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Fault analysis and Predictive Maintenance ofInduction Motor using Machine learning andArtificial Intelligence Algorithm

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Abstract: - Industries required early diagnosis of induction motor faults analysis to avoid complete failure. The use of Machine learning and Condition monitoring todetect fault has huge promise. Machine learning can be used to detect motor fault. To avoid losses, Fault detectionusing machine learning algorithm is an excellent method for preventive maintenance. This research develops a machine learning strategy based algorithms in order to learn the characteristics from vibration signal's frequency distribution. The status includes the parameters such as temperature, voltage, Current etc.

The aim of this project is to protect vital electrical components and to prevent a fast forward artificial neuralnetwork model to detect some of the commonly occurringelectrical faults like over-voltage, Overload, single phasing, unbalance voltage, under voltage, unbalance voltage and current, ground fault, temperature and Vibration due to bearing fault and also winding faults.

Keywords: Artificial Intelligence Algorithm, fault analysis, Induction motor, machine learning, Predictive maintenance.

I. INTRODUCTION

Induction motors are mostly used in industries, Industries use a large number of motors and hence, their manual maintenance is tedious and unreliable. There are different type of starting and protection devices are used. The condition monitoring of the electrical machines can significantly reduce the costs of maintenance by allowing the early detection of faults, which could be expensive to repair. The main faults of induction motors can be broadly classified as follows:

- Bearing related faults: 40%
- Stator winding related faults: 38%
- Rotor related faults: 10%
- Other faults: 12%

Identifying these faults at an early stage and attending to them is very important as otherwise they lead to huge production and financial losses Pre- fault detection and isolation of the healthy parts alsoprevents fault progression and failure of other morevital components. The efficiency of an induction motor depends on the electrical and mechanical factors. There is three-phase power unsymmetrical fault, unbalances voltage, over-voltage, over-load, or mechanical-related faults such as broken rotor shaft, air gap faults, and bearing, damage electrical, mechanical, and environmental factors are including voltage, current, vibration, temperature, and ambient humidity of the motor affect the good performance of the motor. This may cause a vibration and a loud which damages the stator winding. As a result, an induction motor is needed to monitor continuously for safety and reliable operation of industrial induction motors. Industries use a large number of motors and so, their manual maintenance is unreliable. Therefore, many attempts have been made towards automatic maintenance. Earlier, conditional monitoring of electrical machines was employed and the electromechanical relays. But these relays are slow in operation and also lead to huge power losses. Electromechanical relays were later replaced by solid state relays as they consume very less power and are comparatively fast. With theadvent of microprocessors, attempts were made for conditional monitoring of machines by using pre- written programmes downloaded onto themicroprocessor chips. Computer revolution with thedawn of machine learning drew the attention of scientists and they began to think of ways through which these techniques could be used to monitor andsafeguard machines. Machine learning models take the place of human to intelligently monitor andmaintain the specified system tasks [4]. Artificial neural networks are very handy in this regard as theycan handle huge amount of data, have small response time and can effectively handle non- linearity. Machine learning is an application of Al. It's the process of using mathematical models of data to help a computer learn without direct instruction. This enables a computer system to continue learningand improving on its own, based on experience. Thispaper presents a machine learning model for the fault detection and classification of induction motor faults by using three phase voltages, currents and other physical parameters as inputs. The aim of this work is to protect vital electrical components and to prevent abnormal event progression through early detection and diagnosis.

II. DATASET COLLECTION

In this research paper induction motor data is measured by using voltage sensors, current sensors, vibration sensors (piezoelectric piece knocking vibration switch), gas sensor, and temperature sensors. The previous standard data's of induction motors are collected from datasheet of induction motor manufactures. The collected data's are analyse by using machine learning for predictive maintenance without human intervention. Proposedsystem, Firstly, setting up the microcontroller toacquaint parameters from sensors (in Fig.1). After that, the sensors measure and send the parameters to microcontroller for processing. Then, the microcontroller sends information to Thing Speak cloud platform.

III. HARDWARE DESCRIPTION

A. Sensors

Sensors refer to a particular category of devices that can sense or measure defined physical, chemical or biological quantities and generates associated quantitative data. A set of sensors is place at motor to collects the relevant data from motor.

