Power Systems fault Diagnosis using Machine Learning

**ABSTRACT:**

Power systems has many challenges which include fault diagnosis, load frequency control, unit commitment, load scheduling, optimization, etc. In the above-mentioned fault diagnosis is one

of the major issue. This issue can be resolved by using various traditional and artificial intelligence based techniques. This paper focuses on fault detection and classification in electrical transmission system using Machine Learning. The simulation results concluded that Partially Recurrent network is efficient in detecting and classifying the faults on transmission lines with satisfactory performance.

**KEYWORDS**: Artificial neural networks, Deep neural network, Recurrent Neural Network,Fault diagnosis.

**INTRODUCTION**:

The electrical power system consists of various different complex dynamic and interacting elements, which are always prone to disturbance or an electrical fault. Power plants and geographically displaced grids requires fault detection and protection of equipment in minimum possible time so that the power system remains stable.

This Paper is divided into five sections. The section one is background, which discusses the significance of fault detection. Second section explains about Artificial neural networks. Third section gives an overview of Deep neural networks and training methods. Fourth section emphasis the details of transmission line model and its simulation results. The final results are concluded in last section.

**FAULT CLASSIFIACTION TECHNIQUES-Machine learning**

**ARTIFICIAL NEURAL NETWORK:**

An Artificial neural network is a mathematical model or computational model that is inspired by the structure and function of biological neural networks. The algorithm which employed Artificial neural network offers many advantages, but it also suffers with many disadvantages, which are very complex in nature. Some of the important factors are the selection of type of network, architecture of the network (which includes the selection of number of layers, number of neurons in each layer, learning rate.), termination criteria, clustering etc.

**DEEP NEURAL NETWORK**:

Deep neural network is a network with one input layer, one output layer, and more than one hidden layer in between. Each layer performs specific types of sorting and ordering in a process that some refer to as ”feature extraction.” The term “Deep learning” is also used to describe these deep neural networks, as deep learning represents a specific form of machine learning where technologies using aspects of artificial intelligence seek to classify and order information in many ways that go beyond simple input/output protocols. It can be applied to fault detection and classification effectively because it is capable to solve the problem of non linear data very easily. Deep learning does not require labels to detect similarities. Learning without labels is called unsupervised learning. The more data an algorithm can train on, the more accurate it will be.

**RECURRENT NEURAL NETWORK:**

A recurrent neural network is a class of Artificial neural network where connections between nodes form a directed graph along the sequence and exhibits temporal dynamic behavior.It uses memory to process variable length sequence of inputs.Recurrent neural network are designed to take a series of input with no predetermined limit on size.

There are two types of recurrent structures to choose from.

1. The fully recurrent structure connects the first hidden layer to itself through a recurrent synapse connection.
2. The partially recurrent structure adds a feed forward connection,through a synapse,from the input axon to the layer after the first hidden layer.In this case,the recurrent structure acts as a state for the feed forward structure. It uses memory to process variable length sequence of inputs.Recurrent neural network are designed to take a series of input with no predetermined limit on size.

ADVANTAGES:

* Recurrent neural network is useful in time series prediction because it is capable of remembering previous data as well.This is called Long Short Term Memory.
* RNN are even used with convolutional layers to extend the effective pixel neighborhood.

**PROBLEM STATEMENT:**

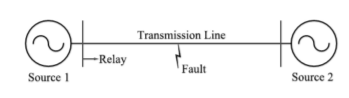
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Fig.1 The system with sources at both ends

A simple three phase system is studied in this paper as shown in fig. 1. The length of the 220 kV transmission line is 200 km and the system frequency is 50 Hz. The transmission line connects two sources and has positive sequence impedance Z1 = 4.76+j59.75 Ω and zero sequence impedance Z0 = 77.70 + j204.26 Ω. The system is modeled in MATLAB, with which the data used in this paper is simulated. The load angle is 20 degrees at the normal operating condition. The fault locations are 0 km, 50 km, 100 km, 150 km, 200 km. The fault resistance is 0.001 Ω, 5 Ω, 10 Ω, 15 Ω, 20 Ω. The fault types are a-g, b-g, c-g, ab, ac, bc, ab-g, ac-g, bc-g, abc, non-faulty. The data set contains 26000 samples. 80% of data set is used for the training, 5% is used for the cross validation , 15% is used for the testing purposes.

**RESULTS:**

Fig .2. Training curves

Neurosolutions software is used for the neural network training and testing. We have used Partially Recurrent Neural Network for the classification problem. The network contains 5 hidden layers and good results are obtained for the classification problem. Fig. 2 shows the mean square error vs epochs.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Output / Desired** | *No\_Fault* | *AG* | *BG* | *CG* | *AC* | *BC* | *CA* | *ABG* | *BCG* | *CAG* | *ABC* |
| *No\_Fault* | 151 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *AG* | 0 | 366 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *BG* | 0 | 0 | 391 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *CG* | 0 | 0 | 0 | 380 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *AC* | 0 | 0 | 0 | 0 | 393 | 0 | 0 | 0 | 0 | 0 | 0 |
| *BC* | 0 | 0 | 0 | 0 | 0 | 369 | 0 | 0 | 0 | 0 | 0 |
| *CA* | 0 | 0 | 0 | 0 | 0 | 0 | 373 | 0 | 0 | 0 | 0 |
| *ABG* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356 | 0 | 0 | 0 |
| *BCG* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 410 | 0 | 0 |
| *CAG* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 329 | 0 |
| *ABC* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 382 |

Table 1: Network output with testing data

**CONCLUSION:**

The Paper uses partially recurrent neural network for the power system fault classification problem. This network is giving the 100% accuracy for the classification problem. Further study has to be done with the fault inception angle and the power factor variations in the network output.