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Transmission Line Fault Classification using Supervised Machine Learning

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Abstract*: Among Generation, Transmission and Distribution systems of power systems 80-90 % of faults occur in transmission lines. A small electricity interruption or disturbances can cause major problems in transmission lines. Major faults in transmission lines occur because of environmental events like high temperatures, animals, wind, etc and also faulty devices connected to transmission lines are also a major cause for these faults. In modern power systems line faults are one the major and significant problems leading to high power losses and electrical devices failure. So, it is necessary to recover these problems in transmission lines immediately to avoid major problems and also need to eliminate the faults quickly. There are few tools and protective devices installed in transmission lines to prevent these faults but during any complex and bigger faults they require more time and also these protective devices may sometimes fails or may be damaged because excessive major faults in transmission lines. But a data driven method can be more helpful than conventional proposed methods as they need less installation cost and fast responsive and even system operators or any individual can easily identify the type of fault. This paper analyzes supervised machine learning algorithms for classifying different faults in transmission lines.

***Keywords*: Machine Learning, Transmission Line Faults, Data-Driven Method,**

I. INTRODUCTION

Transmission line protection is a key requirement for efficient power supply in power systems. Fundamental devices like relay, circuit breakers and fuses are used to safeguard the operations in power systems, but they have few drawbacks . Circuit breakers, relays and fuses fail to operate during high and complex faults in transmission lines so there will be a regular requirement to check whether these devices work properly to resolve power disturbances.

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Protective relay is an important protective device for reliable operation in power systems . This relay classifies the nature of occurring faults from normal events of the power system and helps in phase selection to remove the fault connection from line before circuit breakers opens the circuit interrupting power supply. A major drawback with this device is , it fails to identify faults for complex system models and also unable to learn the system model parameters which lead to major block outs and damage of other components. There exists multiple methods for fault diagnosis in transmission lines but these diagnose the system after faults and also conventional filter methods are not efficient for fault classification because of complex modeling of power system and also these methods fail during complex and dangerous faults. Hence this paper proposes a supervised machine learning based approach for classification of faults in transmission lines. There are various types of fault occurring in transmission line but four faults are major namely, L-G faults ,L-L faults .L-L-G faults ,L-L-L faults. Among these Line-Ground(L-G) faults are most common faults. The proposed work will be able to classify 5 types of faults using classifier algorithms.

II. LITERATURE SURVEY

Fault classification is an important and difficult task , many methods and attempts have been proposed for an accurate detection and classification of faults. In [1] M. Sanaye-Pasand1 proposed an Artificial Neural Network model for fault detection and phase selection, the proposed method uses current signals for learning the pattern of faults in transmission lines. In [2] Mohamad Arif Mohamad Nasrin proposed a deep learning method to classify ten type of faults and main aim is to automate the transmission line complex signals and feature extraction. Parveen Poon Terang [3] proposed a ANN model and implemented this model on IEEE 9 bus system for testing of model. Prasad Avagaddi [4] proposed a fuzzy logic technique. This method uses two fuzzy classifiers for detection of fault and classify types of faults. An fault classification in transmission lines can help engineers understand the causes of the faults and hence an accurate prediction is necessary. Not only data-driven methods but Farhad Namdari proposed a Continuous wavelet transform (CWT) method for extraction of information like voltage, current components. The proposed method is tested for different fault situations and these fault simulations are designed with PSCAD and MATLAB. There are few deep learning based techniques for accurate fault classification and identification, In [5] they proposed an LSTM model on 400kv transmission line and it can classify ten types of faults.

III. PROPOSED METHODOLOGY

This section reviews the proposed methodology for accurate fault classification in transmission lines.

A. Power System Framework

Dataset [6] used for testing the model is simulated with MATLAB. Fault analysis is simulated for various types of faults, the modeled power system consists of four generators with each of capacity 11KV and each of these generators are paired and connected at each end. Figure 1 shows the circuit of used power system model.

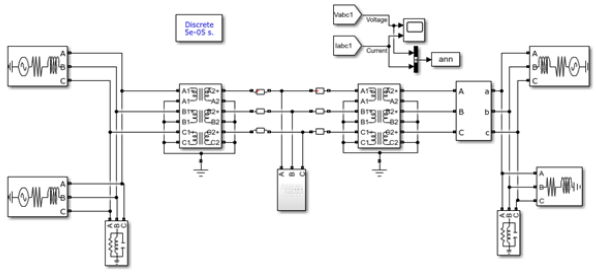

Figure 1. Modeled Power system for fault classification

B. Dataset Description

The collected dataset contains data of three phase transmission line simulated with MATLAB for various faults. The model uses this data for fault classification. The data contains three phase currents Ia, Ib, Ic and three phase voltages Va, Vb, Vc. The output is fault class.

C. Proposed Flowchart for classification

This section discusses the proposed workflow in detail for classifying faults.

