Université Angers

Angers, le 22 novembre 2023

AVIS DE SOUTENANCE DE THÈSE

DOCTORAT (Arrêté du 26 août 2022 modifiant l'arrêté du 25 mai 2016)

Monsieur Chuhao JIANG

candidat au diplôme de Doctorat de l'Université d'Angers, est autorisé à soutenir publiquement sa thèse

le 04/12/2023 à 09h00
POLYTECH ANGERS
AMPHI E
62, avenue Notre-Dame du Lac
49000 ANGERS

sur le sujet suivant :

Towards user-centric optimisation and predictive control approaches of the performance of smart buildings

Directeur de thèse : **Monsieur David BIGAUD**

Composition du jury :
Monsieur David BIGAUD, Professeur des Universités Université d'Angers, Directeur de thèse
Monsieur Abdérafi CHARKI, Maître de Conférences HDR Université d'Angers, Examinateur
Monsieur Didier DEFER, Professeur des Universités Université d'Artois, Rapporteur
Madame Marie DUQUESNE, Professeure des Universités Université de La Rochelle, Rapporteure
Monsieur Alain GODON, Maître de Conférences Université d'Angers, Examinateur
Madame Marie-Lise PANNIER, Maîtresse de Conférences Université d'Angers, Co-encadrante
Madame Ting-Ting VOGT WU, Maîtresse de Conférences Université de Bordeaux, Examinatrice
Madame Monika WOLOSZYN, Professeure des Universités Université de Savoie, Examinatrice

Résumé de la thèse

In response to the energy and digital transitions in the building sector, the concept of Smart Building is gaining importance. The optimized management of these buildings should enable a reduction in costs and energy consumption in the operating phase. However, the improvement of the energy performances should not be at the expense of user comfort. The success of a smart house system largely depends on the active participation of its occupants and it is important considering the "humans in the loop". In addition, for economic and environmental reasons, the deployment of smart sensors and actuators must be done sparingly. In this context, the aim of the PhD is to optimize the placement of multi-physical sensors to detect one or more occupant's actions that will serve to develop efficient user-centric management strategies. A correct detection of occupancy may require using a lot of smart sensors measuring various physical quantities. Furthermore, the few sets of sensors selected must be adapted to describe the comfort at some specific places in the building where the occupants are more likely to be. Optimal sensor placement has been investigated using the effective independent method in order ensure a sparse and efficient characterization of the occupancy and comfort (chapter 3). The inclusion of humans in the loop requires a better understanding of their activities. Machine learning algorithms are then applied to detect either windows openings or the presence of occupants in a room. One of the challenges concerns the efficiency of activity detection for unlabeled data (i.e., when the actual occupancy status is unknown). It has been approached using unsupervised or semi-supervised algorithms (chapter 4). Another challenge is to classify which type of activity is associated with different effects on indoor environmental conditions. To deal with this aspect, it has been proposed in the thesis to use self learning algorithm and root cause analysis methods and more particulary Bayesian networks (chapter 5). Once the occupancy is better understood from a reduced set of sensors, this knowledge is intended to be used to define an efficient user-centric energy management strategy. The consistency of the proposed framework was proven by applying the methods on two complementary case studies. The first one is a simulated case study on which dynamic building energy simulations and computational fluid dynamics simulations are performed to assess indoor temperatures and energy loads for different predefined occupancy scenarios. For the second case study, an instrumentation has been designed and deployed in a real building: the installed smart multi-physical sensors allow collecting data on the indoor environment, as well as on the occupancy.