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Online fault detection and diagnosis in VAV air handling unit by RARX modeling

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Abstract

Assimilation of cost-effective fault detection and diagnosis (FDD) technique in building management system can save enormous amount of energy and material. In this paper, recursive autoregressive exogenous algorithm is used to develop dynamic FDD model for variable air volume (VAV) air handling units. A methodology, based upon frequency response of the model is evolved for automatic fault detection and diagnosis. Results are validated with data obtained from a real building after introducing artificial faults. Robustness of the method is further established against sensor errors arising out of faulty bias during long term use or lack of proper commissioning. It is concluded that the method is quite robust and can detect and diagnose several types of faults. A short and simple method is also included in this paper to detect the faults of VAV units operating in the same zone by comparing their behavior. The new method, which requires very small amount of computation time, was tested with the aforementioned database and shows satisfactory results.

Keywords: Commercial buildings; Equipment; Field; Online FDD; RARX commercial buildings; RARX modeling

1. Introduction

The performance of heating, ventilation and air conditioning (HVAC) systems often do not achieve the same level attained at commissioning stage. During long time operation, sensors and actuators degrade and fail, valves and dampers leak and stick, coils become fouled and any number of other problems may arise. These faults often lead to occupant discomfort, higher health and safety risks, increased energy use and shorter equipment life. The potential savings out of improved energy management and faulty and non-optimal operation of HVAC systems alone in commercial buildings is estimated to be 20–30%. Fault detection and diagnosis (FDD) technique aims to detect, locate and, if possible, predict the presence of the defects causing faulty operation well in time, thereby, reducing energy consumption, new materials and inoperative time.

Energy management practices and its optimization process in buildings being employed by the current supervisory strategies cannot respond efficiently to the occurrence of faults, since, the processes and systems in buildings have become more an electronics black box. When the process enters a failure state, the supervising computer program or methods currently available do not adequately assist in finding the underlying cause of the fault. This task is generally left to the operator judgement, as in general, there is hardly any automatic FDD tool in the building management system. Though, FDD techniques have been devised and used for decades in sensitive areas of operation like process industries and nuclear power plants, the technique employed is dominated by extensive use of sensors (sometimes more than one sensor at one position), and highly reliable as well as costly monitoring instruments. According to the results of a survey, occupants wait for 30–60 min without much complain about the undesirable thermal environment due to malfunctioning of HVAC system [1]. Therefore, providing a cost-effective system for prompt detection and repair of faults is more important than operational reliability.

2. Model-based reasoning

The kernel of model-based FDD is the model, which simulates the functionality of the concerned system. The

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