University of Macau

Abstract

Novel Fuzzy-Neural Networks Technology for Diagnosing Internal Fault of Three-phase Squirrel Cage Induction Motor

by Chan Si Leong, Kevin

Thesis Supervisor: Professor Dong Ming Chui

This study proposed a novel technology – Fuzzy-Neural Networks (FNN) for diagnosing and locating internal faults in three phase induction motor. The fault diagnostic problems had been discussed in decades. The conventional diagnosis methods and Artificial Intelligent (AI) based methods had attracted increasingly attentions. The conventional diagnosis methods, such as Motor Current Signature Analysis (MCSA), Wavelet Packet Analysis and Park's Vector Analysis methods etc. had difficulties of constructing the complicated mathematical models with a lot of assumption parameters, which would cause inaccuracy in fault diagnosis. Instead AI-based methods might overcome these inherent problems of math-based methods and provide more attractive features in motor fault diagnosis. The accurate and fast soft-computing solutions can provide the safety usage and preventive maintenance to motor-driven application systems and also prolong the motor life.

It was explored in past researches that the failures of induction machines are mainly due to rotor bar broken and trouble of stator windings. The key issues in researching modern AI-based motor fault diagnosis are:

1) How to sample and normalize the symptoms of running motors in real-time on-line;
2) What are the mapping relationships between symptoms and motor faults type & location;
3) What are and how to solve the uncertainties happened in fault diagnosis;
4) How to distinguish the symptoms caused by static factors like imbalance power supply, dissymmetric assembling etc. with true inner fault of motor;

Through my 3 years thesis research, a creative APVD method (Absolute Phase Value Difference) for normalizing and pre-processing the input signals was proposed, which can convert the input signals with big scale difference to the symptoms with same scale rank. By adapting the proper Fuzzy-Logic (FL) technology, the fuzzy sets and fuzzy membership functions were defined based on the huge experimental data and their 2-dimensional plots. Then the mapping relationship matrix between symptoms and corresponding motor fault was constructed. Meanwhile, the linguistic hedge was applied to modify the slope of membership functions and adjust the mapping efficiency from symptoms to fault. Based on this kernel mapping matrix, a multi-layer, hierarchical Fuzzy Neural Networks was constructed, the calculation in each layer was deduced. Through supervised training, the link-weight matrix was adjusted properly. Plus adding the fuzzy division to the output layer, the FNN could diagnose the motor fault type / location and indicated it clearly using different color at the output terminal of FNN.

The prototyping FNN system was realized in MATLAB environment. The various testing results showed its advantages compare with traditional motor fault diagnosis methods and other AI-based methods.

Key words: Fault Diagnosis, Uncertainty, Membership Function, Fuzzy Sets, Artificial Intelligence (AI), Fuzzy-Neural Networks (FNN), Absolute Phase Value Difference (APVD)