Structured modelling from data and optimal control of the cooling system of a large business center

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Structured modelling from data and optimal control of the cooling system of a large business center

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Abstract

The optimal cooling operation of a large business center, with five buildings totalling about $70,000\,\mathrm{m}^2$ of interiors, is considered. This problem is relevant due to the high operational costs and energy demand of the cooling system. The latter features four chillers currently managed with heuristic rules. The aim of this study is to redesign the control system to minimize the energy consumption while still meeting the cooling demand. The main challenges are the impossibility to derive a model of the system based on physics, due to its high complexity and lack of information on each subsystem, and the on-off behaviour and hysteretic operational constraints of the chillers. To solve this problem, a structured black-box dynamical model of the system is derived using machine learning techniques, exploiting a dataset of more than 500 days of operation. The employed quantities are easily measurable and include the flow rate and temperature of the cooling water, electric power consumption, and external temperature and humidity. Then, the derived model has been used to optimally tune the feedback control strategy via nonlinear programming, by minimizing the predicted energy consumption while satisfying the cooling demand. Simulation results with a validation dataset indicate that the proposed approach achieves an energy saving of 30% with respect to the controller currently adopted, while keeping the temperature in the desired range. The proposed modelling approach, based on data, results in a high applicability to plants with different layouts and components, whenever measurements of the relevant quantities are available.

Keywords: Cooling station, control for energy saving, identification, modelling, optimization, HVAC systems.

1. Introduction

The topic of energy saving in buildings by optimization of their cooling plants is receiving a growing interest, see for example [13], [18], [3], [29], [26], [19], [22]. This trend is motivated by the large share, over 38% according to [2], of the overall energy consumption attributable to buildings; within that, about 50% pertains to Heating Ventilation and Air Conditioning (HVAC) systems,