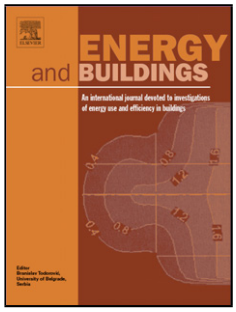

Title: Modelling and Disturbance Estimation for Model Predictive Control in Building Heating Systems

Author: Edward O'Dwyer Luciano De Tommasi Kostantinos Kouramas Marcin Cychowski Gordon Lightbody

PII: S0378-7788(16)30789-7
DOI: http://dx.doi.org/doi:10.1016/j.enbuild.2016.08.077
Reference: ENB 6976

To appear in: *ENB*

Received date: 26-1-2016
Revised date: 26-7-2016
Accepted date: 27-8-2016

Please cite this article as: Edward O'Dwyer, Luciano De Tommasi, Kostantinos Kouramas, Marcin Cychowski, Gordon Lightbody, Modelling and Disturbance Estimation for Model Predictive Control in Building Heating Systems, *<![CDATA[Energy & Buildings]]>* (2016), http://dx.doi.org/10.1016/j.enbuild.2016.08.077

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Energy and Buildings 00 (2016) 1–16

Energy and Buildings

Modelling and Disturbance Estimation for Model Predictive Control in Building Heating Systems

Edward O'Dwyer[a], Luciano De Tommasi[b], Kostantinos Kouramas[b], Marcin Cychowski[b], Gordon Lightbody[a,c]

[a] *School of Engineering, University College Cork, Ireland*
[b] *United Technologies Research Centre, Cork, Ireland*
[c] *SFI MaREI Research Centre, Cork, Ireland*

Abstract

As research in the area of model predictive control (MPC) for building energy systems intensifies, appropriate methods are required to model a building's thermodynamic properties. In this paper, building models are considered from two perspectives - simulation and optimisation. First, a methodology is devised for the development of complex simulation models for control strategy comparison and analysis. A novel spatio-temporal filtering technique for estimation of disturbances is devised and combined with metaheuristic search methods to allow for models to be derived from data in which typical disturbances are present. Adapting the disturbance estimation techniques, methods are then proposed for deriving low-order models from data, suitable for use within an optimisation-based MPC strategy. The modelling concepts are implemented using data from a real building and a potential MPC formulation is assessed.

Keywords: Building modelling, model predictive control, disturbance estimation, metaheuristic search algorithms, principal component analysis

1. Introduction

1.1. Motivation

As concerns grow over human influenced climate-change and energy security, there is a clear need to reduce energy consumption associated with buildings. In [1], the contribution of buildings worldwide to global energy consumption is stated to be approximately 40% while, more generally, in [2] the International Energy Agency state that the services and households sector globally was responsible for 35% of energy consumption, accounting for 30% of CO_2 emissions [3]. While improvements in building standards and regulations will encourage improved efficiency through better insulation and equipment specifications, it is shown in [4] that typically, modern heating systems are

List of Abbreviations

ARMAX	Autoregressive-moving-average model with exogenous input
ARX	Autoregressive model with exogenous input
GA	Genetic Algorithms
MPC	Model predictive control
PCA	Principal component analysis
PEM	Prediction-error identification methods
PI	Proportional-Integral
PSO	Particle swarm optimisation
Q-PSO	Quantum-behaved particle swarm optimisation
QP	Quadratic programming
RC	Resistor-capacitor
SA	Simulated Annealing

Email addresses: edward.j.odwyer@umail.ucc.ie (Edward O'Dwyer), detomal@utrc.utc.com (Luciano De Tommasi), kouramk@utrc.utc.com (Kostantinos Kouramas), cychowm@utrc.utc.com (Marcin Cychowski), g.lightbody@ucc.ie (Gordon Lightbody)