

Data-Driven Models for Energy-Efficient Building Management

Summary

With buildings accounting for a significant portion of global energy consumption, improving energy efficiency is critical to achieving sustainability goals. Traditional building management systems rely on rule-based strategies that are often inadequate for handling the increasing complexity of modern building environments. Data-driven approaches, combined with advanced mathematical modelling, offer a promising alternative by enabling real-time, adaptive control strategies that can significantly reduce energy use. The research will focus on leveraging Koopman operator theory to model and predict complex building dynamics, with the goal of creating more sustainable and energy-efficient solutions for building operations.

Research field:	Information and communication technology
Supervisors:	Prof. Dr. Eduard Petlenkov Komeil Nosrati
Availability:	This position is available.
Offered by:	School of Information Technologies Department of Computer Systems
Application deadline:	Applications are accepted between October 01, 2024 00:00 and October 25, 2024 23:59 (Europe/Zurich)

Description

Research Background

With buildings accounting for a significant portion of global energy consumption, improving energy efficiency is critical to achieving sustainability goals. Traditional building management systems rely on rule-based strategies that are often inadequate for handling the increasing complexity of modern building environments. Data-driven approaches, combined with advanced mathematical modelling, offer a promising alternative by enabling real-time, adaptive control strategies that can significantly reduce energy use.

Research Objective

The primary objective of this PhD project is to develop a Koopman-based framework for modelling and controlling the dynamic behaviour of building energy systems. The Koopman operator provides a linear representation of nonlinear dynamical systems, making it a powerful tool for capturing the intricate interactions between various building subsystems, such as heating, ventilation, air conditioning (HVAC), lighting, and occupancy patterns. By utilizing data-driven techniques, this project will extract relevant features from high-dimensional sensor data to construct accurate and computationally efficient Koopman models.

Key Challenges

- Data-Driven Modelling:** Extracting meaningful dynamics from sensor data and time series to identify the key factors driving energy consumption in buildings.
- Koopman Operator Construction:** Developing scalable algorithms to approximate the Koopman operator for complex, nonlinear systems typical of building environments.
- Optimization and Control:** Applying the developed Koopman models to design optimal control strategies that minimize energy usage while maintaining occupant comfort and adhering to operational constraints.
- Scalability:** Ensuring that the proposed models and control strategies are applicable across different types and sizes of buildings, from residential homes to large commercial complexes.

Desired Candidate Profile

- A strong background in applied mathematics, control theory, or machine learning.
- Experience in data-driven modelling, particularly with time-series data.
- Familiarity with dynamical systems theory and numerical optimization.
- Programming skills (e.g., Python, MATLAB) for implementations and handling large datasets.

Impact and Expected Outcomes



The successful candidate will contribute to the development of cutting-edge methodologies for energy-efficient building management. The outcomes of this project will provide building operators with real-time tools to reduce energy consumption and operational costs, aligning with global sustainability objectives.



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