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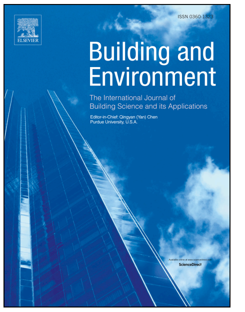

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A new simplified modeling method for model predictive control in a medium-sized commercial building: A case study

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Abstract: Model predictive control (MPC) methods for heating, ventilation and air conditioning (HVAC) systems have been studied to improve the control accuracy and reduce energy consumption in recent years. The accuracy of the model for building thermal dynamics in MPC plays a critical role to accurately control the system. The modeling method also impacts on the real practice of MPC in buildings due to its cost and scalability. Studies have shown that an appropriate simplification of modeling procedure has minor impacts on the model accuracy, but increases the modeling efficiency. In this article, variables including weather conditions, occupancy and electricity are divided into two categories: manipulated variables and random variables. A novel two-step modeling strategy is proposed for simplifying modeling procedure and increasing model accuracy. Manipulated variables are used in step response method to develop system model. A low order system is obtained after the model simplification by observing the response curve. Random variables are used in the power spectral density (PSD) method for modeling. Transfer function is obtained through calculating the cross-power spectral density (CPSD) of the system output and input, the PSD of the input, and the ratio of CPSD and PSD. A MPC strategy with feedforward control structure is proposed to utilize the obtained dynamic characteristics of random variables and effectively compensate the errors caused by these variables. Field test in a medium-sized commercial building is implemented to evaluate the MPC strategy. The result shows that a considerable amount of energy saving is achieved through the proposed MPC.

Keyword: HVAC; Power spectral density; Model predictive control; Feedforward control structure

1. Introduction

In China, buildings are responsible for 28% of the total energy consumption [1]. In commercial buildings, heating, ventilation, and air conditioning (HVAC) system accounts for more than 60% building electricity consumption to meet the demand of occupants' comfort. Therefore, a potential benefit can be achieved and environmental impacts can be reduced through energy saving in building HVAC systems. Compared to HVAC equipment update in existing buildings, the improvement of HVAC control strategies is considered as one of the efficient and cost effective ways to increase the building energy efficiency [2].

Although traditional control methods which include the proportional-integral-derivative (PID) control and the ON/OFF control are still the most commonly used control methods in most