21.5.

Thesis Review

Candidate: Samuel Privara

Title: Building Modelling and Identification for Predictive Control

Relevance

Human housing is one of the largest energy consumers worldwide. With energy consumption becoming a recognised issue, research that leads to energy saving is certainly of great commercial and public interest. Any subject that explores means of reducing the energy consumption is relevant and of interest to any local community. This certainly applies to building technology but also to the operation of buildings, small ones as well as large industrial, commercial, and public buildings. It is thus also not so surprising that the subject itself is not particularly new, but if one follows the subject's history, one finds that emphasis is shifting: building techniques, passive energy housing, solar influx control (active and passive), air conditioning and heating.

Goal Achievement

Section 2 of the short thesis provides the goals:

1. To perform a survey of the currently available approaches
2. To select and analyse the suitable approaches
3. To find a solution to the specific problem of building modelling techniques
4. To develop the model selection and validation methodology

This all in the context of **M**odel **P**redictive **C**ontrol (MPC).

1. Survey : The context is modelling and identification for MPC. The different papers do give a good survey of the identification procedures that apply to models suitable for MPC starting with the 1960-ties ARMAX models, to traditional semi-mechanistic models, and linear state-space models. The identification methods focus on minimising a prediction-error criterion, which is the appropriate choice considering the use of the model in MPC. On the model side one could argue that there are certainly other models and approaches that are not mentioned. I was thinking of generic nonlinear network models or a split of basic mechanistic models and empirical network models capturing the behaviour of the residuals.
2. Suitable models and identification methods: In particular the last paper in the selection entitled "Building modelling: Selection of the most appropriate model for predictive control" gives some answers to the posed question. On the identification method, in my view the most relevant ones are explored in the study.
3. Solutions to specific problems: Two issues of this nature were indeed addressed and to

some extent also resolved: knowledge of some parameters, for example steady state behaviour and pure excitation of the system.

Methodology

The work looked at a good number of identification methods. Most of them one can consider standard as of today. Nevertheless, the material reflects good understanding and insight into the techniques and methodologies.

Results

The main results are probably the experiences gained with modelling such relatively badly defined systems, that seemingly have a lot of structure, but then also quite badly defined internal dynamics and interactions. Handling a priori knowledge, as it has been suggested is not new, but certainly has its place in the subject.
The study provided insight into modelling and control of building systems and provides guidelines on how to go about it.

Contribution

The project demonstrates that by using model-based control in an optimisation framework, as this is the case with MPC, leads to significant reduction of energy consumption without affecting the comfort significantly. Thus purely changing the operation results in less waste of energy.
The use of reference models combined with an update procedure, looks like an attractive way of maintaining a model.

Creativity

The level of creativity is limited, which when seen in the context is not surprising: one explored mostly a combination of existing technologies to reduce the waste of energy. However the project resulted in an active group producing a coherent set of papers that cover the subject well. Productivity level is rather high indeed.

Comments

In my opinion the use of reference model and their long-term update is a technique that, whilst suggested, has not been followed up sufficiently, at least what is documented in the thesis. The comment was made that the simulation models are too complex to be used for control. In my opinion this is not the case. The granularity of the model is not particularly fine and the overall model is rather sparse. The computations are not an issue anymore, not on the here-required level. It may though not be desirable if one has a simpler model that does serve the purpose.
I miss somewhat the discussion on time-scales and their separations. At one point it is mentioned that a third-order input-output "connection" gives satisfactory results. This brings up

the question of a physical interpretation -- construction capacity, room capacity and heating unit ? -- roughly ?
The resistor-capacitor networks definitely have a mechanistic interpretation, namely as linearised mass-energy systems.
The published papers have still a good number of small language faults and typographical mistakes -- a reflection of the publishing houses not having any proof-reading editors anymore.
The community that knows what TrnSys's block Type155 is must be extremely small....! I am not one of them.
If one desires a mechanistic interpretation of an empirical model, one can fit a low-granular physical model to the empirical model. Obviously that rises the question of the structure for the finite-volume mechanistic model and are the nonlinearities essential ?

Conclusion

The thesis does reflect the candidate's competence in identification, control and the application to optimising building operations. Thus:

The author of the thesis proved to have the ability to perform research and to achieve scientific results. I recommend the thesis for presentation with the aim of receiving the Degree of Ph.D.

Trondheim, May 9, 2013

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