MODELING, CONTROL, AND DIAGNOSTICS OF AIR CONDITIONING SYSTEMS WITH CARRIER CORPORATION AND MODELON

Contents

Introduction

These Master Thesis topic is a collaboration between the Department of Automatic Control, Modelon and Carrier Corporation. The intent is to utilize machine learning for modeling, control, and diagnostics of highly non-linear components in air conditioning systems.

Carrier Corporation Background

Carrier Corporation is one of the world's largest provider of building technologies. Its fire safety, security, building automation, heating, ventilation, air conditioning and refrigeration systems and services promote integrated, high performance buildings that are safer, smarter and sustainable.

Building systems, and HVAC systems in particular, are dynamic by nature. In addition, this type of equipment is subject to a number of hard constraints in operation due mainly to the protection of components including the

compressor. This project will investigate strategies for using machine learning for modeling, control, and diagnostics of the non-linear elements of air conditioning systems.

Modelon Background

Modelon provides software solutions and expert services to organizations that use model-based simulation tools to design and develop technical systems. Modelon's libraries, solver, and deployment solutions are leading products available in the market today for modeling, simulation and optimization. Our products enable companies to focus on delivering a unified picture of product system interaction and performance – from product concept to operation.

Modelon is an industry leader in model-based systems engineering with a goal of advancing open-standard technologies, allowing customers to leverage their tools of choice and share models throughout the product development cycle. Today, we serve a clientele base across a wide range of industry sectors which include some of the largest companies in the world.

Project 1: Chiller control using machine learning

Chiller control is a multi-variable control problem that typically utilizes classic feed-back control based on PID controllers tasked with protecting the equipment, maximizing the machine efficiency, and delivering wanted cooling or heating capacity. As the process under control is highly non-linear, and contains delays, this approach is not always efficient.

The purpose of this thesis project is to explore and evaluate the usage of machine learning control on chiller applications with the end goal of creating a controller that better handles non-linearities and delays of the system than the currently used algorithms. The project will include down selection of machine learning techniques to utilize, automation of data generation, testing and verification of the developed controller and benchmarking against current controllers. Detailed models will be used for both for the data generation and the verification and testing of the developed control algorithms.

The work will be driven by Modelica models that well capture the non-linearities of the real system. Modelica is a language for building dynamical models of physical objects. Modelica has its roots in Lund and is now widely used in industry (https://www.modelica.org).

The work will be done at Modelon in Lund with Kristian Tuszynski at Carrier, Anna Lindholm at Modelon, and a supervisor from Lund University (Department of Automatic Control or Centre for Mathematical Sciences).

Student profile: One or two motivated and skilled students with interest in machine learning, automatic control, modeling of dynamic systems, and programming. Experience with Modelica and thermofluid modeling is a merit but not required.

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Project 2: Chiller diagnostics using machine learning

Chiller problems at a customer site are usually not detected before the machine suffers critical failure and shuts down. The total down time is made worse by the fact that the diagnostics information made available to the service technician is limited which results in many man-hours before the root cause of the problem can be found and addressed.

The purpose of this thesis project is to utilize machine learning on a high-fidelity model to develop ways to diagnose the root cause of different problems and find ways of detecting problems before they happen. The project includes milestones to generate data to analyze for the machine learning, down selection of appropriate machine learning algorithms for the identification, training of the algorithms and testing and validation of developed models.

The work will be driven by Modelica models that well capture the needed physics of the real system. Modelica is a language for building dynamical models of physical objects. Modelica has its roots in Lund and is now widely used in industry (https://www.modelica.org).

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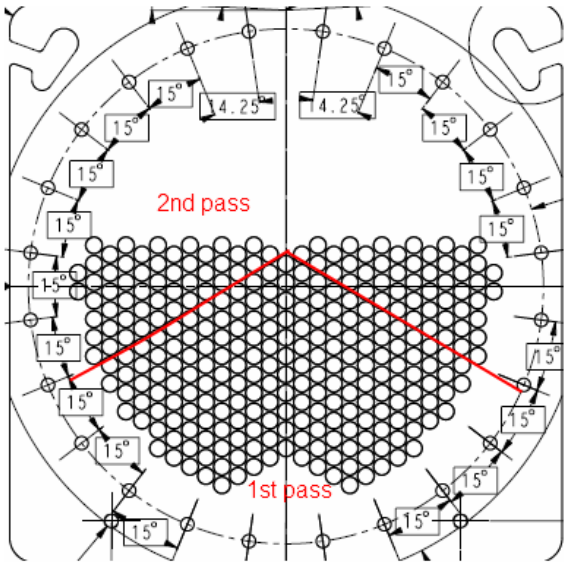
Project 3: Capture non-linear behavior using machine learning

Chiller models contain many non-linear components that are difficult to model in a satisfactory way where the physical behavior is well captured over a large set of operating points. Another issue is that these non-linear equations are often computationally expensive to solve and can cause robustness problems when simulating the models.

The purpose of this thesis project is to investigate the possibility to use machine learning to capture complex non-linear efficiency data for compressors that depends on multiple variables.

Additionally, the project also aims to see how complex non-linear physics in a chiller can be captured using machine learning techniques with the end goal to evaluate how unmeasurable physics can be captured and used for control purposes. Project milestones include identification of data needed for the machine learning, implementation of the algorithms as well as benchmarking the performance and accuracy against currently deployed methods.

The work will be driven by Modelica models that well capture the needed physics of the real system. Modelica is a language for building dynamical models of physical objects. Modelica has its roots in Lund and is now widely used in industry (https://www.modelica.org).



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