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Prediction of Stator Winding Temperature Of PMSM Motor Using Random Forest And Feed Forward Neural Network

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Abstract – *This paper proposes the need for the prediction of stator winding temperature of PMSM Motor. Today there is an increase in acceptance of PMSM as a motor for the choice in various applications such as Electric Vehicles etc. There should be an accurate monitoring of temperature of stator winding in order to avoid the increase in temperature and to make sure that the performance of the motor does not deteriorates. In this work, using the already existing dataset the Random forest and feed forward neural network algorithms are implemented to calculate their mean square error and mean absolute error to conclude which algorithm predicts the temperature accurately.*

Key Words: PMSM Motor, Random Forest, Feed Forward Neural Network.

1.INTRODUCTION

Permanent Magnet Synchronous Motor (PMSM) has wide range of characteristics and hence they are used in Industries. The utilisation of permanent magnets in motors has resulted in good efficiency. Reduction in power consumption and improvement in performance has made them to be utilised in Electric vehicles. Now a days PMSM are very popular in their use as a substitute for a servo drive.

A PMSM follows the same construction as that of the normal synchronous motor the only difference is that the PMSM uses permanent magnets to create the field pole whereas the traditional synchronous motor obtains it through the field rotor.

2.OBJECTIVE OF THE PROJECT

To predict the temperature of the stator winding of PMSM motor using the following algorithms.

Random forest

Feed forward neural network

3.ANALYSIS OF DATASET

The data set comprises several sensor data collected from a permanent magnet synchronous motor (PMSM) deployed on a test bench. The PMSM represents a German OEM's prototype model. Test bench measurements were collected by the LEA Department at Paderborn University.

This dataset consists of more than one million datasets. All recordings are sampled at 2 Hz. The data set consists of multiple measurement sessions, which can be distinguished from each other by column "profile_id". A measurement session can be between one and six hours long.

The motor is excited by hand-designed driving cycles denoting a reference motor speed and a reference torque. Currents in d/q-coordinates (columns "i*d" and i*q") and voltages in d/q-coordinates (columns "u*d" and "u*q") are a result of a standard control strategy trying to follow the reference speed and torque. Columns "motor speed" and "torque" are the resulting quantities achieved by that strategy, derived from set currents and voltages.

4.Methodology

Step1: Import the dataset in .csv format in google colab.

Step2: Read the data.

Step3: Split the dataset into training and testing set.

Step4: Implement the Random forest and feed forward neural network algorithm.

Step5: Calculate mean square error and mean absolute error between the true and predicted value to conclude which algorithm predicts accurately.

5.Random Forest Algorithm

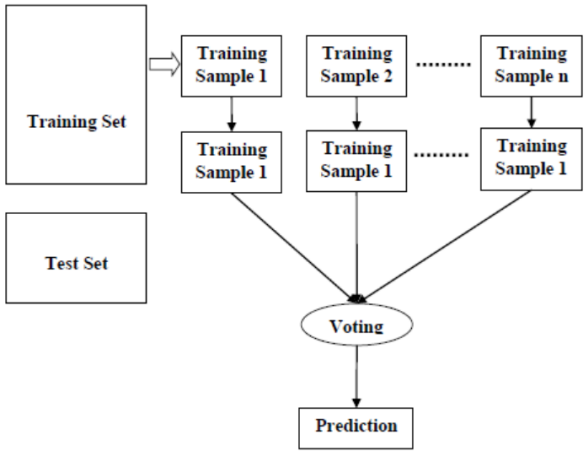
Random forest is a supervised learning algorithm which is used for both classification as well as regression. But however, it is mainly used for classification problems. As we know that a forest is made up of trees and more trees means more robust forest. Similarly, random forest algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result.

