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FAULT DIAGNOSIS DETECTING USING MACHINE LEARNING

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ABSTRACT

The need for alternate transportation is driven by the increased fossil fuel cost and the adverse effects of climatic change. Electric vehicles (EVs) are the best option as they have less carbon footprint and reduced dependency on fossil fuels. Prodigious efforts to enhance the efficiency of EVs resulted in the development of highly efficient three-phase induction motors. Difficulties in designing highly efficient induction motors (IM) with high torque and power factors hindered the success of EV applications. Hence, our aim is to diagnosis fault in the designed IM under variable load conditions. The proposed EV motor is designed for 415V, 50Hz, and 5HP output power rating using ANSYS RMxprt simulation software. A fault detection strategy is also implemented with various machine learning (ML) techniques like Support Vector Machine (SVM), K-nearest neighbors (k-NN), ML perceptron (MLP), Random Forest (RF), Decision Tree (DT), Gradient boosting (GB), Extreme Gradient Boosting (XGBoost), and Deep Learning (DL) for both healthy and faulty conditions. Short Circuit (SC), High Resistance connection (HRC), and Open-Phase circuit (OPC) are considered as faulty states for this study. Motor performance with variable load for all the states healthy and faulty are evaluated through machine learning.

Index Terms— CNN, bearing, attention mechanism, fault diagnosis

I. INTRODUCTION

Automobile sector is playing a vital part in the world's economic growth. Internal combustion vehicles used in most vehicles consume directly the fossil fuel and create a large amount of greenhouse gases affecting the entire world. This paved the way to discover new energy vehicles as an alternative to conventional vehicles, which are Electric Vehicles (EVs)[1]. The core part of an EV is the electric motor which converts electric energy to mechanical energy. Hence it is necessary to build an electric motor that enhances the efficiency of EV and its performance. Induction Motor (IM), Brushless DC motor (BLDC), and Permanent Magnet Synchronous motor (PMSM) are the most commonly used motors for commercial purposes[2].

IM is more effective and economical than other motors due to its reliability, simple mechanical design, and effective fieldweakening characteristics. However, the limitations such as core loss, friction loss, and copper loss, reduces the efficiency of IM[3]. To overcome these limitations and to enhance the efficiency, researchers are focusing to optimize the length of the stator as it can also reduce harmonic losses. Also, IM characteristics are influenced by geometric dimensions like core length and size of the stator and rotor slots[20]. The motor's efficiency is also determined by the materials used for manufacturing. Several materials have been used for the motor design for many years, and the most often used materials for core & winding are Iron (Fe), Carbon steel 1008, and steel 1010 laminated cores, Aluminium (Al), Copper (Cu), and Silver (Ag). Traditionally, Al is used as winding material for IM but the Conductivity is lower than. Though Cu has high conductivity and increased mechanical efficiency than Al, it is costly. Ag, which has higher conductivity than Cu is expensive with a low melting point. Hence, selecting winding

materials and core lamination is vital for achieving higher efficiency and effective motor operation. In addition to material selection, the fault detection (FD) system has also been used an effective approach to increase the performance of motor operation in EVs[5].
Researchers are developing FD strategies for IM based on two approaches. They are Model-based approaches and Data-driven approaches. Model-based approaches attempt to predict the faulty behavior by mathematically modelling the motor[7]. The main disadvantage of this methodology is due to the machine's natural wear, because the degradation of machine components causes a difference between the actual machine and its mathematical model, when the fault magnifies. Furthermore, it is critical that the model assumes that the machine parameters are available, which does not always happen. This makes the diagnosis more challenging because it is necessary to estimate the machine parameters for the appropriate modelling of the machine[19]. Data driven approaches do not require IM model as well as the characteristics of the motor and load coupled to the machine. Furthermore, these methods have been widely used in fault diagnosis of nonlinear complex and timevarying systems and demonstrated promising outcomes in identifying faults[18]

II. LITERATURE SURVEY

A) Design of synchronous reluctance motor utilizing dual-phase material for traction applications

