Anticipative Model Predictive Control based on Linear Parameter Varying Models with Application to Robotics

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The goal of a control system is to achieve stability and a desired level of performance for plants which often have nonlinear (NL) dynamics and constrained levels of operation. Model predictive control (MPC) is a paradigm that can systematically handle such complications based on prediction of the future system behaviour over a prediction horizon. However, MPC for NL systems can lead to computational complexity or inherent conservatism.

Linear parameter-varying (LPV) modelling approach, allows well-defined linear approaches to control NL systems by embedding the nonlinearities in a so-called scheduling parameter (p) and use it online to compensate nonlinearities. Therefore, MPC based on LPV models is an appropriate technique for controlling NL plants.

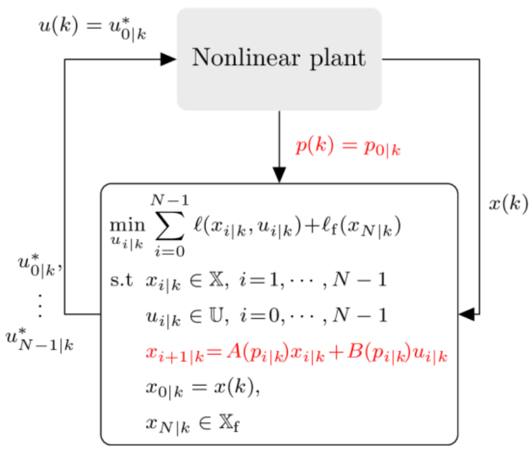

Fig. 1 Closed-loop block clock diagram, the lower block shows the online optimization problem of the LPVMPC approach. The LPV model is in red.

In this project, it is required to develop MPC for NL systems based on LPV models. The main difficulty in an LPVMPC setting is the fact that the scheduling parameter is usually available only at the current time instant, but unknown over the prediction horizon of the MPC problem, which affects its prediction strategy. However, when p is an indigenous parameter, i.e., depends on the system's state, then it is possible to anticipate its value for few step-ahead. Investigate these values from the previous MPC iteration can be an intuitive solution to this problem, provided that the rate of change of p is not significantly fast.

Therefore, this project will investigate the possibility of anticipating the scheduling parameter over the MPC prediction horizon from previous MPC iterations tacking into account possible prediction error according to the admissible values of p. The study will be carried out with application to a nonlinear dynamics of a two degree-of-freedom (DOF) robotic manipulator.

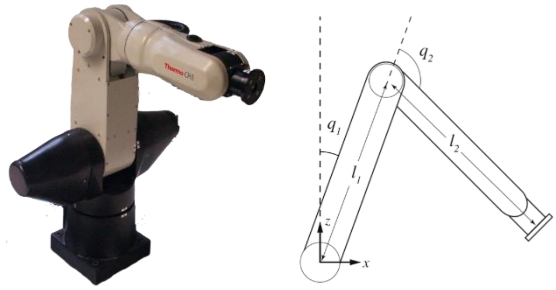

Fig. 2. The CRS A465 robotic manipulator and a side view of the 2-DOF model.

Project activities:

- Understanding the MPC/LPV fundamental concepts
- Converting the nonlinear dynamics of the 2DOF robotic manipulator into LPV representations.
- Using quadratic programming (QP) tools to solve the LPVMPC optimization problem.
- Using the LPVMPC results from previous iteration to anticipate the scheduling parameter values over the current prediction horizon of the MPC algorithm.
- Deriving possible error bounds and take them into account in the MPC computation.
- Analysing the stability and feasibility of the proposed LPVMPC optimization problem under such anticipative scheme.
- Evaluating the application of the proposed LPVMPC scheme onto the 2DOF robotic manipulator.

<u>Prerequisites:</u> Basics of automatic control and linear systems theory.