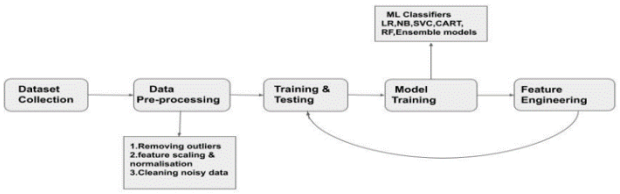

Figure 2. Flowchart/Block Diagram

- *Phase1: Data Collection*

Monitoring real time power system data is difficult to maintain because of high demand of electricity consumption and also storing the data can be difficult due to security and privacy issues. Hence data is generated with MATLAB simulation for various faults.

- *Phase 2: Data preprocessing*

Data preprocessing is needed because data generated will have duplicate values and also it is difficult to model an algorithm with messy data. We perform techniques like outlier detection, data normalization and data scaling .

- *Phase 3 & 4: Training, Testing and Modeling*

Various supervised machine learning algorithms are used for modeling and testing on generated data. Algorithms like Logistic Regression, Support vector classifier, Decision Trees, Random forest classifier. And comparison of algorithms is made to find the best performing algorithm for fault classification.

- *Phase 5: Feature Engineering*

Feature engineering helps to improve model performance by building pipelines as data transformation and dealing with NaN values.

IV. EXPERIMENTS AND RESULTS

Various experiments are performed to increase the models performance. The problem we deal with is multi-class classification. The number of samples present in each class is shown in figure 3.

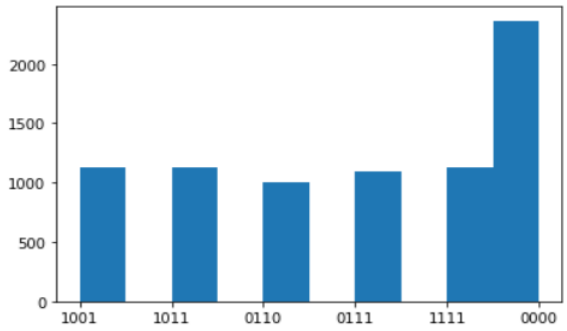

Figure 3. Number of samples for each class

1001 indicates Line-Ground fault, 1011 indicates double Line- Ground fault, 0110 indicates Line-Line fault,0111 indicates LLL fault, 1111 indicates LLL-Ground fault. Main goal of this proposed model is to correctly classify these faults in transmission lines.

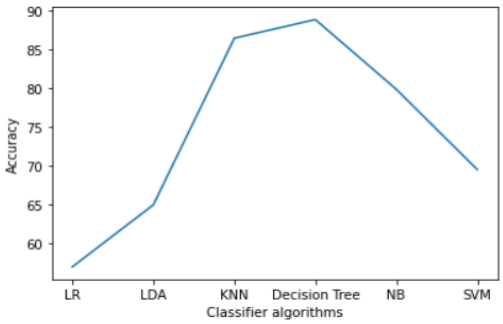

Figure 4. Comparison of Classifiers on various Algorithms

Among all machine learning classifiers Decision Trees achieved an accuracy of 88.9% on test data and figure 4 shows the algorithms comparisons. But we need to improve the performance of algorithms, we used ensemble algorithms like Random Forest, Gradient boosting (GB), Adaboost and Extra tree classifiers. Figure 5 shows the comparison of all algorithms . Random forest classifier achieved accuracy of 87.09 % but less than Decision Trees.

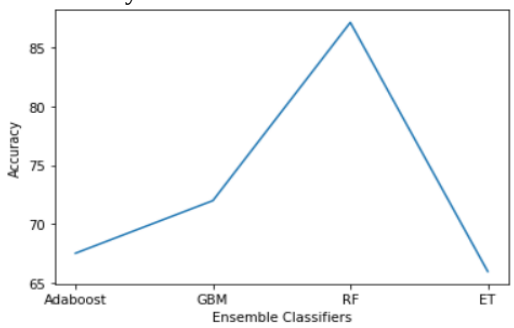

Figure 5. Ensemble Model Performance and Comparison

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Considering all experiments best performance is shown by the Decision Tree classifier with an accuracy og 89 %. But it is necessary to evaluate classifier models based on metrics precision, F-score, recall. Figure 6 shows the classification report of Decision tree classifier.

	precision	recall	f1-score	support
0000	1.00	1.00	1.00	469
0110	1.00	1.00	1.00	218
0111	0.60	0.62	0.61	203
1001	1.00	0.98	0.99	236
1011	0.98	0.99	0.98	219
1111	0.64	0.63	0.64	228
accuracy			0.89	1573
macro avg	0.87	0.87	0.87	1573
weighted avg	0.89	0.89	0.89	1573

Figure 6. Classification report of Decision Tree Classifier

V. CONCLUSION

Machine learning has wide range of applications in power systems one such use case can be classification of types of faults in transmission lines. From proposed method Decision Tree classifier achieved an accuracy of 89% but techniques like deep learning, fuzzy logics can also be applied. This work can be useful for maintenance department in power systems to fastly diagnose the cause of faults and also this reduces the effort of technicians they spend on knowing the type of fault occurred while repairing.

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