PREFERENCE-DRIVEN PERSONALIZED THERMAL CONTROL USING LOW-COST LOCAL SENSING

Hejia Zhang

Personalized thermal controls are beneficial for occupant productivity in office buildings. Recent research efforts on learning personal thermal comfort support the integration of personalized preferences in optimal building control and further implementation in real buildings. This thesis presents the development and field implementation of personal preference-based thermal control in real offices, emphasizing the role of model predictive control (MPC) and low-cost local sensing. Probabilistic thermal preference profiles, a low-cost thermal sensing network and a MPC framework were integrated into a centralized building management and control system. The customized, preference-based HVAC control implemented in the offices indicated the comfort benefits of monitoring local thermal conditions (vs wall thermostats) for different preference profiles and showed 28-35% energy savings with personalized MPC (vs personalized static setpoint control).

Regarding the practical limitations in collecting sufficient data from occupants to train their thermal comfort model, this thesis then presents a Bayesian meta-learning approach for developing reliable, data-driven personalized thermal comfort models using limited data from individuals. A high-dimensional neural network was developed, considering general thermal comfort impact factors (environmental variables, clothing level and metabolic rate) as well as personal thermal characteristics (expressed as a vector of continuous latent variables) as model inputs. The model parameters in the neural network were trained with subsets of ASHRAE RP-884 database. The trained neural network is transferrable, so that the thermal preferences of new individuals can be predicted by inferring their personal thermal characteristics using limited data. The results show that the developed Bayesian meta-learning approach to infer personal thermal comfort performs better than existing methods, especially when using limited data.

Moreover, this thesis also discusses the potential of balancing thermal comfort and energy cost by setting dynamic temperature constraints in personalized MPC. A co-simulation framework of EnergyPlus and MPC is constructed using EnergyPlus Python API. Dynamic temperature constraints are selected based on personal thermal profile, weather conditions and utility rate variations. The performance of the personalized MPC with dynamic constraints shows a balance between thermal comfort and energy cost in cooling season.