Machine learning may play a role in building energy models

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Glass walls line the hallway in Folliard Alumni Center. Credit: Florida Institute of Technology

More than 40% of all U.S. energy use and greenhouse gas emissions are associated with the building sector. A study from Florida Tech

researchers is exploring whether machine learning can help reduce this environmental impact.

The research was featured in a paper posted in the January edition of the journal *Energies* titled "A Novel Approach for Optimizing Building Energy Models Using Machine Learning Algorithms." Authored by Hamidreza Najafi, associate professor of mechanical and engineering, and Benjamin Kubwimana, a master's mechanical engineering graduate, both from Florida Tech, the study uses a new approach for both building energy modeling (BEM) and optimization of building energy models.

The current practice for building energy simulation software tools requires a lot of manual entry of large lists of detailed inputs—design and operational variables, including characteristics of the building such as wall, building envelope and window materials, or operational parameters, such as setpoint temperatures for different thermal zones.

"When it comes to optimization of BEMs, it is quite challenging because of the large number of variables involved in BEMs and the possibility of developing BEMs with thousands, or millions, of different combinations of these variables," Najafi said. "Achieving a truly optimal design for a building requires assessing all of these possible design/operating parameters, which is computationally very costly, and often not possible."

Najafi and Kubwimana's work involves developing a Python-language software script that allows automated entry of the data into a physics-based building energy simulation tool called EnergyPlus. Using a series of variables as inputs through this Python script, a large variation of multiple parameters is covered, resulting in the creation of large data sets that can be used to develop a surrogate energy simulation model.

A data-driven model using machine learning algorithms, specifically

artificial neural networks, is then trained using these datasets. Two optimization approaches—genetic algorithm and Bayesian optimization—are applied on the surrogate model to achieve the optimal design for the building. The approach can be easily adjusted to account for different design or operational parameters.

"This process can be automated, so the data from the sensors in the building can be supplied into computer models to facilitate continuous adaptation of the digital twin into the current operating condition of the building," Najafi said. "This could help the building owner predict how much energy they're going to consume based on changes that may occur in the operational parameters. This allows for proper planning of budgeting for the energy cost and prediction of energy consumption and energy production, as well as reduction in CO_2 generation associated with energy savings."

This study was part of a broader effort for improving BEMs and expanding their applications. Enhanced BEMs can be used as digital twins of buildings and provide value for owners and developers not only prior to the construction but also during the building's lifespan. That study was published in the *ASME Journal of Engineering for Sustainable Buildings and Cities* in December 2022.

"In this study with one of my Ph.D. students, Mariana Migliori, we explored the impact of COVID-19 on the energy performance of buildings and how to adapt BEMs to remain accurate in the event of changes in the operational condition," Najafi said. "We performed a case study based on the data that we collected from Florida Tech's Folliard Alumni Center as well as the physics-based models that we previously developed for the building and were able to develop a data-driven model that could adapt to the new operating conditions in view of the COVID-19 situation with extended operating hours for the HVAC systems and changes in the schedule of occupancy."

More information: Benjamin Kubwimana et al, A Novel Approach for Optimizing Building Energy Models Using Machine Learning Algorithms, *Energies* (2023). DOI: 10.3390/en16031033

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