5.1 Working Of Random Forest Algorithm

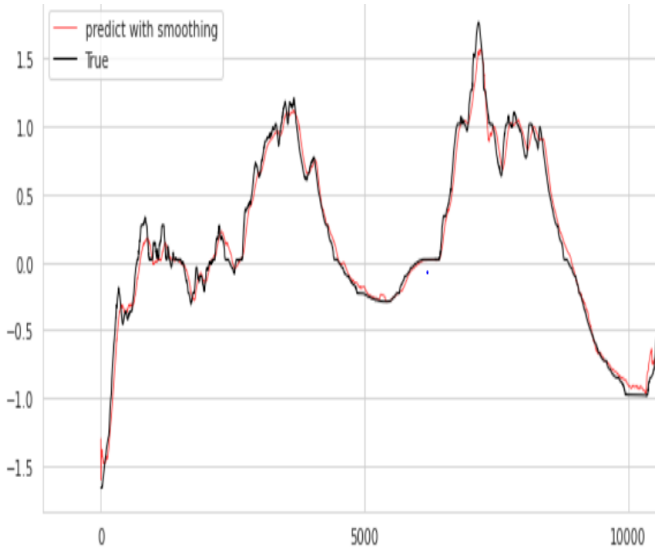
We can understand the working of Random Forest algorithm with the help of following steps –

- **Step 1** – First, start with the selection of random samples from a given dataset.
- **Step 2** – Next, this algorithm will construct a decision tree for every sample. Then it will get the prediction result from every decision tree.
- **Step 3** – In this step, voting will be performed for every predicted result.
- **Step 4** – At last, select the most voted prediction result as the final prediction result.

The below diagram illustrate its working



After implementation of the Random Forest Algorithm the output is displayed as shown below



In the graph

x-axis – time in seconds

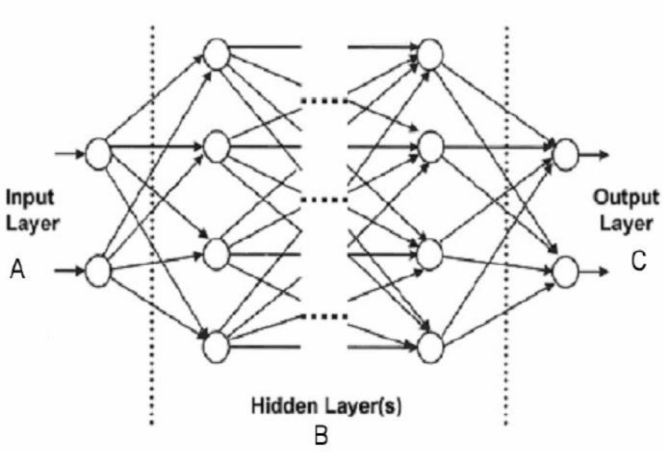
y-axis – temperature of stator winding

The graph is obtained by plotting the temperature with respect to time at a fixed voltage.

5.2 Working Of Feed Forward Neural Network Algorithm

Deep feedforward networks, also often called feedforward neural networks, or multilayer perceptrons (MLPs), are the quintessential deep learning models. The goal of a feedforward network is to approximate some function f*. For example, for a classifier, y = f*(**x**) maps an input **x** to a category **y**. A feedforward network defines a mapping y = f(x;θ) and learns the value of the parameters θ that result in the best function approximation.

These models are called feedforward because information flows through the function being evaluated from **x**, through the intermediate computations used to define f, and finally to the output y. There are no feedback connections in which outputs of the model are fed back into itself.



After the implementation of Feed forward neural network algorithm the graph is obtained as follows

In the graph

x-axis – time in seconds

y-axis – temperature of stator winding

The graph is obtained by plotting the temperature with respect to time at a fixed voltage.

5.3 Mean absolute Error (MAE) and Mean Square Error (MSE)

The Mean Square Error (MSE) and Mean Absolute Error (MAE) between true and predicted value after implementing Random Forest Algorithm is

```
MSE: 0.0073030826126044 15
MAE: 0.06630035887029616
```

The Mean Square Error (MSE) and Mean Absolute Error (MAE) between true and predicted value after implementing Feed Forward Neural Network Algorithm is

```
MSE: 0.13810103418272712
MAE: 0.29594657718674905
```

6. Conclusion

From the graph and error we could conclude that the Random Forest algorithm outperforms the feed forward neural network.

7.Reference

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