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Brief paper

Event-triggered robust model predictive control of continuous-time nonlinear systems ☆

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ABSTRACT

The event-triggered control is of compelling features in efficiently exploiting system resources, and thus has found many applications in sensor networks, networked control systems, multi-agent systems and so on. In this paper, we study the event-triggered model predictive control (MPC) problem for continuous-time nonlinear systems subject to bounded disturbances. An event-triggered mechanism is first designed by measuring the error between the system state and its optimal prediction; the event-triggered MPC algorithm that is built upon the triggering mechanism and the dual-mode approach is then designed. The rigorous analysis of the feasibility and stability is conducted, and the sufficient conditions for ensuring the feasibility and stability are developed. We show that the feasibility of the event-triggered MPC algorithm can be guaranteed if, the prediction horizon is designed properly and the disturbances are small enough. Furthermore, it is shown that the stability is related to the prediction horizon, the disturbance bound and the triggering level, and that the state trajectory converges to a robust invariant set under the proposed conditions. Finally, a case study is provided to verify the theoretical results.

1. Introduction

The event-triggered control has received increasing interests in recent years, due to its advantages over the time-driven control. In time-driven control systems, the continuous measurement signal is sampled with a fixed time period and the control signal is applied periodically without considering dynamical characteristics of the system. This may lead to redundant sampling and control actions, wasting computation and communication resources. On the contrary, the event-triggered control takes into account detailed system behaviors (e.g., the system error deviates away from a prescribed set or the performance index violates a specified level), and uses them as signals to trigger control actions, resulting in a possible aperiodic system but with smaller average sampling rate. It is in this way that the event-triggered control strategy is capable of saving system resources without compromising the control performance. In fact, in Åström and Bernhardsson (2002) it has been proven that the event-triggered control can, sometimes, achieve even better control performance yet using a much smaller average sampling rate, in comparison with the time-driven control.

Motivated by this fact, great attention has been paid to studying event-triggered control strategies for different types of systems. For example, Tabuada has designed an event-triggered scheme for a class of nonlinear systems based on the input-to-state stability (ISS) concept in Tabuada (2007), where a lower bound of the inter-execution time is guaranteed to avoid the Zeno behavior. The state-feedback control with event-triggered schemes for linear systems has been studied in Heemels, Sandee, and Van Den Bosch (2008), Henningsson, Johannesson, and Cervin (2008), Lunze and Lehmann (2010), Mazo, Anta, and Tabuada (2010) and the output-based event-triggered control has been reported in Donkers and Heemels (2012). Wang and Lemmon have proposed a self-triggered feedback control strategy for guaranteeing the $\mathcal{L}_2$-gain stability in Wang and Lemmon (2009) and furthered their efforts to design an event-triggered scheme for distributed networked control systems in Wang and Lemmon (2011).

In particular, the design of event-triggered strategies for model predictive control (MPC) is of great importance because it enables the reduction in frequencies of solving optimization problems

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