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Optimized Support Vector Machine for Fault detection and Classification on the Monitored Satellite power system information

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Abstract:

Satellites are used for many application purposes as semi independent controlled system which has to be frequently monitored to diagnosis of operation of components. Failure of fault prediction of the satellite in time manner will lead to heavy irreparable damages. Especially power system failure is common power related issues in the satellite mission. Further many power monitoring sensors has been deployed in the satellite to represent the information about power. The conventional manual level evaluation of monitoring sensors has been augmented with data driven fault diagnosis approach which reduce the false alarm and burden on operating personnel. However automated power monitoring system will produce more advantages on diagnosis of the fault in the satellite using the sensor information. Despite several advantages, it faces many challenges on the failure of sensor measuring the power in the satellite. In this paper, a Support vector machine is been used to identify the failure of the power system and power system measuring sensor accurately in time and frequency domains. Initially model extract the fault features using feature extraction technique and classifies the fault on basis of the extracted features under complex monitoring task. Experimental results of the proposed model has been evaluated using benchmark publically available dataset named as Advanced Diagnostics and Prognostics Testbed (ADAPT), a publicly-available dataset. The performance analysis of the proposed model yields better accuracy on the classifying the monitored information on comparing with conventional approaches.

Keywords **— Satellite Fault Analysis, Machine learning, Power system, Support Vector Machine, Principle Component analysis.**

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I. INTRODUCTION

Satellites are used for many application purposes as semi independent controlled system which has to be periodically monitored to compute normal mode of satellite operation among its components. Failure of fault prediction of the satellite components in timely manner will lead to heavy irreparable damages on the mission operation. Specifically, power system of the satellite will be frequently leads to several challenges in terms of faults. Hence power system monitoring has been become crucial step in satellite [1]. It is monitored by deploying power monitoring sensors to obtain the power information.

The conventional manual evaluation system using information of monitored sensors has been augmented with data driven fault diagnosis

approach and model based fault diagnosis approach to reduce the false alarm rate and burden on satellite operating personnel[2]. However automated power monitoring system will produce more advantages on diagnosis of the fault in the satellite using the sensor information. Despite several advantages, it faces many challenges on the failure of sensor measuring the power in the satellite [3].

In this paper, an AI based methods such as Support vector machine is been used to compute the power system failure of the satellite on the processing of the sensor information with respect to time and frequency domains [4]. Initially model extract the fault features from the high dimensional data through feature extraction technique and classifies the fault on basis of the extracted complex functional features. Features are extracted from publically available dataset named as Advanced Diagnostics and Prognostics Testbed[5] which is considered as power system dataset.

The remaining article is sectioned as follows, section 2 describes the review of literature related to fault detection technique and it is followed by section 3 to define the proposed methodology for fault detection using machine learning architectures termed as support vector machine in addition to feature extraction technique and section 4 discusses the experimental result with respect to the detection accuracy and finally section 5 concludes the paper

II. RELATED WORK

In this section, review of literatures on various machine learning model based fault detection models applied to power system ADAPT dataset has been examined on various conceptual features has been detailed as follows

A. Regression Techniques for Satellite Fault Diagnosis

In this literature, regression model has been employed as machine learning technique for satellite power fault analysis on telemetry data which is high dimensional in nature. Initially telemetry data is clustered using k means clustering technique with aggregation of dynamic stochastic neighbor embedding technique for dimensionality reduction. Further reduced data is processed using regression analysis in order to classify failure of the power system and failure cause on telemetry parameters which lead to satellite failure on constructing the fault tree analysis [6].

B. Artificial Neural Network for Satellite Fault Classification

In this literature, artificial neural network has been employed as machine learning technique for satellite power fault analysis on telemetry data which collect considerable of heterogeneous sensed data using remote terminal unit and phasor measurement units. It is considered as fast fault diagnosis model as detection and classification of power system fault conditions is very crucial for reliable operation. Artificial neural network is capable determining the micro fault in the power system especially on fault orientations and severity degrees [7].

III. PROPOSED MODEL

In In this section, Optimized Support Vector Machine for Fault detection and Classification on the Monitored Satellite power system information has been designed for processing the sensed power system information of the satellite

Dimensionality Reduction – K Means clustering

In this part, dimension of the dataset is reduced using k means clustering. It eliminates the, irrelevant and outlier dimensions of the dataset. Dimensionality reduction also avoids the over fitting issues. It reduces the features through Clustering on the basis of correlation by determining the distance between the selected point and centroids point[8].

