Master Project

Learning Complex MPC Controllers: An Inverse Optimization Approach

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Context

Model Predictive Control (MPC) is widely used as a control strategy in various fields, more commonly, in process control applications. In MPC, a control input is generated by minimization of a cost function. The cost function is composed of stage costs, which are a function of the states and the inputs.

As the prediction horizon in MPC increases, the number of variables to be optimized increases. The optimization program therefore becomes tedious and could not be used in application with low sampling time.

As a step to address this problem, we learn a one-step quadratic cost (function of the inputs and the cross between input and the states) using inverse optimization. For each time instance, the tuple comprising of the state, optimum input and the total cost i.e. (x_t, u_t^o, F_T) is used to learn the one-step cost function. The idea is that the one-step cost function closely mimicks the actual cost function and the optimization procedure becomes much simpler as there only remains to solve a quadratic program. The core part of the problem lies in learning the function $F_T(x_0, u_0)$ using inverse optimization. We take quadratic functions of x_0 and u_0 as our hypothesis class.

$$J = \min u^T R u + F_T(x_0, u_0) \quad \text{s.t. } u \in \mathcal{U} \tag{1}$$

$$J = \min u^T R u + \begin{bmatrix} x_0 \\ u_0 \end{bmatrix}^T \theta \begin{bmatrix} x_0 \\ u_0 \end{bmatrix} \quad \text{s.t. } u \in \mathcal{U} \tag{2}$$

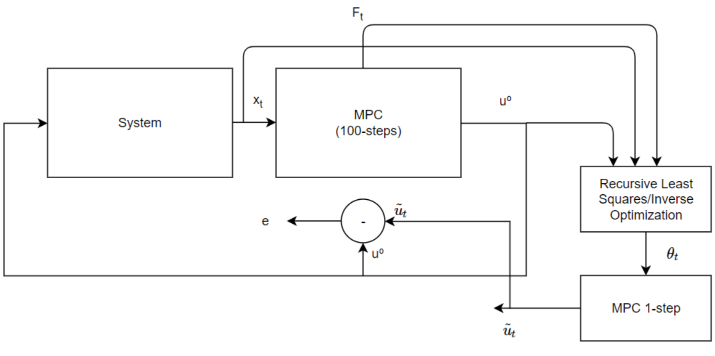

Figure 1: 1-Step MPC Block Diagram

Project tasks

The project tasks is to design an inverse optimization technique to learn the 1-step MPC function, and also have some performance guarantee in terms of the suboptimality or regret bounds. The developed technique will be recursive in nature, and the 1-Step MPC should improve with more iterations/training. The implementation will be done on Matlab.