

A Neural-Net and Fuzzy-Inference Based Method for Fault Detection and Diagnosis in Modern Process Systems

Abstract

The thesis proposes a quite novel and easily generalized fault detection and diagnosis (FDD) scheme for typical modern process systems, by integrating multilayer neural network and fuzzy inference system, the two powerful machine learning algorithms. With adequate sensors installed to and monitoring software widely applied to modern process systems, a vast amount of data relating to operating conditions of target processes could be recorded and stored, which provides potentials and foundations for applying new FDD methods to it. However, due to the facts that all these data are indiscriminate data without being labelled with tags (e.g., normal or abnormal), and that almost all of these data are collected under fault-free operating conditions, the unlabeled and unbalanced characteristics of data of process systems also brings challenges for the application of new FDD methods.

By combing the two methods, neural nets and fuzzy inference system, we could make full use of the advantages (e.g., abundant fault-free data), and meanwhile avoid the disadvantages (e.g., few and unclassified faulty data) of the characteristics of process systems. Idea behind this is that, neural nets, especially multi-layer neural nets have powerful function approximating capacity and are able to automatically learn from a huge amount of historic data, thus it could be used to model system normal behaviors by feeding it enough fault-free operating data; meanwhile, fuzzy inference system could well incorporate expert knowledge as well as operators' maintenance experience about the target system, in the form of fuzzy linguistic rules, and perform a human-like reasoning process to determine the cause of faults according to symptoms -- the deviations between observed system behaviors and model-predicting behaviors, hence dealing with the problem of lack of faulty data.

The basic procedures of the proposed scheme could be briefly described as: firstly using multi-layer neural network to build a reference model for the target system under healthy operating conditions; secondly, by comparing observed system behaviors and predicted behaviors from the built model, deviations in behaviors, called residuals, could be generated, and a preliminary fault detection is made based on out-of-limit principle; finally, if any fault is detected in last step, then the fuzzy inference system would further analyze the residuals to give an answer about which types of faults might have occurred with corresponding degree of certainty.

A case study on a typical process system, chiller plant, is carried out where experimental data collected by ASHRAE Research Projects 1043 is utilized to validate the proposed FDD strategy Besides, comparative study with another two typical FDD approaches is also conducted based on their respective experimental results on the same chiller plant and data to further demonstrate the effectiveness and superiority of the proposed scheme, and meanwhile to investigate the scope of application of the scheme