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Utilizing the Kolmogorov-Arnold Networks for chiller energy consumption prediction in commercial building

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ABSTRACT

Accurate prediction of chiller energy consumption is essential for optimizing energy usage and reducing operational costs in commercial buildings. Traditional predictive methods often struggle to capture the complex, nonlinear relationships inherent in energy consumption data. This study proposes the use of Kolmogorov-Arnold Networks (KAN) to address this challenge, leveraging their ability to model intricate nonlinear dynamics with high precision. The study introduces KAN as a novel application for real-world chiller energy prediction, using actual data obtained from a commercial building. The methodology involves comparing KAN's performance with Artificial Neural Networks (NN) and a hybrid metaheuristic algorithm combined with deep learning, namely the Teaching-Learning-Based Optimization with Deep Learning (TLBO-DL). The results show that KAN achieves an R^2 value of 0.9465 and an RMSE of 6.1023, outperforming NN (R^2: 0.9281, RMSE: 6.7709) and TLBO-DL (R^2: 0.9366, RMSE: 6.2892). The novelty of this research lies in the innovative application of KAN to chiller energy consumption prediction, coupled with advanced parameter tuning and improved computational efficiency. This study not only demonstrates the superior accuracy of KAN but also contributes to the field by showcasing its practical utility and effectiveness in energy management systems.

1. Introduction

Commercial buildings are well-known for their high energy consumption, with chiller systems essential for maintaining comfortable indoor climates. These systems are critical to Heating, ventilation, and air conditioning (HVAC) operations, significantly impacting the building's energy usage. The efficiency of chiller systems directly influences overall energy consumption and operational costs [1,2]. Understanding and accurately predicting chiller energy usage can help identify inefficiencies, predict maintenance needs, and improve system performance [3]. This task is further complicated by the complex, nonlinear relationships inherent in energy consumption patterns, which are influenced by various factors including system load, ambient conditions, and operational settings [4]. Recent advancements include the development of control methods that leverage weather forecasting data in conjunction with deep reinforcement learning algorithms to optimize HVAC system performance. These methods aim to enhance predictive accuracy and operational efficiency by incorporating external variables, such as weather conditions, which significantly impact energy

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