

Hybrid Predictive Control with a Prescribed Degree of Stability

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Abstract – In this paper we will consider one class of hybrid controllers. Each control strategy is a mix of continuous dynamics and discrete events philosophy. Here we consider a finite set of model predictive controllers (MPC) which is the only advanced control technique to have had a significant and wide spread impact on industrial process control. There are several advantages for wide acceptance of MPC: guaranteed stability, constraints handling and easy extension to multivariable and nonlinear systems. In this paper we add else one important property: significantly increasing of transient performance. Proposed controllers, also, have prescribed degree of stability as a tuning parameter.

Key words: hybrid control, predictive controller, prescribed degree of stability, asymptotic stability

I. INTRODUCTION

The model predictive control (MPC) is the only advanced control methodology which has made a significant impact in industrial control engineering.

- (i) The extension to multivariable case is easy
- (ii) It handles constraints. The higher performance levels are associated with pushing the limits. That frequently leads to more profitable operation
- (iii) In industrial applications control update rate are relatively low and there is enough time for on-line computation

The authoritative survey papers are presented in [1]–[3]. It is noticed that most control laws, for example PID, do not explicitly consider the future implication of current control actions. MPC on the other hand explicitly computes the predicted behaviour over some horizon. One can therefore restrict the choice of current proposed input trajectories to those that do not lead to difficulties in the future.

The key problem in MPC is the stability. It had been known from [4] that making the horizon infinite in predictive control leads to guaranteed stability, but if was not known how to handle constraints with infinite horizons. The paper [5] made a breakthrough. The key idea is to reparametrize the predictive control problem in terms of finite number of parameters so that the optimization can still be performed over a finite dimensional space. So MPC remains a quadratic programming (QP) problem. In [6] is presented thought that no longer any reason to use finite horizon. In this paper such ideas will be used.

Here we will consider hybrid MPC. The hybrid system can be interpreted as digital real-time systems which are embedded in analog environments. The paper [7] proposes framework for modeling and controlling models of systems described by interacting physical laws, logical rules, and operating constraints. The propositional logic is trans-

formed into linear inequations involving integer and continuous variables. So is given mixed logical dynamical (MLD) systems.

In this paper the concept of multiple models and concept of switching MPC is used. The analog part of the system is described by finite set of discrete-time models. As a set of controllers is used a finite set of MPC with the prescribed degree of stability. Here the switching rule is based on the selection of the best performance of the closed-loop systems. In the form of theorem is proved that hybrid system is asymptotically stable in the Lyapunov sense and performance of system is no worse than the best non-switching strategy.

The MPC has applications in many areas such as discrete-event systems [8], cooperative control [9], digital electronic [10] and financial engineering [11].

Hybrid model predictive control is perspective area of research relevant to a range of important problems such as supervisory schemes in the process industry.

II. MULTIPLE MODELS

In this part of paper we consider multiple model description of processes. It will be assumed that the process model is a member of admissible process models

$$F = \bigcup_{p \in P} F_p \quad (1)$$

where P is index set which represents the range of parametric uncertainty so that for each fixed $p \in P$ the subfamily F_p accounts for unmodeled dynamics. Usually, P is compact subset of finite-dimensional normed linear vector space [12].

Here we will suppose that system for large class of structured uncertainty can be described with collection of linear time invariant systems

$$x(k+1) = A_p x(k) + B_p u(k), \quad p = 1, 2, \dots, s \quad (2)$$

where $x \in R^n$ and $u \in R^m$ are state and control signal of the system respectively. Relation (2) describes the continuous part of system. The event driven part can be described in next form

$$p^+(t) = \phi(p(t), \sigma(t)) \quad (3)$$

