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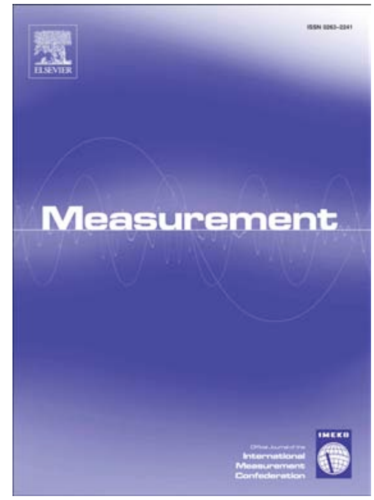

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A Soft Computing Method for the Prediction of Energy Performance of Residential Buildings

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Abstract

Buildings are a crucial factor of energy concerns and one of the most significant energy consumers. Accurate estimation of energy efficiency of residential buildings based on the computation of Heating Load (HL) and the Cooling Load (CL) is an important task. Developing computational tools and methods for prediction of energy performance will help the policy makers in efficient design of building. The aim of this study is therefore to develop an efficient method for the prediction of energy performance of residential buildings using machine learning techniques. Our method is developed through clustering, noise removal and prediction techniques. Accordingly, we use Expectation Maximization (EM), Principal Component Analysis (PCA) and Adaptive-Network-based Fuzzy Inference System (ANFIS) methods for clustering, noise removal and prediction tasks, respectively. Experimental results on real-world dataset show that proposed method remarkably improves the accuracy of prediction in relation to the existing state-of-the-art techniques and is efficient in estimating the energy efficiency of residential buildings. The Mean Absolute Error (MAE) of the predictions for HL and CL are respectively 0.16 and 0.52 which show the effectiveness of our method in prediction of HL and CL.

Keywords: *Residential Buildings, Adaptive-Network-based Fuzzy Inference System, PCA, Estimation of Energy Efficiency, Heating Load, Cooling Load.*

1. Introduction

Energy Performance of Buildings (EPB) has recently become a major issue due to growing concerns of CO2 and greenhouse gas emissions, and their perpetual adverse impact on the environment (Park et al., 2016; Tsanas & Xifara, 2012). Residential buildings worldwide account for surprisingly more than 40% of energy consumption, and hence, offer an opportunity to improve energy performance (Balaras et al., 2007). According to reports, over the past decade, the EPB has steadily increased (Pérez-Lombard et al., 2008), while the majority of energy consumption in buildings is due to heating, ventilation and air conditioning (HVAC) (Yao et al., 2005). Among all systems, HVAC systems consume approximately 43% of total operating energy in residential buildings and about 33% of operating energy in commercial buildings. HVAC systems are the main source of GHG emissions in buildings. As a result, the reduction of energy consumption and greenhouse gas (GHG) emissions in HVAC systems can significantly improve the environment. In addition, when considering the energy usage by buildings, HVAC systems account for almost half of energy consumption in buildings and between 10 percent and 20 percent of all energy used in developed countries. Therefore, moving towards energy-efficient design of buildings with enhanced energy conservation properties would be a solution to diminish growing demand of energy supplies.

When it comes to design of sustainable buildings more towards energy efficiency, Heating Load (HL) and Cooling Load (CL) computations are essential to select proper heating and cooling equipment to maintain pleasant indoor air condition (Tsanas & Xifara, 2012). Accordingly, early predictions of HL and CL would assist engineers to design more sustainable buildings regarding energy consumption level (Chou & Bui, 2014). Building engineers require information regarding the characteristics of the building, conditioned space, climate and intended use in order to estimate capacities of required heating and cooling (Tsanas & Xifara, 2012). Consequently, accurately predicting HL and CL of building is a challenging task.