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Induction Motor Condition Monitoring System Based on Machine Learning

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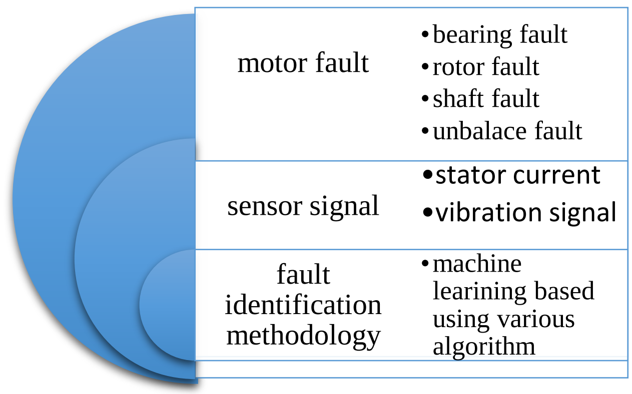
Abstract *– In this paper, a machine learning based fault identification method is offer for induction motor using stator current and vibration signals. Four classification algorithms, support vector machine (SVM), random forest, Gaussian naïve Bayes, multinomial naïve Bayes used in this paper to evaluate the performance and suitability of different classifiers for induction motor fault identification. It is found that all algorithm provide different classification accuracy for identification of fault. Provide highest accuracy algorithm hence improving the accuracy of fault identification.*

Key word *– fault identification, induction motor, machine learning.*

1. INTRODUCTION

In 21st century, induction motor used in various industries all over the world. Due to environmental stress and loading condition induction motor can failure hence production can be stop of industries and result financial losses. To avoid such situation should provide condition monitoring technique for induction motor. In this paper induction motor monitored for various fault condition then apply machine learning fault identification technique to identify the fault in induction motor. In this paper, four algorithms: support vector machine (SVM), random forest, Gaussian naïve bayes, multinomial naïve Bayes their performance and suitability for induction motor fault identification are evaluated. The arrangement is as follows: in section second recommended induction motor fault classification which shows different fault in induction motor: bearing fault, stator fault, rotor fault, and others fault. The sensor signal means stator current and vibration signal offer in section third. In section forth proposed methodology is recommended in which details of fault

Identification process shows with a sequence of experimental setup, data acquisition, data processing, classification algorithm, model evaluation, and last prediction. In fifth section experimental setup proposed for taking the dataset for machine training purpose. The training dataset is taken for four fault condition and one healthy condition. The fault condition are: bearing fault condition, shaft fault condition, rotor bar fault condition, unbalance fault condition. That training dataset is used



for train the machine using four algorithm are: Gaussian naïve bayes, multinomial naïve bayes, random forest, support vector machine. Each algorithms shows different accuracy for fault identification method this proposed in section sixth classification algorithm. The highest accuracy algorithm is used for fault identification method to detect accurate fault while predicting when a new testing data test used for fault identification method this shows in section seventh. In section eighth gives conclusion.

2. INDUCTION MOTOR FAULT CLASSIFICATION

An induction motor occur different types of fault in various part of it. The main fault of induction motor is bearing fault, rotor fault, stator fault, and some others fault each fault has unalike percentage possibility of occurring. In fig. 1. Shows fault in induction motor.

2.1 Bearing fault

Mostly the fault occur in induction motor is bearing fault which is 40% possibility from the different fault in induction motor. This fault occur due to lubrication is

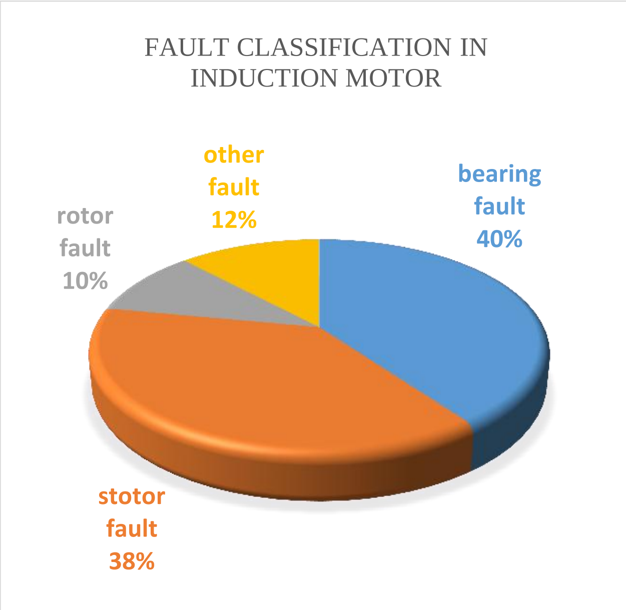


Fig. 1. Fault classification of induction motor

not well, misalignment, overloading and hence noise and vibration is started in induction motor which reflected into the stator current and vibration signal.

2.2 Stator fault

Stator fault is related to the stator winding which is 38% possibility from the different fault in induction motor. The stator winding fault occur due to insulation failure in between two adjacent conductor of winding this called inter turn fault. Hence resultant stator current produced large heating due to that magnetic field in the motor becomes imbalance and start motor vibrate.

