Sigurd Skogestad. Possible Master specialization projects. Autumn 2018.

# **Project: Modelling and control of slug dampening in subsea pipes – Virtual Harp separator**

***Main Supervisor: Prof. Sigurd Skogestad
Co-supervisor: Dinesh Krishnamoorthy and Statoil ASA***

This master project deals with modelling and control of slug dampening in long subsea transport pipelines. The first part of the project involves modelling a subsea pipeline with liquid and gas slug flow. The second part of the project involves implementing optimal control of the gas and liquid outflows to dampen the effect of slugs in the downstream processing equipment. This project can be carried out over two semesters (specialization project and Master thesis). The master student ideally would have good working knowledge of MATLAB. This master project is part of SFI SUBPRO.

# **Project: Implementation of Scenario MPC using statoil in-house MPC tool**

***Main Supervisor: Prof. Sigurd Skogestad
Co-supervisor: Dinesh Krishnamoorthy and Statoil ASA***

Optimization under uncertainty is an important topic in many industries and has been receiving considerable attention from both academia and industry. Scenario MPC (also known as feedback min-max MPC or multistage stochastic MPC) is a closed-loop optimization scheme where the notion of feedback is explicitly taken into account by optimizing over different control trajectories rather than a single control trajectory. This is done by representing the evolution of uncertainty by a scenario tree and optimizing over the entire scenario tree.

Scenario MPC has been successfully implemented in Matlab for production optimization problem. This project involves the implementation of scenario MPC in the Statoil in-house MPC tool known as SEPTIC for a production optimization problem. This project is part of SFI SUBPRO.

P**roject: Steady-state Real-time optimization of Ammonia reactor process using transient measurements**

***Main Supervisor: Prof. Sigurd Skogestad
Co-supervisor: Dinesh Krishnamoorthy and Julian Straus***

This master project deals with the optimal operation of a heat integrated ammonia reactor process. The main drawback of traditional steady-state real-time optimization is that transient measurements cannot be used for updating the model. The process needs to reach a steady-state operating point, before the models can be updated and reoptimized. Dynamic RTO and economic MPC on the other hand can use transient measurements, but solving dynamic nonlinear optimization problem online can be computationally intensive. To address the steady-state wait-time issue of static RTO and the computational cost of dynamic RTO, a hybrid RTO approach was recently proposed, where dynamic models are used for model adaptation and the static counterpart of the updated model is used for static optimization. The main aim of this project is to apply the Hybrid RTO approach to the ammonia reactor case study. The student must have a good working knowledge of MATLAB and build upon existing MATLAB models to implement the control structure.

# Project: Energy Efficiency through Control

Supervisor: Sigurd Skogestad. Co-supervisor: Cristina Zotica 

Figure: Rankine Cycle

About 80% of the electric power in the world is generated by thermal power plants. The scope of this project is to analyze and compare a decentralized control structure (with PID controllers) with model predictive control (MPC) for a simple heat to power Rankine cycle. These types of cycles are used for conversion of thermal energy into electrical power, in a 4-stage process: compression (1-2), heat addition (2-3) in an evaporator, expansion (3-4) in a turbine which drives a generator to produce electricity, and condensation (4-1). The working fluid is commonly water (steam), but recent technological development also include organic fluids, which are more suitable for waste heat recovery processes with low temperatures.

This project will address challenges such as what is the optimal operation that maximizes the energy efficiency under varying heat sources quality (which is the case for waste heat recovery processes), and how to design a control structure that achieves this.

The student should have an interest in operation and control, and knowledge in optimization is recommend (but not required). Experience with Matlab/Simulink or Modelica is a benefit.

For any question or more information, please send an email to cristina.f.zotica@ntnu.no

Co-supervisor: Cristina Zotica

# Project: Implementation of a discrete controller on a real process (lab setup)

Supervisor: Sigurd Skogestad. Co-supervisors: Cristina Zotica and Sigve Karolius

All controllers in real plants are discrete controllers, and this project is a good opportunity to learn how to implement this type of controller. In this case, the process is the experimental rig used in the Process Control lab, where the temperature is controlled by manipulating the power supplied to a light bulb, as shown in the adjacent figure. The scope of this project is to revise and improve a controller implementation that already exists in Python. The code for the discrete controller should be in developed in such way that it is easy to maintain and adapt for possible future lab setups. Basic knowledge in Python is required.

Figure: Experimental Setup

The project can be extended with a system identification of the three lab setups, based on experimental data of the input (lightbulb power) and output (temperature). Standard tools in Matlab (system identification toolbox) can be used for this purpose.

