Abstract

Aligning to Singapore's smart nation and smart city goals, the buildings could be upgraded into smart buildings in Singapore. The concept of smart buildings is making buildings more energy-efficient and high performance on thermal comfort of residents with non-intrusive wearable sensors and internet of things (IOTs). It can result in reducing the emissions of greenhouse gases, and the created innovation economy in smart building's implementations can lead to greener, cleaner and smarter buildings toward sustainable growth and life enhancements for Singapore.

The components of Air-Conditioning and Mechanical Ventilation (ACMV) systems are air handling units (AHU), water chiller units (WCU), liquid dehumidification units (LDU), air ducts, diffusers and smart dampers. The environmental parameters, such as air temperature, air velocity, air relative humidity, air carbon dioxide concentration and so forth, are modeled through recent state-of-the-art machine learning approaches that are classified as supervised learning, unsupervised learning or reinforcement learning, and the models can be further optimized by computationally intelligent algorithms (i.e. genetic algorithm, particle swarm optimization, augmented firefly algorithm, batch/stochastic gradient descent, etc.). During my PhD study, it had shown that our optimal solutions altering operation schemes can conserve energy resources by about at least 20% compared to ordinary operation conditions on the platform of NTU laboratory.

The indoor thermal comfort of residents can be evaluated under two ways. One way is a passive approach to make use of ambient sensors to obtain current environmental profiles, such as air temperature, air velocity, air relative humidity, air carbon dioxide concentration and so forth. Based on the developed Fanger’s Predicted Mean Vote (PMV) model, the indoor thermal comfort sensation of residents is indirectly determined. Another way is an active approach to directly obtain residents’ physiological parameters through wearable and non-intrusive devices. The main physiological parameters in my PhD study showed that height, weight, clothing, gender, skin temperature and skin temperature gradient can make significant impacts over indoor thermal comfort sensation of residents. It had showed that active approach (at least 70% predicting accuracy) presents better results than passive approach, and there are still a lot of potential researches to be carried out in active approach study. Based on the thermal comfort models and ACMV systems models, objective functions had been established for balancing energy consumption and thermal comfort sensations. The objective functions had been further optimized by optimization algorithms for looking up optimal solutions in searching spaces. The results had presented that the ACMV systems can perform about at least 14% more efficient than ordinary operating conditions without sacrificing the thermal comfort sensations of occupants on the platform of NTU laboratory.