BUILD SIMUL
DOI 10.1007/s12273-013-0138-3

Modeling and optimization of HVAC systems using artificial neural network and genetic algorithm

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Abstract

Intelligent energy management and control system (EMCS) in buildings offers an excellent means of reducing energy consumptions in HVAC systems while maintaining or improving indoor environmental conditions. This can be achieved through the use of computational intelligence and optimization. The paper thus proposes and evaluates a model-based optimization process for HVAC systems using evolutionary algorithm for optimization and artificial neural networks for modeling. The process can be integrated into the EMCS to perform several intelligent functions and achieve optimal whole-system performance. The proposed models and the optimization process are tested using data collected from an existing HVAC system. The testing results show that the models can capture very well the system performance, and the optimization process can reduce cooling energy consumption by about 11% when compared to the traditional operating strategies applied.

Keywords

HVAC systems,
self tuning models,
artificial neural network,
energy management and control systems,
optimization

Article History

Received: 23 August 2012
Revised: 19 April 2013
Accepted: 3 May 2013

1 Introduction

Great efforts have been invested in minimizing the energy costs associated with the operation of HVAC systems. Intelligent Energy Management and Control Systems (EMCS) can provide an effective way of decreasing energy costs in HVAC systems while maintaining indoor environmental conditions (ASHRAE 2011). This EMCS can include several intelligent functions such as optimum set points and operating modes (ASHRAE 2011; Nassif 2012; Nassif et al. 2005; Wang and Jin 2000; Zheng and Zaheer-Uddin 1996) and fault detection and diagnosis (Seem 2007; Lee et al. 1996). The intelligent EMCS can be achieved through the use of the computational intelligence and optimization (Hagras 2008; Kusiak and Xu 2012). The paper thus proposes model-based optimization process for HVAC systems using genetic algorithm and artificial neural networks. The process can be integrated into the EMCS to perform such intelligent functions and achieve optimal whole-system performance. The HVAC optimization problems are solved using the genetic algorithm (GA) inspired by natural evolution which is successfully applied to a wide range of applications including HVAC systems (Deb 2001; Goldberg 1989; Xu et al. 2009; Mossolly et al. 2009). The HVAC optimization problems are dynamic and the problem changes over the course of the optimization. Thus, the GA with proper enhancement and the ability of continuously track the movement of the optimum over time are developed and used. Components models are required for the optimization process and for any other functions. Depending on the type of functions and the accuracy required, the models can vary from simple to more sophisticated calculations. However, it is of practical importance to develop a simple, yet accurate and reliable model to better match the real behavior of the subsystems and overall system over the entire operating range. Models can be developed by two distinct methods (ASHRAE 2009): forward models and data-driven models. Forward models may need detailed physical information that is not always available. Moreover, it is almost impossible to develop a model based on physical knowledge that perfectly

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