ON MODEL PREDICTIVE CONTROL OF SWITCHED LINEAR AND SWITCHED AFFINE SYSTEMS

ABSTRACT

This thesis deals with the design and analysis of *stabilizing model predictive control (MPC) schemes for switched systems*. We consider two classes of switched systems which are *switched linear systems (SLSs) and switched affine systems (SASs)*. SLSs consists of a finite set of linear time-invariant (LTI) subsystems and a switching index that decides switching among the subsystems. Optimal control of SLSs deals with the problem of computing an optimal switching index and control input schemes, which are to be optimized together for minimizing the cost function. This leads to a mixed-integer optimization problem for which the computational complexity increases exponentially with the number of time instants or switching instants. The initial works in this area study the linear quadratic regulator (LQR) problem of continuous-time SLSs also known as the switched LQR (SLQR) problem. Later on, LQR problems for discrete-time SLSs are studied which is known by the name discrete-time switched LQR (DSLQR). To reduce the computation and storage required for the DSLQR problem, approaches such as dynamic programming with pruning and relaxed dynamic programming are proposed in the past. Recently, model predictive control (MPC) of SLSs is studied which gives suboptimal solutions to the infinite horizon DSLQR problem by solving a finite horizon DSLQR problem in a receding horizon manner. In the MPC of SLSs, the major challenges are ensuring stability (because of its receding horizon nature) and reducing online computation (in the case of large prediction horizons). The stability of the SLS with MPC is not guaranteed in general and the stability depends on the prediction horizon.

This motivates our study in SLSs and the main focus of the thesis is to *design stabilizing MPC schemes for a class of SLSs with at least one stabilizable subsystem*. Firstly, stabilizing MPC schemes are designed for a class of SLSs using Lyapunov inequality-based pruning which permits switching to only stabilizable subsystems. The MPC scheme is then modified to incorporate switching to nonstabilizable subsystems using a pruning based on Lyapunov-Metzler inequality. The stability and feasibility of the MPC schemes are studied and the proposed MPC schemes ensure global exponential stability of the SLSs without constraints. The MPC schemes are also extended to incorporate constraints on states and inputs of SLSs for which stability results are presented. Further, we consider the design of MPC schemes for SASs which are a subclass of switched systems with an affine term. The affine term makes the exponential or asymptotic stabilization of SASs difficult. Consequently, we focus on the *practical stabilization of SASs under the MPC scheme*. In the proposed approach practical stability is guaranteed for MPC schemes for SASs with arbitrary prediction horizons using an offline pruning algorithm with cost approximation. In addition, the thesis also presents the application of the proposed MPC schemes to networked controls systems and switching power converters.