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Chiller energy prediction in commercial building: A metaheuristic-Enhanced deep learning approach

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ABSTRACT

Chiller systems hold a critical role in upholding comfort and energy efficiency within commercial buildings. Precise prediction of chiller energy consumption is imperative for operational optimization and the reduction of energy expenditures. This paper introduces an innovative methodology that integrates deep learning (DL), specifically Fixed Forward Neural Networks (FFNN), with Teaching-Learning-Based Optimization (TLBO) to enhance the accuracy of chiller energy consumption forecasts. Drawing on a diverse dataset from a commercial building, encompassing vital input parameters such as Chilled Water Rate, Building Load, Cooling Water Temperature, Humidity, and Dew Point, the study conducts a comprehensive comparison of metaheuristic algorithms (Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Barnacles Mating Optimizer (BMO), Harmony Search Algorithm (HSA), Differential Evolution (DE), Ant Colony Optimization (ACO), and the latest RIME algorithm). TLBO's adept navigation of the intricate parameter space of DL yields highly precise predictions for chiller energy consumption. The study's outcomes underscore TLBO's potential, along with other metaheuristics, in optimizing DL and refining energy management practices in commercial buildings. This research significantly contributes to the evolving discourse on the symbiosis between DL, particularly FFNNs, and metaheuristic optimization, offering a robust framework for chiller energy consumption prediction, thereby advancing sustainability and cost-effectiveness in building operations.

1. Introduction

Commercial buildings consume a significant amount of energy, and chiller systems play a crucial role in maintaining comfort and energy efficiency. As a fundamental element within building Heating, Ventilation, and Air Conditioning (HVAC) systems, the building chiller system not only entails substantial energy consumption but also carries a heightened risk of safety and reliability issues when functioning under faulty conditions [1]. Chiller energy consumption prediction is essential for optimizing building operations and reducing energy costs. Accurate prediction of chiller energy consumption can help building managers to make informed decisions about energy usage and reduce energy waste [2]. Recent studies have highlighted the importance of advancing methodologies for chiller energy prediction and building energy management practices. For instance, an approach to optimize datasets and improve the accuracy of machine learning models for chiller load prediction in commercial buildings has been introduced in Ref. [3]. Moreover, the use of transfer learning techniques to enhance building energy predictions in data-scarce contexts has been proposed in Refs. [4,5]. They explore both algorithm-centric and data-centric perspectives, providing practical guidelines for developing cost-effective data-driven solutions for building energy predictions.

Additionally, ref. [6] presents a method for online cooling load prediction tailored for super high-rise buildings. Given the relevance of cooling load prediction to chiller energy consumption in such structures, this method offers valuable insights applicable to optimizing energy usage in similar architectural contexts. Chiller systems, renowned for their substantial energy demand, substantially contribute to the energy consumption of commercial buildings. Given the contemporary emphasis on energy efficiency and sustainable building practices, the optimization of HVAC systems, particularly chillers, has assumed a central role in facilities management and operational cost reduction efforts [7].

The importance of precise chiller energy predictions in practical applications cannot be overstated. In commercial buildings, where energy use is substantial, chillers are essential for occupant comfort and

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