While interior permanent magnet (IPM) machines have been considered the state-ofthe art for traction motors, synchronous reluctance (SynRel) motors with advanced materials can provide a competitive alternative. IPM machines typically utilize neodymium iron boron permanent magnets, which pose an issue in terms of price, sustainability, demagnetization at higher operating temperatures, and uncontrolled generation. On the other hand, SynRel machines do not contain any magnets and are free from these issues. However, the absence of magnets as well the presence of bridges and center post limit the flux-weakening capability of a SynRel machine and limit the achievable constant power speed ratio for a given power converter rating. In this paper, a new material referred to as the dual-phase magnetic material will be evaluated for SynRel designs. This material allows for nonmagnetic regions to be selectively introduced in the bridge and post regions, thereby eliminating one of the key limitations of the SynRel designs in terms of torque density and flux weakening. This paper will focus on advanced SynRel designs utilizing dual-phase material targeting traction applications. The paper will provide a detailed comparison between a dual-phase SynRel design, a conventional SynRel design, and a spoke PM design with rare-earth-free magnets. It will highlight the key tradeoffs in terms of power density, efficiency, and fluxweakening capability.[16]

B) Design of a new enhanced torque inwheel switched reluctance motor with divided teeth for electric vehicles

This paper presents a new switched reluctance motor (SRM) with wide speed range for the application of electric vehicles. It has an in-wheel structure for direct drive and multiple teeth per stator pole to enhance output torque. Also, the number of rotor poles is more than that of stator teeth. A 6/16 threephase in-wheel SRM with the concepts of multi-teeth per stator pole and more rotor poles than stator teeth has been proposed for analysis. The torque performance of the topology with multi-teeth per stator pole is proven by theoretical analysis. Moreover, a new design formula is introduced for a novel combination of stator and rotor poles. The parameters of the motor are optimized by genetic algorithm method for the maximum torque output. Then the torque performance is computed by finite-element method (FEM) and compared with its counterparts, including three-phase 6/8 and 6/10 SRMs. The FEM results exhibit higher torque density for the proposed topology.[15]

C) Electric, hybrid, and fuel-cell vehicles: Architectures and modeling

With the advent of more stringent regulations related to emissions, fuel economy, and global warming, as well as energy resource constraints, electric, hybrid, and fuel-cell vehicles have attracted increasing attention from vehicle constructors, governments, and consumers. Research and development efforts have focused on developing advanced powertrains and efficient energy systems. This paper reviews the state of the art for electric, hybrid, and fuel-cell vehicles, with a focus on architectures and modeling for energy management. Although classic modeling approaches have often been used, new systemic approaches that allow better understanding of the interaction between the numerous subsystems have recently been introduced.[13]

III.CNN

The overview of our proposed system is shown in the below figure

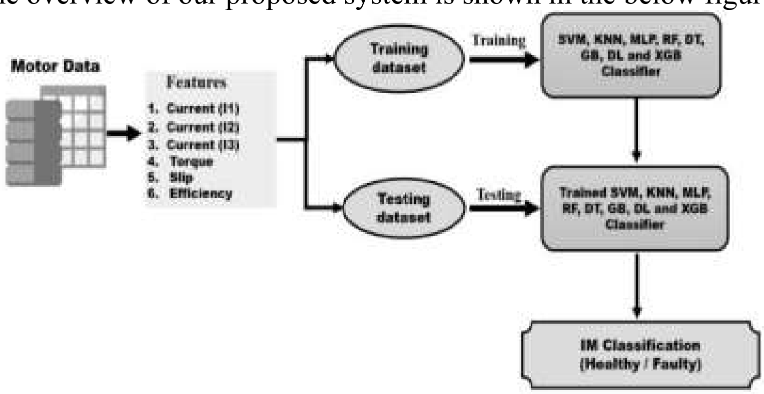

Fig. 1: System Overview

Implementation Modules

Dataset

In this module, we collect the dataset from internet. We take the all the data. This data can be analyzed and extract the best features to preprocess the data.[9]

Train Model

In this module, after spilt data as train and test data in the ratio of 80% and 20% respectively. The train data can be used for train the model and the test data can be used for test the model performance. In this project we applied machine learning Models and to train the model we are using fit() method in python programming.[10]

Feature Selection

Feature selection is a critical step in the feature construction process. In text categorization problems, some words simply do not appear very often. Perhaps the word “groovy” appears in exactly one training document, which is positive. Is it really worth keeping this word around as a feature ? It’s a dangerous endeavor because it’s hard to tell with just one training example if it is really correlated with the positive class or is it just noise. You could hope that your learning algorithm is smart enough to figure it out. Or you could just remove it[12]

