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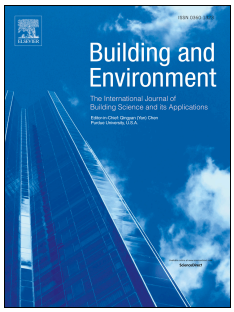

A flexible control strategy for energy and comfort aware HVAC in large buildings

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A Flexible Control Strategy for Energy and Comfort Aware HVAC in Large Buildings

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Abstract

A data driven framework for the energy and comfort management in large buildings with multiple zones and dynamic occupancy patterns is presented in this paper. For such cases, precise heat conduction models derived using the classical thermal physics laws will be cumbersome. The approach uses the historical data to develop a multi-variable model through Structural Equation Modeling (SEM) so as to identify the relative dominance of the direct and indirect effects of thermal coupling among the neighboring zones, occupancy and the external climate variations on the thermal behavior of the building zones. Based on the information gathered from the SEM, we can predict the return temperatures more accurately, which in turn is employed to incorporate a flexible control strategy for the HVAC system. A controller fed with the temperature error and occupancy error, between the predicted and measured values, regulates the supply air fan speed via VFD motor and outside air damper valve openings. This has resulted in the energy savings while maintaining the occupant thermal comfort at the reasonable levels. The framework proposed has been evaluated using real data collected from an HVAC system of a big airport terminal building. The results show that the accuracy of prediction is relatively higher than with other regression techniques; and that the HVAC system is energy efficient and can ensure occupant comfort on real-time basis in large buildings.

Keywords: `HVAC Control, Energy Efficiency, Comfort Management, Data Driven Modeling, Structural Equation Modeling.`

1. Introduction

Development of better modeling and control techniques for heating, ventilation and air conditioning (HVAC) systems has been continuing as an active research area due to the high significance of carbon emission reduction, and for providing occupancy driven energy and comfort management [1, 2, 3]. This becomes pertinent in the recent times, because of the establishment of large buildings for commercial, business or entertainment purposes, like airport terminals, shopping malls, software centres, and such other establishments where the HVAC systems become imperative part of the buildings for ensuring user comfort and for attracting the large clientele. Control of HVAC systems for energy efficiency then becomes contingent along with lighting and access control. Since most of these buildings have large volume spaces without intermediate walls in between, the air handling units (AHU) and the chiller units need more coordination in control. Accordingly, the variable speed electric drives that regulate the air volume and the flow rate to the zones would ensure required comfort levels with improved efficiency [4]. Here the user comfort and energy consumption become two conflicting objectives leading to pareto-optimal control fronts.

Adoption of suitable dynamic models for automatic control in the presence of the complex relationships between variables like change in the occupancy in different zones of the building, interaction with the environment, and relationship between occupant comfort and the zone climatic conditions like temperature, relative humidity, illumination levels, etc. is very intricate and challenging [5]. In tropical countries like India, the energy consumed by HVAC can exceed 50% of the total energy consumption of a building and a recent study shows that a huge increase in the sale of air- conditioners reported in India for the use in homes/buildings due to increased urbanization and the economic development [6]. Same is the situation in other developing economies. Hence, every possible step must be taken to reduce the energy demand and the environmental impact of wastage of energy by adopting efficient control and management techniques for the HVAC systems. It has been shown that significant improvement would be possible in that direction through intelligent automation.

HVAC consumes more than 40% of total energy in buildings [7]. Indoor air in the building is to be conditioned (heating/cooling) as per the climate outside (winter/summer), and the occupancy to offer a comfortable and healthy stay for the tenants. However, occasionally

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