B. Voltage Sensor

The voltage sensor being used here is implemented using 3 transformers. Since we have to monitor the Three phase supply (R, Y, B) provided to various industrial applications in industry so we are connecting these 3 transformers which are 230V-12V step-down voltage transformers to corresponding 3 phases of supply. Each transformer having a 230V at its primary winding and delivers a step-down voltage of 12V at its secondary winding. The voltage at secondary winding of each transformer is then rectified to a dc voltage of 5V using 3 Full wave bridge rectifiers and current limiting resistors and fed to the 3 I/O pins of microcontroller.

C. Current Transformer

A current transformer is an instrument transformer where the secondary current is considerably proportionate to primary current and differs in phase from it by ideally zero degree *Current transformers* reduce high voltage currents to a much lower value and supply an correct path of safely sensing the real electrical current flowing in an AC transmission line utilizing a standard current measure by an device. The predominant of functioning of a basic current transformer is slightly different from that of an ordinary voltage transformer.

D. Vibration sensor

A vibration sensor is a device that detects mechanical vibration. It measures the vibration levels in your machine and alerts you to any potential problems, like equipment failure or worn parts that need replacement.

E. Temperature Sensor

Temperature sensor is used to measure the temperature with an electrical output proportional to the temperature. The LM35 device does the function of measuring the surrounding temperature.

F. Microcontroller

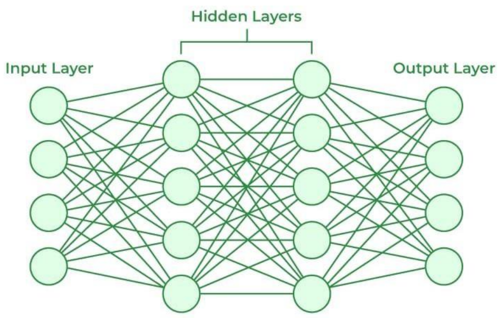
A microcontroller (MCU) is a small computer on a single integrated circuit that is designed to control specific tasks within electronic systems. It combines the functions of a central processing unit (CPU), memory, and input/output interfaces, all ona single chip.

IV. MACHINE LEARNING WITH ARTIFICAL NEURAL NETWORK

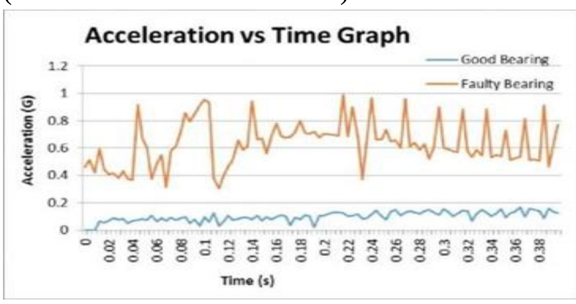
Machine learning (ML) is a branch of artificial intelligence and computer science that focuses on the using data and algorithms to enable Al to imitate the way that humans learn, gradually improving its accuracy. Machine learning allows the user to feed a computer algorithm an immense amount of data and have the computer analyse and make data-driven recommendations and decisions based on only the input data. Machine learning can help demystify the hidden patterns in IoT data by analysing massive volumes of data using sophisticated algorithms. Machine learning inference can supplement or replace manual processes with automated systems using statistically derived actions in critical processes.

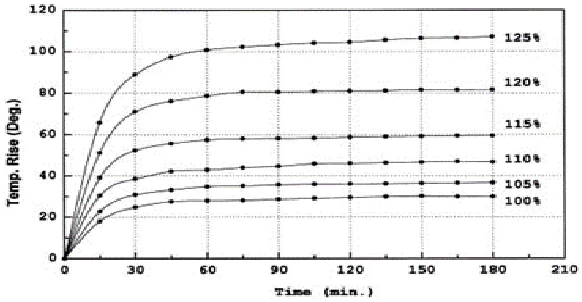
- Data collection. The first step in the machine learning process is data collection.
- Data pre-processing.
- Choosing the right model.
- Training the model.
- Evaluating the model.
- Hyper parameter tuning and optimization.
- Predictions and deployment.

To interface the developed ANN model with the motor system, the data need to be collected continuously in real time from current and voltage sensors. The obtained values are transmitted to Wi-Fi router by using a reliable Wi-Fi connection. This data is then transferred and collected on a cloud platform (any of the many available) by using an Ethernet cable between the router and storage system. From the cloud, the data is continuously transmitted onto the MATLAB workspace. When a fault occurs, the trained (From uploaded data sheet) ANN model detects the fault immediately and notifies the control system to take action. The Artificial Neural Network (ANN) is designed to mimic human brain to think for itself and take action without being explicitly programmed. Just like a human brain, the ANN model consists of artificial neurons or nodes as the basic building blocks. The nodes are arranged in layers: input layer, output layer and one or more hidden layers.



