BUILD SIMUL (2012) 5: 95 – 106
DOI 10.1007/s12273-012-0059-6

Genetic algorithms based optimization of artificial neural network architecture for buildings' indoor discomfort and energy consumption prediction

Florent Boithias (✉), Mohamed El Mankibi, Pierre Michel

Lyon University, ENTPE, DGCB/LASH, rue Maurice Audin 69518 Vaulx-en-Velin, France

Abstract

Growing concerns about energy consumption reduction and comfort improvement inside buildings make it more and more necessary to be able to predict with fine precision building's heating loads and indoor discomfort. This article proposes a method based on genetic algorithms (GAs) to optimize the architecture, training parameters and inputs of an artificial neural network (ANN). The ANN is doomed to predict energy consumption and indoor discomfort in future work on the development of an on-line method for control setting optimization. Simple and advanced controllers were used in this study: ON-OFF, PID and fuzzy controllers. Validation of the optimized ANN showed good prediction accuracy, as regression coefficients $R2$ for consumption and discomfort were respectively greater than 0.77 and 0.84 for the three tested controllers. Various prediction "distances" and ANN training data quantities were tested. Conclusion is that prediction at a 2-hour "distance" and a 3-day quantity of data are the best tested optimization conditions.

Keywords

neural networks,
optimization,
genetic algorithms,
discomfort prediction,
energy consumption prediction

Article History

Received: 3 May 2011
Revised: 25 September 2011
Accepted: 30 November 2011

1 Introduction

In the last decade, there has been a growing demand for improving indoor comfort while reducing energy consumption and greenhouse gases emission. It is still necessary to make efforts in that sense today, as fossil resources' price is expected to increase again and concerns about the healthiness of indoor environments are still at high level. Indoor comfort is a very important issue as human beings meanly spend 80% of their time inside buildings (Chao et al. 2004). Moreover, poor comfort in employees' environment can reduce their productivity at work (Bergland et al. 1990).

Growing concerns about energy consumption reduction and comfort improvement inside buildings make it more and more necessary to be able to predict with fine precision building's heating loads and indoor discomfort. Such information can be used for instance for design optimization and heating devices' control optimization, which are ways of improving comfort and reducing energy consumption (El Mankibi and Michel 2005; Boithias et al. 2009). However, in most cases, prediction requires modeling which is a long and expensive task.

The aim of this study is to develop and optimize the performance of artificial neural networks (ANNs) for indoor discomfort and energy consumption prediction. Optimized parameters are architecture parameters (number of ANNs, number of hidden layers, number of neurons per layer, activation function), training parameters (performance function, learning rate, momentum) and inputs (climatic conditions, indoor temperature, previous outputs, occupation rate, heating device's control setting). Outputs of the ANN are fixed: indoor discomfort and energy consumption. Two objective functions have been developed in order to assess ANN outputs.

ANN prediction of indoor discomfort and energy consumption can be used for future work in developing an on-line method for control setting optimization. The main idea is to save research efforts in physical model development, calibration and validation, replacing models by ANNs.

E-mail: florent.boithias@gmail.com