A novel hybrid modeling method for predicting energy use of hydronic radiant slab systems

Liping Wang, James Braun, Sujit Dahal

Abstract:

Hydronic radiant slab systems use floors or ceilings, in which tubes with circulated hot water for heating or chilled water for cooling are embedded to provide large surface area heat exchangers, to condition spaces. Radiant slab systems have substantial thermal capacity with extended hours for free cooling, which could lead to substantial building energy savings and opportunities for reducing peak cooling and heating demands. Accurately predicting the performance of radiant slab systems can be challenging due to the large thermal capacitance of the radiant slab and room temperature stratification. Current methods for predicting heating and cooling energy consumption of hydronic radiant slabs include detail first-principle-based (e.g, finite difference) and reduced-order (e.g, thermal resistor-capacitor (RC) network) models. Creating and calibrating detailed first-principle models, as well as RC network models for predicting the performance of radiant slabs requires substantial modeling efforts. To develop improved control, monitoring, and diagnostic methods, there is a need for simpler models that can be readily trained using in-situ measurements.

In this study, we explore a novel hybrid modeling method integrating a simple RC network model with an evolving learning-based algorithm growing Gaussian mixture regression (GGMR) modeling approach to predict the heating and cooling rates of a radiant slab system for a Living Laboratory office space at Purdue University. The RC network model provides heating or cooling load to the GGMR model as one of the inputs. We will compare three modeling approaches for the radiant system: 1) an RC network model, 2) a GGMR approach, and 3) a combination of the RC and GGMR models. Model accuracy and model development efforts will be compared and discussed for the different approaches.