2.3 Rotor fault

Rotor fault is 10% of total fault in induction motor. Broken rotor bar fault are cause due to hot spot, sparking, thermal imbalance, moisture abrasion of rotor material, mechanical stress, thermal stress, and manufacturing defect. Also due to the overheating end ring fault occur which is included into rotor fault.

2.4 Other fault

The other fault is 10% of total fault of induction motor. In other fault eccentricity fault is included which occur due to non-uniform air gap in between the stator and rotor which cause by the bearing fault or manufacturing defect. Hence shaft and unbalance fault occur and motor start vibration.

3. CLASSIFICATION SENSOR SIGNAL

Any fault occur on the induction motor that fault reflected in the two parameter stator current, vibration signal. Electrical, mechanical and magnetic asymmetries occur then stator current changes hence by monitoring stator current various fault can be detect. The stator current value is large at fault condition that cannot directly measure therefore we use clamp on current transformer. The vibration monitoring technique is used for the identification of mechanical fault. The vibration signal is taken by the accelerometer that is piezo-electric transducer which convert the vibration into equivalent voltage signal and it becomes easy to measure it.

4. PROPOSED METHODOLOGY

The induction motor monitoring method and fault identification method classifies, fault condition and healthy condition of induction motor. The induction motor fault identification method identify four different fault condition: bearing fault, shaft fault, broken rotor bar fault and also identify the healthy condition of induction motor. The fault identification method is based on machine learning which has two part: training and testing. In training stage dataset is used which taken by performing experiment on induction motor for various fault condition and healthy condition and that dataset is called training set which used to train the algorithm. In testing stage dataset is used which verify accuracy of algorithm. Fig. 2. Shows flowchart of proposed fault identification method. The first step is collecting the training dataset by performing experiment on induction motor for bearing fault, shaft fault, broken rotor bar fault, unbalance fault, and healthy condition. The second step is data preprocessing in which clean data, reset data, split data, and transform data in feasible dataset for the analysis. Third

Step of algorithm selection and model evaluation. This evaluation is based on the types of problem, training time and accuracy. In this fault identification method four classification algorithm is used. Gaussian naïve bayes, random forest, multinomial naïve bayes, and support vector machine used to evaluate the suitability and performance of above four classifiers for induction motor fault identification method. In this method found that all algorithm provided different classification accuracy for all the fault. Hence provided highest accuracy algorithm to fault identification method. At the last step predicting the testing set and get result. This fault identification method can correctly detect fault in induction motor, hence improving the accuracy of fault identification method.

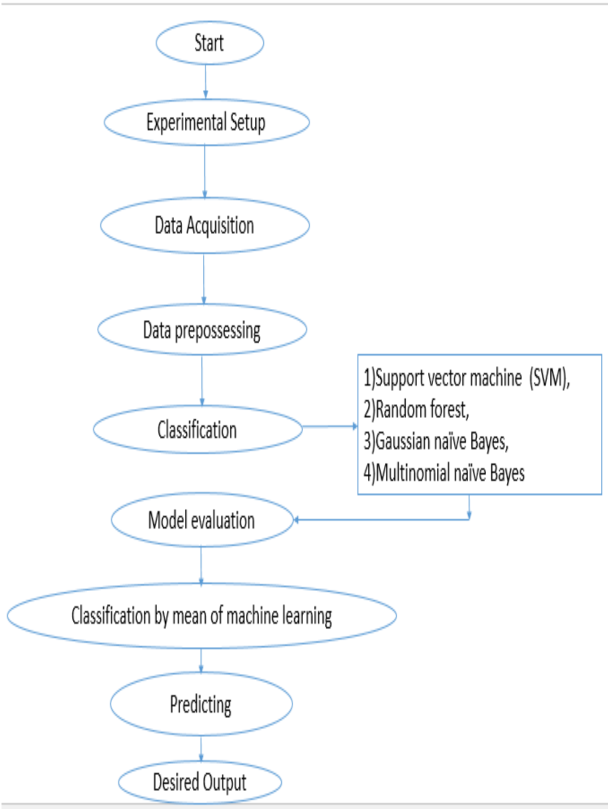


Fig. 2. The flowchart of proposed method

5. EXPERIMENTAL SETUP

Fig. 3. Shows the induction motor was tested for healthy and four fault condition: bearing fault, shaft fault, broken rotor bar fault and unbalace fault. Fig. 4. shows experimental setup in which three phase power supply is directly connected to the three phase induction motor and a dynamomerter coupled to shaft of motor through a belt pulley serves as the load. Induction motor loadding condition is adjusted by the dynamomerter's control knob. Clamp on current transformer is used to measuring purpose and it feed stator current signal to power quality analyser for monitor and record three phase current. The tri-axial accelerometer mounted on the top of motor which sence the vibration at the axial, vertical and horizontal direction and send to the four channel sensor signal conditioner. For vibration data acquisition four channel osciloscope is used which connected in between sensor signal conditioner and computer. In each test condition three phase staror currents (I_1, I_2, I_3) and vibration at x-axis, y-axis, and z-axis recored simultaniously. Each fault create unbalace into the motor, which will reflected into stator currents signals and vibration signals.

