Fault tolerant Model Predictive Control

This project will address fault tolerant model predictive control (FTMPC), focusing on actuator faults. In particular, the project aims to develop an FTMPC scheme for systems with slowly developing actuator faults, by estimating and integrating in the MPC formulation the remaining capacity of the faulty actuator. The project task is mostly suited for students interested in theory and computational methods of MPC.

A master thesis project will later be defined which will build on the results of the Fall project.

Supervisor: Professor Bjarne Foss.
Co-supervisor: Postdoc Brage Knudsen.

A penalty-function heuristic for mixed integer nonlinear programming

This project will explore the application of a heuristic optimization method, the Feasibility Pump (FP), for solving mixed integer nonlinear programs (MINLP). The goal of the project is to consider and extend the FP heuristic as a L1 penalty function, in order to increase the efficiency of the method. The project requires a strong interest in optimization, and in particular, an interest in learning optimization with mixed continues and integer variables.

A master thesis project will later be defined which will build on the results of the Fall project.

Supervisor: Prof. Bjarne Foss
Co-supervisor: Postdoc Brage R. Knudsen

Optimal adaptive control with dynamic programming

Optimal control of uncertain systems frequently involves some level of excitation for learning purposes. The excitation generates informative data that the controller uses to improve the model. An example is driving an unfamiliar car on icy roads and approaching a red light. Even if you are in a hurry, the best course of action is to test the brakes before it is too late, and thereby improving your "model of the car."

This type of optimal control strategy is called Dual Control, and enables better control through active learning, for instance operating closer to constraints, better disturbance rejection, and less wear of equipment. The problem can be solved with dynamic programming (Bellman) and a variety of approximate methods, including recent ones based on model-predictive control. The dynamic-programming approach involves expanding the model with belief states that model the uncertainty. Related fields are Machine Learning, Optimal Experiment Design, and Uncertainty Quantification.

The goal of this project is to solve a set of illustrative problems, including the car example above, using dynamic programming. Additionally, other techniques can be used depending on the student's interests and background. The project requires a strong grasp of optimization, parameter estimation/system identification, adaptive control, and systems theory. Recommended courses include TTK4135 Optimization and Control, TTK4215 System Identification and Adaptive Control, and TDT4120 Algorithms and Data Structures.

A master thesis project will later be defined which will build on the results of the Fall project.

Supervisor: Professor Bjarne Foss.

Co-supervisor: Postdoc Tor Aksel Heirung at University of Berkeley, California

<u>Continous time optimal control of differential algebraic systems</u>

In this project we will develop a method for solving iteratively optimal control problems of nonlinear systems described by differ-ential algebraic equations (DAE). The method is able to reduce the description of DAE systems to a description based on ordinary differential equations, for which more tools have been developed in re-cent years. Moreover, by relaxing the algebraic equations the model is able to decouple systems and dynamics allowing the development of distributed optimal control strategies. Finally, the method also admits constraints on the algebraic variables and as a consequence over the state variables.

A master thesis project will later be defined which will build on the results of the Fall project.

Supervisor: Professor Bjarne Foss.
Co-supervisor: PhD student Marco Aguiar at Federal University of Santa Catarina, Brazil / NTNU