CCS-Lund Collaboration MS Thesis Topics
Chiller Architecture Selection and Numerical Analysis

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Summary

The purpose of this note is to outline an area of collaboration between CCS and the Department of Automatic Control at Lund University. The intent is to develop a series of MS thesis areas and to have MS students working in CCS design centers with UTC mentors. This document describes one area that is of mutual interest and also gives a structure for the collaboration in listing the area, the mentors, the location that the student will work at and identifies the type of publishable work that is expected to emerge from the work.

MS Thesis Topics & Support

Proposed projects

- **Development of closed loop incompressible flow component library + creating simple variable speed pump control system:**

  There is a growing need to expanding the number of incompressible flow models in the UTCTSD library. The current models are not well adapted to handle more complex flow networks and there are components missing to be able to simulate a closed water loop.

  Capturing the real flow dynamic of a closed water loop would, amongst other things, allow closer study and testing of the start-up of a chiller (which is still the main problem for chiller control validation) as well as the creation of models representing the water flow in a chiller plant.

  Project outputs:
  - Create a library with component variants of incompressible pipe flow integrated in the UTCTSD library
  - Create system model of chiller with closed loop water loop with variable speed pump controller

  Challenges:
  - Integration of new models in complex a Modelica library
  - Creation of non-compressible flow models configurable to handle multiple scenarios and problems

- **Create simplified Modelica component HX models:**

  Most tests done to validate controllers today are done using very detailed models. This results in very long simulation times and/or robustness problems such as limit cycles or chattering.

  This high model fidelity is in many cases not needed as the tests themselves do not depend on an exact dynamic response from the models. Having simplified models for these types of tests would allow much faster execution of the automatics tests without losing the validity of the test results.

  Project outputs:
  - Create simplified heat exchanger models (for example NTU/LMTD models) using Modelica
  - Use existing automatic testing infrastructure in Simulink to validate controller and compare the result with the result when using the high fidelity models
  - Evaluate when these type of models are "enough"

  Challenges:
  - Creation and integration of new Modelica models in an existing library (UTCTSD)
  - Set-up tests using these new models on an existing controller to evaluate performance and results compared to existing high fidelity models.

- **Implementation of MPC for fan speed of air cooled chiller**

  Current control infrastructure is built on several SISO control loops and mode switching. An interesting alternative would be to explore the feasibility of running Model predictive control instead.

  As a first step the fan speed optimization of an air-cooled chiller will be explored where the current table based approach will be replaced with a MPC controller.

  Project outputs:
  - Implement MPC controller optimizing the fan speed of an air cooled chiller
  - Demonstrate execution of the MPC tool chain using existing Modelica models
  - Comparisons of results when using current approach versus the MPC approach

  Challenges:
  - Setting up the necessary tool-chain to support the development
  - Development of the algorithm for the controller

Mentor and Supporting Team

- Kristian Tuszynski, James Fan (mentor)
- Johan Åkesson (supporting team)

What is new & publishable?

The intention is to have a working relationship that uses an open-source modeling platform with system (plant) models that are already available in literature. These plant models will be developed in an open source Modelica library.

- Open source incompressible library and outline of pump design & control
- Control oriented HX models and use in chiller control design & analysis
- MPC implementation of typical constrained control in chiller applications

Location

The primary working location will be at the Carrier Design Center in Montluel, France which is a hub for modeling and controls activities for Carrier commercial products. The student will work closely with both senior and junior engineers (which will be learning along with the student).