**Using a model predictive controller (MPC) for economic optimization**

Supervisor: Johannes Jäschke Cosupervisor: Jose Otavio Matias

***Are you reading through Master project proposals and worried that most of them seem purely theoretical?***

***You might already be thinking of how it would be nice to work in a hands-on project that requires creativity and programming skills.***

***What can you do? Give up? Certainly not! This project is perfect for you!***

**Goals**

In this project, we will code a model predictive controller (MPC) that explicitly integrates an economic optimization structure into the dynamic control layer. Then, we will ***implement*** it in a small lab rig.

**What is MPC?**

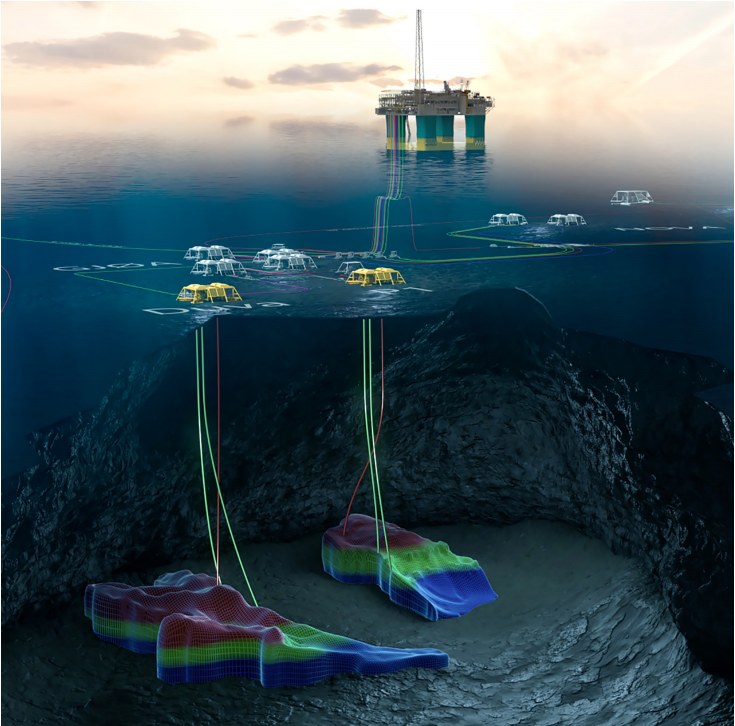
“Model predictive control has its roots in optimal control. The basic concept of MPC is to use a dynamic model to forecast system behavior and optimize the forecast to produce the best decision - the control move at the current time.”[1]

**Why is MPC important?**

MPC is process control solution that is widely accepted in industry. In early 2000s, 4600 MPC applications were reported [2]. Since then, numerous projects have been implemented in different processes, from automotive industry to oil wells networks. Moreover, several vendors report a significant number of successful applications in industry [3].

Some of MPC benefits to the operation [4]:

* improves process response to feed variations
* improves product quality control
* respects process constraints related to equipment or environment
* increases process regularity



**How?**



**Why this project?**

Usually, the steady-state operation of industrial processes is optimized by a real-time optimization (RTO) layer. It computes the optimal operating point based on a complex non-linear model. Next, a model predictive control layer is responsible for implementing these decisions in real time.

In this project we want to integrate both layers by including the gradient of the economic objective function in the controller cost function. The main advantage of this strategy is that the resulting problem can still be solved with a quadratic programming (QP) routine at each sampling step.



The experimental rig

**How?**

1. First, we obtain the linear models for the MPC using the coefficients of the step response curve of the experimental rig. The rig emulates a 3-well oil network.
2. Then, we code the integrated optimizer/controller (one-layer optimization) and implement it in the experimental rig.
3. Finally, we compare its results with the one obtained via Real-time Optimization (RTO), which is the current industrial solution.

**What are we looking for in candidates?**

The project will give you a chance to learn (in practice) how a model predictive controller works and the difficulties in implementing one. Moreover, it will give you a chance to be creative and come up with technical solutions for a real problem. To successfully complete the project, you should:

* Be interested in modeling and numerical simulation;
* Be familiar with programming;
* Be creative, with a strong ability to work problem oriented.

For more information about the project, contact Associate Professor Johannes Jäschke ([johannes.jaschke@ntnu.no](mailto:johannes.jaschke@ntnu.no)) or Postdoc Jose Otavio Matias ([jose.o.a.matias@ntnu.no](mailto:jose.o.a.matias@ntnu.no))

**References**

# [1] Rawlings, J. B., Mayne, D. Q., & Diehl, M. (2017). Model predictive control: theory, computation, and design (Vol. 2). Madison, WI: Nob Hill Publishing.

# [2] Qin, S. J., & Badgwell, T. A. (2003). A survey of industrial model predictive control technology. Control engineering practice, 11(7), 733-764.

# [3] <https://www.aspentech.com/en/applications/msc/adaptive-process-control> (accessed 11.03.2020)

[4] <http://folk.ntnu.no/skoge/vgprosessregulering/lectures/mpc-strand/mpc-strand-okt2013/MPC_Statoil_Lecture_161013.pdf> (accessed 11.03.2020)