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Sensitivity analysis of building physical parameters to maximize heating energy saving using MPC

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Extended Abstract

Buildings are one of the largest energy consumers and emitters of CO_2, and they consume a significant portion of the overall energy in the world [1]. There is an increased interest in using model-predictive control (MPC) to optimise building performance in many aspects such as saving heating energy [2]. Further, as MPC uses future control scenarios and can optimise the outcomes, there is a great potential for linking to and optimising the use of energy storage within buildings using this control strategy. This study aims to investigate the influence of MPC on heating energy consumption while the indoor air temperature is maintained at an acceptable level.

In the control of heating systems at each time step the system output (e.g. indoor air temperature) is measured and compared to desired references (e.g. indoor air temperature set point) and an appropriate change to the system inputs (e.g. the mass flow rate (MFR) going through a radiator) is employed. A refined solution is to use machine learning techniques to derive a model of the building dynamics based on collected data which is then used to optimise the choice of MFR. The model will take a sequence of MFR and other external variables (e.g. external temperature, solar radiation and wind) and predicts the indoor air temperature over a prediction horizon. MPC is employed to perform an optimisation over the prediction horizon. The optimisation searches for a sequence of MFR that minimises a cost function that considers the predicted indoor air temperatures against the desired reference (set point air temperatures). The cost function can consider a series of desirable features, such as maintaining the indoor air temperature to desired set points, reduce energy consumption, and actuator wear (e.g. valves).

The case study is an office building located in the UK. Due to the response to external conditions (temperature, solar radiation, and wind), it is possible that the potential savings from the use of MPC vary depending on the buildings physical characteristics. Therefore, this research studies different physical parameters of building to characterise how MPC has an influence on building performance. The studied parameters are, a) two different thermal insulations as new and old buildings, b) three different floor areas of the building, and c) three orientations of the building. All buildings will be studied with an indoor air temperature set point of 22 °C (±1 °C).

The before-mentioned parameters are separately and simultaneously studied to optimise building performance. According to these parameters, the results can show how the influence of MPC, for instance, a saving of heating energy consumption can be maximised for each parameter and all parameters.

References

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