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A / S Architecture and Building Systems

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Design of a simplified Resistor-Capacitor Model

Semester Project

ITA – Architecture and Building Systems
Swiss Federal Institute of Technology (ETH) Zurich

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Zurich, October 30, 2016

Abstract

Acknowledgements

I would like to thank PJ for being a really cool guy

Contents

List of Acronyms

AP	Acidification Potential
ASF	Adaptive Solar Facade

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Introduction

1.1 Motivation and Literature Review

In December 2015, the COP21 agreement was signed by 195 countries, setting a legally binding goal of reducing greenhouse gasses such as not exceed 1.5°C. The agreement covers accountability, transparency and better reporting of emissions, greater effort towards adaptation and improving the resilience of cities, reducing emissions, and supporting sustainable practices in developing countries. While Europe and other developed countries started introducing building energy requirements since the 1980s, the inclusion of rapidly developing nations with different climates in COP21 creates huge potential for global energy and GHG reductions within the building industry.

Improving energy efficiency in buildings does more than just reduce greenhouse gas emissions. It also comes with cost savings and increased earnings for energy exporting countries, improved energy security and higher productivity for businesses[1]. In 2014, the global energy efficiency market was worth approximately $USD90$ billion. The projected increase to $USD125$ billion by 2020, which is expected to be driven mainly by energy policy, would still fall short of the $USD215$ billion required to reach just the 2°C target[1]. The energy transition in Switzerland, particularly the decision to phase out nuclear energy by 2034, means that maximizing domestic energy efficiency is high on the agenda.

Increasing energy efficiency criteria assumes that thermal comfort conditions are met. Efforts toward increasing energy efficiency have led to the re-assessment of comfort theory, from Fanger's PMV model [2] in the 1970's, typically applied to fully conditioned buildings, to adaptive models now included in ASHRAE standard 55, ISO 7730 and EN15251. These models provide a more realistic representation of comfort in naturally

ventilated buildings, in addition to being simpler than the PMV model, since they exploit the linear correlation between comfort temperature and outdoor temperature.

Transposing these models into codes unlocks a great deal of energy saving potential by simply shifting temperature setpoints. However, it is worth bearing in mind when using such ratings that adaptive comfort is also influenced by psychological factors, such as ability to control and adapt to indoor environment, and connection with the outdoors [**?**]. Closed loop building control carries the potential to unlock further system efficiency, and has been the dream , there may be the mistaken temptation to greater automation will have an impact on overall occupant satisfaction and consequently productivity. This notion has implications

Active systems need to be durable

Energy certification of existing buildings. Performative design of new buildings. Predicting the performance of refurbishments to assess return on investment. Two different types of simulation tools.

Resistor Capacitor models as used in building physics. Earliest use, subsequent progress. Use in codes Importance of the stochaistic term [3]

1.2 Problem Statement

Because they inherently correct for imperfections and variations in the building fabric, stochaistic models are particularly useful when models need to be fitted to a building whose actual properties are unknown.

Technologies such as the ASF need robust, accurate models to generate dynamic control inputs in real time.

Simulation of existing buildings for retrofit purposes is time-consuming and not always accurate. An alternative would be a model that uses sensor data to self calibrate

Traditional simulation approach is not good at describing short-time variations, which are important for control applications.

Potential impacts: time savings in design, platform for innovative active integrated systems, more accurate models.

Lack of transparency of source code when wanting to make modifications to test novel building technologies

1.3 Objectives of Research

A simple, robust, real-time model is needed to control increasingly complex building-integrated systems.

model predictive control? - would require real-time weather forecasts

Find the best fitting model to sensor data to avoid running building simulations.

OR: Use sensor data to calibrate adequately accurate model

- Review literature and select appropriate models
- Set up an 1R-1C thermal model for a single zone as a learning exercise
- program 5R-2C thermal models as per ISO codes.
- Investigate options for discrete solvers
- Write good, transferable, open-source code in Python, making the program operable off linux (more reliable)
- Manage inputs
- output data in a useful and transferable format
- Validate the model:
- against physical data, possibly ASF and CP, or from existing datasets
- Against other models (physics based models) of the same building.
- Add complexity:
- Create a graphical interface with a modular R-C model as input
- Set up PID controller for actuators (ASF) - requires model for ASF
- provide occupancy modelling ... (agent based?)
- use computer vision to compute effective window opening factor from photographs of facade and orientation OR just calculate from rhino geometry

1.4 Thesis Outline

Methodology

We did some stuff to solve our problem statement

Results

The results were really cool

Discussion

We had some really cool results

Conclusion

In conclusion, the results were really cool

Appendix

Appendix A: My first appendix

A blind-ended tube connected to the cecum, from which it develops embryologically. The cecum is a pouchlike structure of the colon, located at the junction of the small and the large intestines.

Bibliography

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[3] Peder Bacher and Henrik Madsen. Identifying suitable models for the heat dynamics of buildings. *Energy and Buildings*, 43(7):1511–1522, 2011.