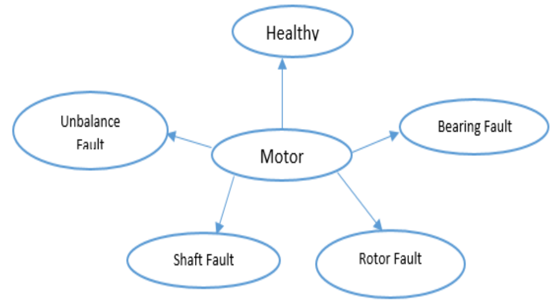


Fig. 3. Experiment plan of the applied fault on motor

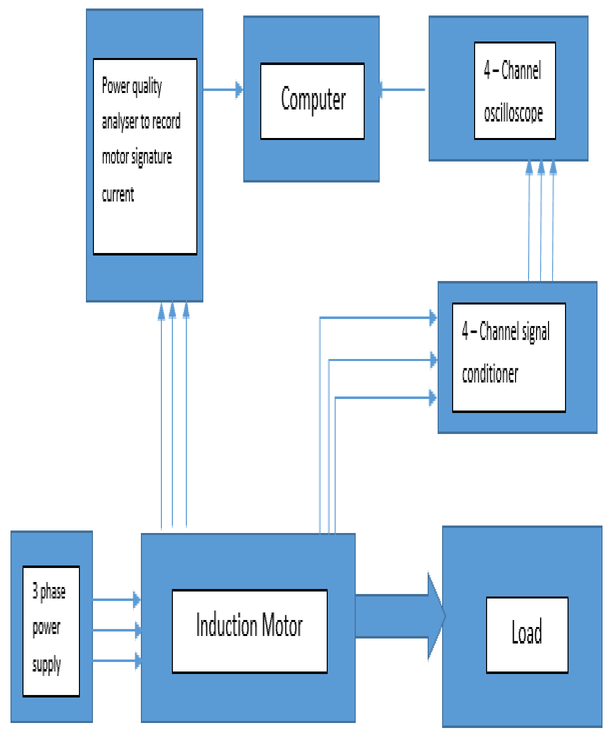


Fig. 4. Block diagram of experimental setup

6. ALGORITHM CLASSIFICATION

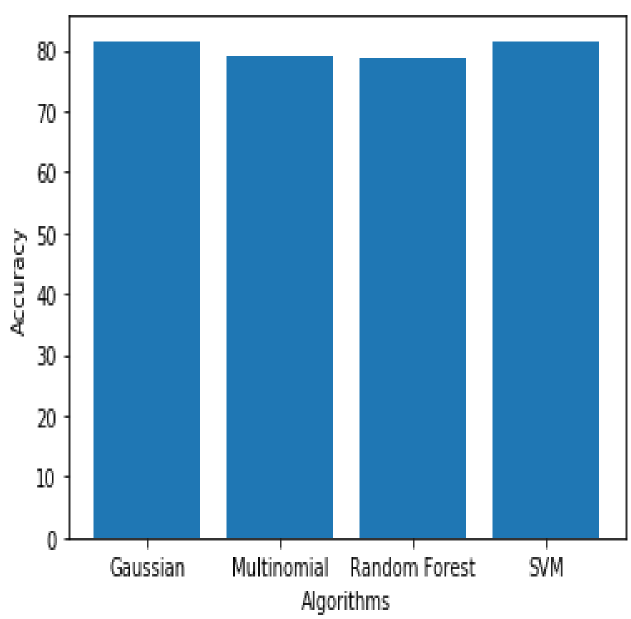
The evaluation of algorithm is based on the accuracy measures. Table no. 1 shows the result of various algorithm classification. For Gaussian naïve bayes result demonstrated that the classifier obtains 0.82 which mean that 82% accuracy. For multinomial naïve bayes classifier obtain 0.80 which mean that 80% accuracy. The result of application random forest classifier obtain 0.79 which mean that 79% accuracy. The result application support vector machine classifier obtains 0.82 which mean that 82% accuracy.

Table 1: Result of Algorithm Classifiers

Classification method	Accuracy
Gaussian naïve bayes	81% - 82%
Multinomial naïve bayes	79% - 80%
Support vector machine	81% - 82%
Random forest	78% - 79%

7. FAULT IDENTIFICATION RESULT

The fault identification accuracy for all fault using stator current and vibration signal is shown in fig. 4. The accuracy of multinomial naïve bayes and random forest is less than Gaussian naïve bayes and support vector bayes. The accuracy of support vector bayes and Gaussian naïve bayes is nearly same.



8. CONCLUSION

Because of large application of induction motor in industries accurate fault detection is very important to avoid down-time and huge financial losses. In this paper, proposed a machine learning based fault identification method for various fault of induction motor. Four classifiers, Gaussian naïve bayes, multinomial naïve bayes, random forest, support vector machine shows different accuracy. Hence by proving highest accuracy algorithm fault can detect.

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