Intelligent Application of Fault Detection and Isolation on HVAC System

By

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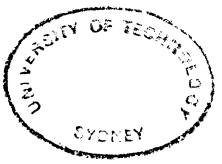

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I, Davood Dehestani, certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of the requirements of a degree, except as fully acknowledged within the text.

I also certify that this thesis has been written by me. Any help that I have received in my research work and in the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

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Abstract

Efficient heating, ventilation, and air-conditioning (HVAC) systems are one of the big challenges today around the world. The fault detection and isolation (FDI) play a significant role in the monitoring, repairing and maintaining of technical systems for the final destination of safety and cost reduction. FDI makes an infrastructure to effectively reduce total cost of maintenance and thus increases the capacity utilization rates of equipment. Reduction of energy wasting in the system by real-time fault detection is another goal. Among all HVAC system's studies, the focus of this thesis is on developing of fast and reliable FDI structure that can cover all subsections of HVAC system including cooling tower, chiller and air handling units (AHU) which greatly affect building energy consumption and indoor environment quality.

The first stage of this study is to develop and validates a mathematical HVAC model then follows by simulation and sensitivity analysis. The simulation makes a good capability of producing artificial fault free and faulty data for review of any upcoming failure over the HVAC system. These data with wide range of fault severities can be used to assess the performance of HVAC automated fault detection and isolation (AFDI) system.

Two categories of process history diagnosis methods have been reviewed and assessed for the development of AFDI algorithms at second stage of this study. Principal component analysis (PCA) and support vector machine (SVM) classification are two chosen algorithm which have been analysed in depth and initially tested by simulated data from stage one. This review has been continued by developing online SVM algorithm with incremental learning technique and then tested both on simulated and operational data.

An experimental rig is designed and applied in the last stage of this research. This setup is configured inside the HVAC laboratory of UTS to collect operational data for the operating test. Operational data as outcome of this stage was then used for test of developed AFDI from last stage. Artificial neural network (ANN) algorithm compressed in frame of black box model for fault free reference. Finally, a combination of black box model and developed AFDI was tested and evaluated for cooling tower and air handling unit (AHU) faults based on operational data. The result shows increasing of robustness, performance and accuracy for the proposed AFDI over the operational data.

Keyword: heating, ventilation, and air-conditioning (HVAC), fault detection and isolation (FDI), mathematical model validation, Support Vector Machine (SVM), robust fault detection (RFD).