Models for heating system optimisation

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I. Motivation

Heating, Ventilation and Air Conditioning (HVAC) systems generally have high energy requirements [1], hence there is considerable interest in the development of modelling techniques, optimisation tools and micro–climate control algorithms for buildings. Pertinent to this research area is the Lancaster University Main Campus, for which a central energy centre supplies the hot water used to heat around 50% of the buildings. Although the Building Management System provides an abundance of energy data for the entire campus, which is further enhanced by the availability of data from the Hazelrigg weather station, regulation of the energy centre production is presently sub-optimal.

II. Scope

This project concerns simple, flexible models suitable for improving control system robustness and overall system optimisation. Lancaster's energy centre provides multiple methods of heat production, such as gas boilers and a biomass generator. The models are being used to explore options for hierarchical control, with a particular focus on optimising the use of the boilers and generator. To achieve this, non-minimal state space model predictive control methods [2] are being adapted for this application. A novelty of the research is the incorporation of weather forecasting and human occupancy data into the control calculations. The Poster associated with this Abstract considers the Charles Carter Building as a case study example. This building has a central atrium, surrounded by lecture theatres, offices, meeting rooms and break-out spaces.

III. Methods

Numerous approaches for modelling heat transfer inside buildings have been developed. These are often categorised into models that are statistically identified from data [3] or are physically–based [4]. The present project has investigated the use of a data–based mechanistic (DBM) approach [5] and another hybrid approach based on an electrical analogy, with the latter the focus of the Poster. This analogy, which has a long track record for use in buildings modelling [6], observes that Fourier's equation for one dimensional heat transfer takes the same form as Ohm's law, providing a system for creating and resolving complex heat transfer problems using an established set of laws. Fig. 1 illustrates the response of such a model, as applied to the Charles Carter Building.

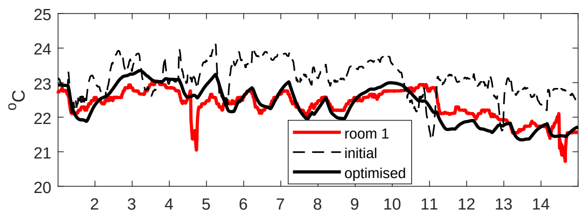

Fig. 1. Measured room temperatures for the first two weeks of September 2017 (axis: days), compared with the output of an electrical analogy model, for an illustrative room of the Charles Carter Building. The response of an initial model with physically–based coefficients (dashed) is compared to the response with coefficients that have been numerically optimised from measured data (solid).

References

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