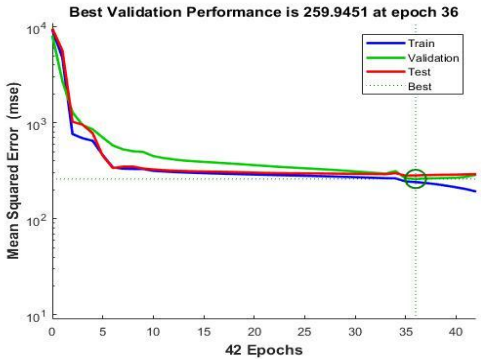

Fig.6: Neural network performance during training, testing & validation.

6. CONCLUSION

In the present research, an attempt is made to predict fault location for a HVDC link using ANN models by utilizing receiving end and sending end data to train ANN model. The model developed is able to predict fault location accurately. The developed ANN model with the configuration of 4-10-1 is trained using back propagation algorithm LM. The results show that LM will give accurate results and thus proving to be very efficient method.

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BIOGRAPHIES