RARX ALGORITHM BASED MODEL DEVELOPMENT AND APPLICATION TO REAL TIME DATA FOR ON-LINE FAULT DETECTION IN VAV AHU UNITS

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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 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. It is concluded that the method is quite robust and can detect and diagnose several types of faults

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 leads 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 % [1]. 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 judgment 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 to 60 minutes without much complain about the undesirable thermal environment due to malfunctioning of HVAC system [2]. Therefore, providing an cost-effective system for prompt detection and repair of faults are more important than operational reliability.

MODEL BASED REASONING

The kernel of model-based FDD is the model, which simulates the functionality of the concerned system. The difference between the system measurement and its model output corresponding to a healthy system is called residual. A large variation in residuals may indicate fault in the system. A straightforward “Physical Model” can be obtained if the characteristics of each component in the system are described by equations derived from the basic laws of physics. In practice though, it is almost impossible to make a model on the basis of strict physical knowledge of the system that exactly simulates the real behavior of a particular system since reliable values of model parameters are often not available as either the design data or the manufacturer’s data are often not provided by the manufacturer and even if provided, they are quite general to describe the actual operation.

Since prediction of individual process behavior in a system is not the ultimate goal in fault detection, a simple “Black Box Model” can well be used in most cases for a subsystem. In black box modeling, the whole system is represented by a set of parameters obtained by system identification process. These parameters usually do not have any physical meaning. Black box models are easier to set up and require much less detail information about the system to be modeled. Another advantage of the black box Model Based Diagnosis (MBD) is that even with a new system, for which no repair experience exists, it can be used. A vague model is always obtainable from a relatively small training data sets and can be further refined as data accumulates in the process. Since system variables change without direct outside influence (their values depending upon earlier applied signals), the dynamic response of the system may also be