For any question or more information, please send an email to cristina.f.zotica@ntnu.no

**Project: Analysis of Process Control Case Studies**

Supervisor: Sigurd Skogestad. Co-supervisors: Adriana Reyes and Cristina Zotica

In this specialization project, you would generate the documentation for existing and new projects of the Process Control course (TKP4140). This purpose of the TKP4140 project is to integrate all the concepts and fundamentals taught in the course. Each project consists of three parts:

1. Modeling and Simulation: first principle modeling of a simple system using ODEs and simulating the response. Here some parameters should be updated.
2. System Analysis: linearization, state-space representation, obtaining transfer functions, model simplification applying the half-rule to the transfer functions.
3. Controller design: implementing/tuning a controller, analyzing stability, obtaining performance indexes.

You will have the possibility to deepen the analysis, compared to what is done in the TKP4140 project. In the “controller design” part, in the cases in which both a feedforward and a cascade controller can be implemented, you would analyze both options and compare them. Additionally, for the TKP4140 project, analysis is limited to the use of tools for SISO systems. For this project, you could analyze the most interesting system using more appropriate tools for MIMO (multiple input, multiple output) systems.

In this project you will work with Matlab/Simulink. If you have any further questions, you can send an e-mail to adriana.r.lua@ntnu.no or drop by our office (K4-239).

**Project: Advanced control structures for energy efficient refrigeration systems**

Supervisor: Sigurd Skogestad. Co-supervisor: Adriana Reyes

Integrated and cascade refrigeration systems, as well as systems with integrated energy storage, are interesting because they can reach a high overall efficiency. Cascade NH3/CO2 systems are highly attractive for the food processing industry because they require a low charge of ammonia and only CO2 is present in the processing or storage areas. Some of these systems are configured in a way such that energy can be stored so that it can be used when energy costs are higher. Other systems integrate heating and cooling capabilities for different applications.

In this project you would analyze and implement possible advanced control structure configurations for one of such systems. By advanced control structure we mean PI(D)-based structures that are used when single-loop, feedback PI(D) is not sufficient. The idea is to design a control structure that achieves (*near*)-optimal operation, also with set-point changes and in the presence of disturbances.

In this project you could work with Matlab/Simulink and Modelica.

If you are interested in this project and would like more information you can send an e-mail to adriana.r.lua@ntnu.no or drop by K4-239.

**Project: Process control and energy efficiency at Norske Skog.**

Supervisor: Sigurd Skogestad

Co-supervisor at Norske Skog, Skogn: Andreas B. Volden

Co-supervisor NTNU: Cristina Zotica

Norske Skog at Skogn (50 km north of Trondheim) is suggesting many interesting process control projects. Many of them are related to “green” areas such as energy efficiency, use of energy from waste biomass and effluent treatment.

Subproject NSS1: Steam boiler control, bottleneck identification and moving towards optimal operation (continuation of Master thesis by Eirik Torp)

Subproject NSS2: Steam network dynamics, performance and control

Subproject NSS3: Optimizing control and operation of two dewatering processes (two projects)

Subproject NSS4: Control loop analysis and improvement for an activated sludge effluent treatment plant

Subproject NSS5: Control loop diagnosis, disturbance identification and improved control of thermomechanical pulp production

Subproject NSS6: Developing a novel approach for best practice to split range control including different manipulated variables

Subproject NSS7: Compressed air network dynamics, performance and control

For more details about each subproject see here:

http://folk.ntnu.no/skoge/diplom/prosjekt18/Norske\_Skog\_Skogn\_ABV.pdf

For more information: Andreas-Burheim.Volden@norskeskog.com

**Project: Process control Case study at Perstorp**

Supervisors: Krister Forsman and Sigurd Skogestad

Krister Forsman is Professor II at NTNU and has given guest lectures in the process control course about industrial control strategies. He leads the control group at Perstorp, which is a Swedish chemical company with many plants all over the world and many interesting control problems. To keep the application current and of interest to Perstorp the specific application will be decided later. The work will generally involve the following (mostly using Matlab):

1. Derive a simple process model (Simulink/Matlab)

2. Match to current operation data

3. Propose an improved control strategy. This will often involve suggestions for moving the throughput manipulator and introducing cascades or simple model-based strategies.

Typically, the project may deal with the modelling and matching with data, and the master thesis will focus on the control part.

More information: Krister.Forsman@perstorp.com