Feature Extraction – Principle Component Analysis

Principal component analysis is used to obtain the most distinguishing features for identifying the fault. It computes the features for extraction on basis of variance. The principle component of the fault sensed dataset describes the

greatest amount of variance dimension. PCA contains the feature vectors composed of sensor monitored power system information[9]. Feature vectors are processed using covariance matrix to produce the Eigen vector.

$$Cov(x,y) = (\Sigma_{i=1}^{n} a(xi - x)(yi - y))/(n-1)$$

Fault Classification – Support Vector Machine

Support vector machine is machine learning model employed to classify and detect the fault in the power system of the satellite by feature vector of the monitored information. Support vector machine process the vector on determining the hyper plane. Hyper plane is space of linear functions of the vector elements on frequency and time domains. Time series analysis learns the temporal data in hierarchical manner. Abnormal data is generated by varying the fault type and location. Figure 1 represents the block diagram of the proposed model[10].

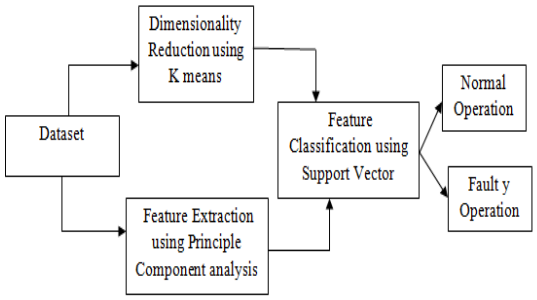

Fig 1: Block Diagram of the proposed model.

IV. SIMULATION RESULTS

In this work, fault analysis of the satellite power system has been experimented using support vector machine classifier on benchmark dataset. The fault analysis experiment was carried out using MATLAB R2018 .The dataset used in this work is ADAPT benchmark dataset The experimental results of the proposed model have been computed and evaluated on using K fold cross validation is described in detail in below sections. Initially dataset is segmented into training and validation set.

ADAPT dataset includes the information about the power generation, power storage, power distribution, control and monitoring. The ADAPT dataset has multiple sensor measurements recorded in the form of multivariate time series data. All sensor values (81 or 20 as may be the case) are recorded over specific interval as time stamped measurements. It has been classified using SVM to separates data points of one class from the other classes of sensed information

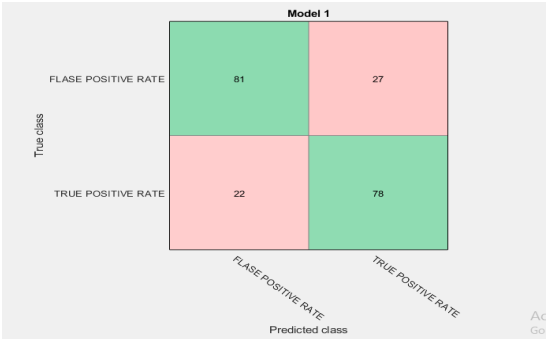

Fig 2: Confusion matrix of the validation set

The figure 2 represents the confusion matrix to compute the accuracy of the fault analysis proposed approach on cross fold validation. Accuracy is computed on basis of true positive, true negative, false position and false negative values.

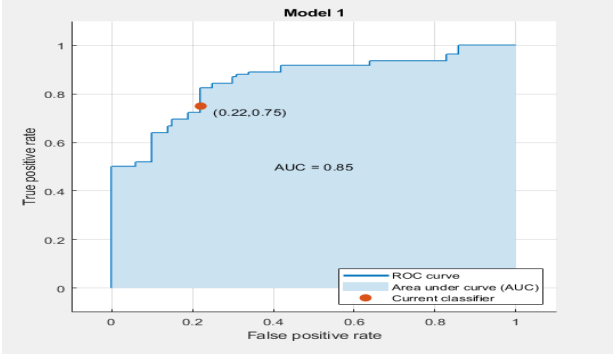

Fig 3: ROC Analysis and AUC analysis of the classification result

Figure 3 represents the ROC analysis and AUC Analysis of the classification of the fault analysis approach. Compared with conventional approaches, the proposed approach achieves the highest AUC value of 0.976.

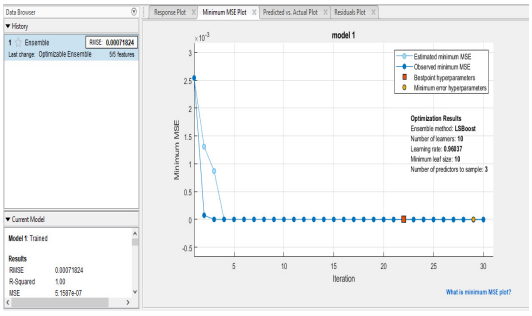

Fig 4: Mean square Error Analysis

Figure 4 provides the mean square analysis on the proposed model changes of the validation with respect to 5 fold. Finally proposed model is capable of determining the satellite power system fault accurately using various parameter situation and max argument functions.

CONCLUSION

A new satellite power system fault analysis model using support vector machine has been designed and simulated in matlab. The model is tested using ADAPT dataset and it performance has been cross validated with 5 fold. Dataset is composed of time series data, so it has been processed using k means and principle component analysis for feature reduction and extraction. Further proposed model is capable of detecting the fault with high accuracy. Finally the ROC and AUC analysis are carried out for proposed system against conventional approaches.

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