Chapter 121
Prediction of Temperature in Buildings Using Machine Learning Techniques

Juan José Carrasco
University of Valencia, Spain

Gonzalo Vergara
University of Valencia, Spain

Juan Caravaca
University of Valencia, Spain

José M. Martínez-Martínez
University of Valencia, Spain

Mónica Millán-Giraldo
University of Valencia, Spain

Javier Sanchis
ai2-Universitat Politècnica de València, Spain

Emilio Soria-Olivas
University of Valencia, Spain

ABSTRACT

Energy efficiency is a trend due to ecological and economic benefits. Within this field, energy efficiency in buildings sector constitutes one of the main concerns due to the fact that approximately 40% of total world energy consumption corresponds to this sector. Climate control in buildings has the potential to increase its energy efficiency planning strategies for the heating, ventilation and air conditioning (HVAC) machines. These planning strategies may include a stage for long term indoor temperature forecasting. This chapter entails the use of four prediction models (NAÏVE, MLR, MLP, FIS and ANFIS) to forecast temperature in an office building using a temporal horizon of several hours. The obtained results show that the MLP outperforms the other analyzed models. Finally, the obtained predictors are deeply analyzed to obtain information about the influence of the HVAC settings in the building temperature.

INTRODUCTION

In the last decades, energy efficiency has become crucial for the principal governments in many developed countries. Despite the increasing existence of renewable energies (such as wind power or solar energy), the main energy sources are still limited and they have a large impact on the economy (U.S. E.I.A., 2013;

DOI: 10.4018/978-1-5225-1759-7.ch121

European Commission, 2010). Apart from this economic interest, the attention to energy efficiency is also increasing owing to the concern about the environment sustainability. Limited energy resources, like oil fuels or nuclear energy, affect to environmental health, by increasing the pollution levels and causing alterations in the natural world. Recently, there is a trend in the administration to promote the rational use of energy (European Commission, 2003), in order to minimize the negative effects produced in the environment and economics, but maintaining the benefits that energy produces to the society.

Energy consumption in buildings is mostly due to the Heating, Ventilation fans and Air Conditioning (HVAC) systems (Swenson, 1995; Perez, 2008). Therefore, it is necessary an optimal planning and control of the settings in HVAC equipments to ensure a decrease of energy consumption, while indoor temperature is within a comfort range. One possible strategy to optimize the HVAC energy consumption, consist on planning the setpoint temperature, i.e. this is the target temperature set in the HVAC equipments. This strategy can be achieved using a predictor with a horizon of several hours to anticipate when the temperature is going to be of the comfort range (Dounis, 2009). The anticipation of the temperature being uncomfortable can activate modifications in the setpoint temperature to avoid this inappropriate temperature. In that way, temperature will be kept constantly the comfort range and abrupt changes in the HVAC will be avoided, decreasing the peaks of power consumption in HVAC equipments due to sudden changes in their configuration (Maasoumy, 2012).

This growing interest in energy efficiency in buildings has motivated the realization of the present work. The main objective of this chapter is the long-term temperature prediction inside an office building using a set of variables measured in 28 real HVAC equipments. The prediction is achieved with linear (Multiple Linear Regression) and non-linear models (Multilayer Perceptron, Fuzzy Inference System, and Adaptive Neuro Fuzzy Inference System) that are compared to a Naïve model in which temperature predicted in the next hour is the current temperature. In addition, the effects of the setpoint temperature in the prediction are analyzed, in order to make possible an anticipation which may involve a decrease of energy consumption. In that way, prediction models are trained and evaluated with real data acquired in different HVAC equipments of a real office building. Finally, the temperature models are analyzed, with the aim of obtaining maps from which extract rules.

The remainder of the chapter is organized as follows: Section “Background” presents a brief literature review. Section “Data Sets Used” describes the real data set employed in the experiments. A description of the models used in the experiments for the temperature prediction is given in Section “Models used to forecast temperature”. Section “Results obtained” presents the experimental setup and the obtained results. Finally, a summary of the most important conclusions is given in Section “Conclusion”.

BACKGROUND

Several strategies have been proposed in the literature to forecast indoor temperature in buildings, and many of them make use of Artificial Neural Networks (ANNs). (Lu, 2009) have shown the suitability of neural networks to perform predictions of indoor temperature and relative humidity, using Nonlinear AutoRegressive with eXternal input model (NARX) and Genetic Algorithm (GA). (Paniagua, 2011) have presented an Extreme Learning Machine (ELM) approach for real problem of indoor temperature prediction in greenhouses, showing the goodness of the proposed method. Moreover, there are emerging trends based on decision making like reinforcement learning that can be used to model nonlinear phenomena and have already shown good results with chaotic time series prediction (Kuremoto et al.,