(Need to add table of data sheet)





Machine Learning data and learn from it, whereas IoT can transport data via the internet. The two can be combined. IoT devices transmit data to a database, where a Machine Learning algorithm can use it to learn new things. Machine Learning algorithm gets more intelligent the more data stream from IoT device. currents, Temperature, Vibration and gases as the input. The model is trained for each of the seven electrical faults and physical fault using approximate values from data sheet.

To calculate the full load current or the amperage of a 3-phase motor, First, know your motor's specifications including the power rating (P), voltage requirement (V), power factor (cos), andefficiency (n). If P is in kW, use this equation:amperage = 1000 × P/ (1.73205 x V x cos x η).

The power (P) can be calculated as theproduct of the line voltage (V) and line current (I), multiplied by the power factor (pf):

$$P = V * I * pf$$

The power factor represents the ratio of real power to apparent power and is typically provided by the motor specifications or can be measured during motor operation.

By substituting the power formula into theresistance formula, the equation can be rewritten as:

$$R = (V^2)/ ((V* 1 * pf) * I^2)$$

Simplifying further:

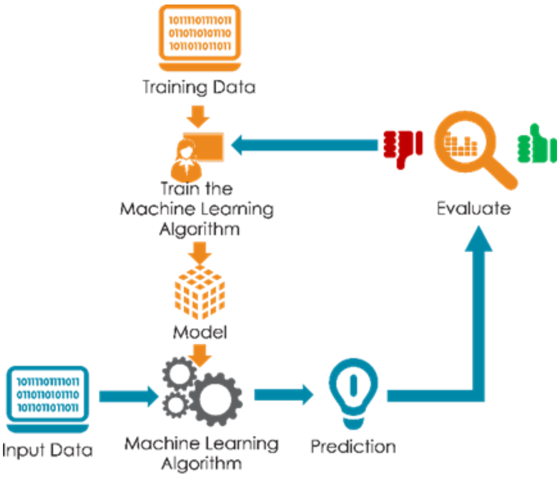
$$R = V/ (I * pf)$$

Please note that this calculation assumes a balanced three-phase motor. If the motor is unbalanced, additional factors need to be considered. Additionally, this formula assumes thatthe motor is operating at its rated voltage and currentvalues.

RESULT AND STUDY

In this work, the artificial neural network model is created and trained by using three phase voltages, Relation between Current, Temperature and Voltage is that when Temperature increasesCurrent will decrease and Voltage will increase. And vice versa.

DATA SHEET						
3KW THREE PHASE INDUCTION MOTOR SQUIRREL CAGE F CLASS INSULATION						
	INPUT			OUTPUT		
SL NO	PARTICULARS	MINIMUM RANGE	MAXIMUM RANGE	LOW	HIGH	RISK
1	VOLTAGE	380	415	WARNING GREEN	WARNING YELLOW	WARNING RED
2	CURRENT	3.15	5.77	WARNING GREEN	WARNING YELLOW	WARNING RED
3	TEMPERATURE	150°C	155°C	WARNING GREEN	WARNING YELLOW	WARNING RED



V. FEATURE SCOPE

Predictive maintenance of electrical equipment, including induction motors using MACHINE LEARNING approaches is still in proposal stage in many developing countries including India. ANN due to its ability to learn from previous experiences can effectively address catastrophic failures and is perfect to handle non- linearity in data. The proposed ANN model is satisfactorily interfaced with real systems and is proven to be reliable. Hence it can serve as the most efficient and economical predictive maintenance tool in future. The proposed model can also be extended for D.C and synchronous motors. All management level can access the data of machine at anywhere. All management members can access the Real time data of machine at anywhere.

VI. CONCLUSION

This work depicts the potential of machine learning tool (ANN) in detecting the electrical faults of a three phase induction motor. The data collected in real time three phase induction motor was used to train and test the neural network. The developed neural network classifies all the test data into their respective classes with almost 100% accuracy. The accuracy of the trained model is reflected by the results obtained using the test data and also from the regression plot. In case there are errors in classification, the accuracy can be improved by increasing the number of hidden layers and by choosing optimum number of neurons. The proposed model gives accurate results and hence, prevents event progression during the occurrence offaults and protects vital electrical equipment.

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