

Switching control based on concept of topological entropy

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In this paper the switching control with dwell time via limited capacity digital communication channel was considered. We have investigated stability of switched systems with multiple (distinct) equilibria. The main result is the theorem for global convergence of the system to a set of these equilibrium points. A procedure for computation of minimum dwell time using convex analysis is also described.

1. Introduction

The control systems with communication networks are distributed systems in which communication between sensors, actuators and controllers is performed via digital communication channels. Such kinds of systems are described by combination of control theory and theory of communication. The presence of digital channel introduces next constraints: limited capacity, delay and the observation and control packets may be lost [1]. In the case of state estimation the Bernoulli process describes loss of observations [2]. Packets of network communication channels typically use one of two fundamentally different protocols: TCP or UDP [3]. In the first case there is acknowledgement of received packets, while in the second case no feedback is provided on the communication link.

In this paper we consider the problem of control under data rate constraints. The problem incorporates ideas from both control and information theory [4]. The general set up of the problem is the following. Given a plant, communication channel with limited data rate, and control objectives, to find a controller that uses the channel in the feedback loop such that the overall system achieves the control objectives. The reference [5] has a focus on the use of networks in distributed systems and on quantization in messages sent over networks.

In this paper we study optimal control via digital channels using topological entropy of the open loop system. The concept of entropy was introduced by Kolmogorov [6] using ideas from Shannon works [7]. From that time the entropy appears as a numerical invariant for a class of deterministic dynamical systems. Different notions of topological entropy of dynamical systems were introduced in [8] and [9]. The important paper [10] uses the concept of topological entropy into the theory of networked control systems. In that paper the feedback topological entropy was introduced and condition of local stability of nonlinear systems via a limited capacity channel was given. In reference [11] the problem of observability and optimal control of linear systems via limited capacity digital communication channels is considered. The result is inequality between data rate of the communication channel and topological entropy of the open loop system. The authoritative presentation of mathematical theory for networked control systems is given in [12].

In this paper we consider hybrid systems with digital communication channel. Hybrid systems describe the interaction between software modeled by finite state systems (such as finite state machines) and physical world described by differential equations [13]. From the classical control theory point of view the hybrid systems can be described as a switching control between analog feedback loops [14]. To different aspects of such kind of systems the following references are devoted [15]-[17]. The stability problem is considered from the point of view of multiple Lyapunov functions. For the problem under consideration we consider more general problem for switched systems. Namely, we consider switching systems with dwell time and with multiple distinct equilibria. It will be shown that if the dwell time of the switching events is greater than a certain lower bound, then the trajectory of switched system