Preprocess

In this module, we preprocess the induction motor data in which we follow the steps like, data cleaning, data transform and data normalization using python library numpy[15]

Classification

In this module, user enter induction motor data and classify them using tested machine learning models whether it is fault or not.[18]

Implementation Algorithms

CNN

In deep learning, a convolutional neural network (CNN, or ConvNet) is a class of artificial neural network (ANN), most commonly applied to analyze visual imagery. CNNs are also known as Shift Invariant, based on the shared-weight architecture of the convolution kernels or filters that slide along input features and provide translation-equivariant responses known as feature maps.[20]

Support Vector Machine

In machine learning, support-vector machines (SVMs, also support-vector networks) are supervised learning models with associated learning algorithms that analyze data for classification and regression analysis. An SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier.[19]

Gradient Boosting Classifier

Gradient Boosting is a powerful boosting algorithm that combines several weak learners into strong learners, in which each new model is trained to minimize the loss function such as mean squared error or crossentropy of the previous model using gradient descent. In each iteration, the algorithm computes the gradient of the loss function with respect to the predictions of the current ensemble and then trains a new weak model to minimize this gradient. The predictions of the new model are then added to the ensemble, and the process is repeated until a stopping criterion is met.[20]

IV.RESULTS

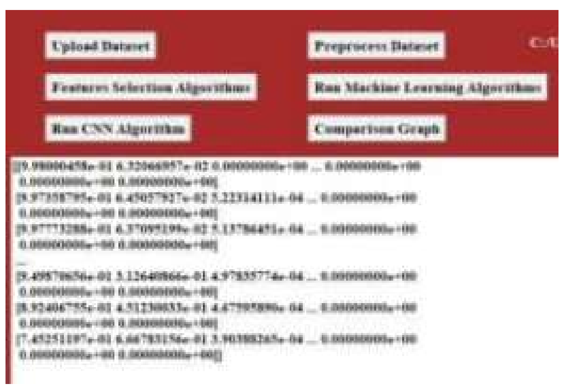

Fig. 2: Upload Dataset

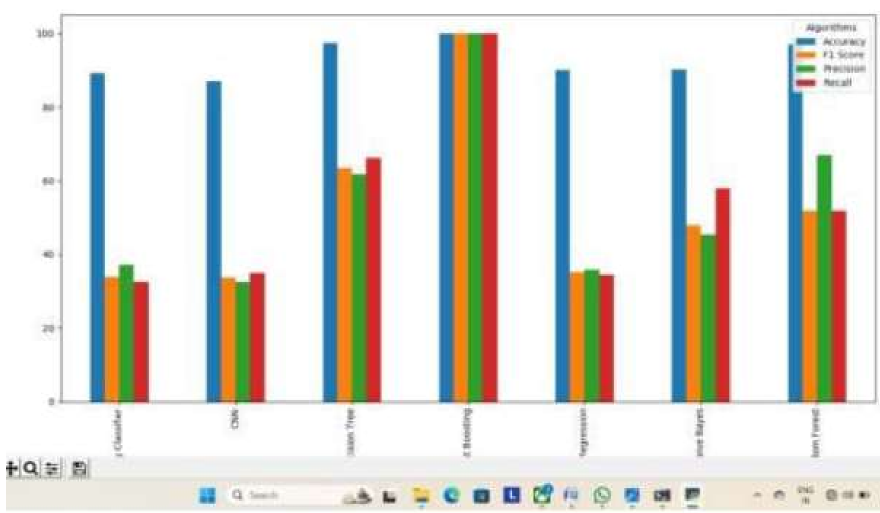

Fig. 3: Models Accuracy Graph

V. CONCLUSION

This project described the ML-based FDD strategy for Ims under Healthy and Faulty condition. Data is generated using simulation-based models in ANSYS Simplorer for the proposed strategy. The data generated is used for training, validation, and testing various algorithms such as Support vector Machine (SVM), K-nearest neighbors (k-NN), Multilayer perceptron (MLP), Random Forest (RF), Decision Tree (DT), Gradient boosting (GB), Extreme Gradient Boosting (XGBoost), and Deep Learning (DL). To enhance the efficiency of the ML based FDD, feature extraction and selection methods are utilized for this model.

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