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An intelligent approach to assessing the effect of building occupancy on building cooling load prediction

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ABSTRACT

Building cooling load prediction is one of the key factors in the success of energy-saving measures. Many computational models available in the industry have been developed from either forward or inverse modeling approaches. However, these models usually require extensive computer resources and lengthy computation. This paper discusses the use of the multi-layer perceptron (MLP) model, one of the artificial neural network (ANN) models widely adopted in engineering applications, to estimate the cooling load of a building. The training samples used include weather data obtained from the Hong Kong Observatory and building-related data acquired from an existing prestigious commercial building in Hong Kong that houses a mega complex and operates 24 h a day. The paper also discusses the practical difficulties encountered in acquiring building-related data. In contrast to other studies that use ANN models to predict building cooling load, this paper includes the building occupancy rate as one of the input parameters used to determine building cooling load. The results demonstrate that the building occupancy rate plays a critical role in building cooling load prediction and significantly improves predictive accuracy.

1. Introduction

Following the oil embargo of 1973, both the political and scientific communities began to pay more attention to opportunities to improve energy efficiency. Current statistics on energy use in different sectors show that the building sectors use approximately 40% of the world's electricity supply, which is used for heating, air conditioning, ventilation, lighting, and the operation of various types of building services system equipment [1]. The figure is somewhat higher for building services systems operated in tropical or sub-tropical areas, where air conditioning accounts for at least 50% of a building's total energy consumption [2]. The situation is even worse in Hong Kong, as most commercial buildings are fully air-conditioned and mechanically ventilated. As much as 60% of the energy used in Hong Kong's high-rise commercial buildings is powered mechanical ventilation and air-conditioning systems. Therefore, the ways to properly managing the building energy demands retain a lot of research attention, especially in air-conditioning systems.

Energy auditing is generally an effective tool that can assist facility managers in developing energy-saving plans and achieving energy-saving goals [3]. However, energy audits are typically expensive and time-consuming, which discourages building owners and managers from investing both the time and money required for a full energy audit exercise. Researchers have responded by developing inexpensive audit methodologies designed to identify buildings that are likely candidates for energy savings. These methodologies have been made possible by rapid advancements in computer hardware and software developed for building design. Many studies have adopted computer-based simulation models to evaluate building energy consumption levels [3].

Generally, the main stream of energy analysis employs forward approach which the energy predictions are based on a physical description of the building system such as geometry, building construction details, HVAC equipments and operation schedule. Most of the existing detailed energy computer-based simulation tools such as DOE-2, EnergyPlus and BLAST follow the forward modeling approach. However, the process of establishing the simulation model is very time-consuming and resource-intensive, especially for complex mixed-purpose buildings with unregulated operating schedules.

Inverse modeling approach is another method relying on existing building parameters such as energy use, weather or any relevant performance data to identify a set of building parameters such as prediction of cooling load. Typically, regression analyses are employed to estimate the representative parameters for building

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