

COMPUTATIONALLY EFFICIENT FORMULATIONS FOR MODEL PREDICTIVE CONTROL AND THEIR APPLICATIONS

Abstract

Model Predictive Control (MPC) is one of the most widely used control techniques in the industry. The popularity of MPC is apparent as it handles many input-output variables and constraints simultaneously. Despite the advantages, MPC faces some challenges. The computation time taken for MPC is extortionate as it has to solve an optimization problem at each sampling instant. In the quest to reduce computational effort, researchers have proposed various techniques like move blocking, sub-optimal control, etc. These strategies suffer from stability and performance guarantee issues. With a focus on extending the application domains of MPC, this thesis proposes several computationally efficient formulations for Model Predictive Control. This thesis attempts to address the computational issue from various angles: varying prediction horizon, reduction of constraints, event triggering framework, and approximate dynamic programming approach. To reduce the number of variables in the optimization problem, the thesis proposes a simple technique by which a short prediction horizon can be determined. The analysis of the disturbance effect in the proposed method led to a superior algorithm compared to the initial proposal. In the practical implementation of MPC, the constraints are active for only a fraction of the entire plant operation time. Hence, we propose the constraint-aware formulation in the optimization problem. In this technique, the constraints are determined that may be active in the immediate future and considered in the optimization problem. The thesis further presents an event-triggering formulation that reduces average computation time. When the system response is in line with the desired response, the control sequence doesn't have to be recalculated but uses previously calculated control inputs. The design of suitable triggering conditions enabled it to handle disturbances effectively. In addition, the thesis also presents an approximate dynamic programming formulation to suitably approximate cost function. Without much loss of performance, the computational time is reduced significantly. A Multi-tank system with nonlinear system dynamics is used to carry out the validation of the proposed algorithms.