An Optimization Model for the Identification of Temperature in Intelligent Building

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ABSTRACT

Methods for the reconstruction of temperature fields in an intelligent building with temperature data of discrete observation positions is a current topic of research. To reconstruct temperature field with observation data, it is necessary to model the identification of temperature in each observation position. In this paper, models for temperature identification in an intelligent building are formalized as optimization problems based on observation temperature data sequence. To solve the optimization problem, a feed forward neural network is used to formalize the identification structure, and connection matrixes of the neural network are the identification parameters. With the object function for the given optimization problem as the fitness function, the training of the feed forward neural network is driven by a genetic algorithm. The experiment for the precision and stability of the proposed method is designed with real temperature data from an intelligent building.

Keywords: Feed Forward Neural Network, Genetic Algorithm, Intelligent Building, Optimization Method, Smart Home, System Identification, Temperature Field

INTRODUCTION

With the rapid development of modern information technology on computer, communication and automation (Braun, 2007; Luo, Lin, Chen, & Su, 2006; Yang & Peng, 2001; Deo, 2006), intelligent building (Flax, 1991; Ralegaonkar & Gupta, 2010; Chen, Clements-Croome, Hong, Li, & Xu, 2006) is presented to describe the phenomena that more and more new building, especially new large public building are equipped with more and more smart equipments (Krukowski & Arsenijevic, 2010; Seo, Oh, Suh, & Park, 2007; Sazonov, Janoyan, & Jha, 2004; Hagras, 2008; Osterlind, Pramsten, Robertson, Eriksson, Finne, & Voigt, 2007). Because there are many automated equipment in an intelligent building, the energy consumed in an intelligent building is cared by user and researcher. Because the distributing of temperature and it’s variety in intelligent building are related to the energy efficiency and comfort grade of the building.
closely, many researchers put their attention on temperature filed in intelligent building. If the temperature field in an intelligent building can be forecasted rightly, the process of energy consuming of the building can be interfered for higher energy efficiency while the comfort grade is kept better level on. To reconstruct temperature field with observation data of discrete observation position in intelligent space, more and more researchers are focused on the identification of temperature in intelligent building.

Although the identification of temperature field in a building is researched widely (Carmody & O'Mahony, 2009; Li, Qin, & Yue, 2008; Jiménez & Madsen, 2008; Zhang, 2009; Jiang, Mahadevan, & Adeli, 2007; Malti, Victor, & Oustaloup, 2008) and some valuable models are gained, most of those models are depended strictly on some constrains such as specific architecture structure, specific heat source as incentive environment. It is difficult and costly to gather those parameters related to temperature field in a building because the architecture of the building may be variety and there are many kinds of building equipment as heat source in intelligent building. For most building equipments can be treated as heat source and the architecture of that building may be variety, it is difficult to collect values of those parameters in real time. To value those parameters with time requirement satisfied, temperature of some observation positions in an intelligent building can be sampled in long term time and the temperature field in the building can be constructed according to the analysis result of those observation data (Lu, Miao, & He, 2009; Yu, 2006).

Identification structure and parameter estimating methods are two key factors of temperature identification (Xiao, Bai, & Yu, 2006; Zhong & Song, 2008). Because temperature in an intelligent building is influenced by many complicated parameters (Wang & Xu, 2005; Hassan, Guirguis, Shaalan, & El-Shazly, 2007), it is practical to assume that all of those parameters are stable in recent time. With this assumption, it is right to construct the identification model of temperature field in intelligent building with high frequency observation data of temperature in that building (Yu, Yi, & Zhao, 2008). To forecast the temperature near an observation position in a building, an optimization model for the reconstruction of temperature in an intelligent building and a method for the temperature identification in that building with feed forward neural network as identification structure and genetic algorithm for the parameter optimization of the method are presented in this paper. The rest of this paper is organized as following. The identification structure based on feed forward neural network and the optimization of identification parameters based on genetic algorithm are presented. Experimental results are shown with observation data of temperature in the electronic reading room of south laboratory in Anhui Architecture University.

**MODEL FOR TEMPERATURE IDENTIFICATION**

The identification model for temperature field inside a building is a function with time, maintenance structure and other thermodynamic parameters as variable. If the maintenance structure of the building and other parameters are not clear, temperature field inside the space can be identified based on temperature context of space. Suppose \(<t_1 \ldots t_n>\) be \(n\) observation temperature value of an observation position with constant time interval, \(t_n = f(t_1, t_2 \ldots t_{n-1})\) where \(t_n\) is the estimate value of \(t_n\) according to \(t_1, t_2 \ldots t_{n-1}\) and \(f\) is estimating method, \(g(f)=(t_n - t_g)^2/2\). If \(g(f_0) = \min g(f)\), \(f_0\) should be the basic temperature identification model for \(<t_1 \ldots t_n>\) and \(t_{n+1}\) can be estimated as \(f_0(t_1, t_2 \ldots t_{n+1})\). Although it is reasonable to estimate \(f_{n+1}\) as \(t_{n+1} = f_0(t_1, t_2 \ldots t_{n+1})\), it is inefficient if the value of \(n\) is large enough for \(f_0\), it is the function with all observation temperature data as variable.

**Definition 1**: Suppose \(<t_1 \ldots t_n>\) be \(n\) observation temperature value of one observation position with constant time interval, \(t_m = f(t_{m-k}, t_{m-k+1} \ldots t_{m-1}), k < m \leq n\) is the estimate value for \(t_m\) and \(f\) is estimate
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