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# Mixing data and knowledge for modeling and control of building energy systems

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## Abstract

The talk is about energy management in building which is probably one of the main challenges of demand side management to quickly increase renewable part of the energy mix. The aim is not to define a specific result but more to present and discuss some results and approaches developed in the context of Singapore/France Create program.
DesCartes is a CNRS@CREATE[1] program which aims to develop disruptive hybrid AI to serve the smart city and enable optimized decision-making in complex situations for critical urban systems. It is a cross disciplinary program involving 80 stem and non-stem researchers from France and Singapore. The presented work is part of a work package dealing with Complex Systems and Physics for Hybrid AI, applied among other to flexibility of energy systems.
Here we are focusing on Building Energy Management System (BEMS) modeling and control methodologies for hybridization. Some existing BEMS approaches are model free like simple rule-based controls which may be sub-optimal, or reinforcement learning which requires a large number of interactions with the real environment for learning. Others are model based like model predictive control, using machine learning models, or using explicit mathematical/numerical model which is hard to obtain and subject to uncertainties. Both strategies are not compared here and have their own advantages and cons.
Two independent hybridization studies have been achieved:
1 – Machine learning driven parameter identification of physic-based building thermal model.
2 – Comparison of two knowledge assisted model free controllers: action masking reinforcement learning and behavioral cloning strategies.

Model based BEMS requires models that are both fast and capable of adapting to the reality. To do so we investigated in Quang-Hung Nguyen's PhD an hybrid approach which consists on a generic physic-based lumped parameter model of a building, where values of the parameters vary according to the changing conditions affecting the building. Parameters are updated from the past week measures using either a least square minimization which is time consuming and subject to divergence, and a model that has learnt identified values behavior. Both methods provide the same prediction accuracy while parameters updated gains in execution speed from few minutes to some milliseconds.

Model free BEMS needs to improve their learning efficiency. To do so, we investigate in Sharath Ram Kumar's PhD, a behavioral cloning strategy which starts from expert knowledge embedded in a rule-based controller and able to adapt with online learning. We also investigate an action masking strategy, to reduce action space in order to satisfy expert knowledge constraints. It achieves a cost reduction of 6% compared to a baseline, and also outperforms the behavioral cloning strategy.

[1] https://descartes.cnrsatcreate.cnrs.fr/