

## Global exponential stability of switched systems\*

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**Abstract** This paper proposes a method for the stability analysis of deterministic switched systems. Two motivational examples are introduced (nonholonomic system and constrained pendulum). The finite collection of models consists of nonlinear models, and a switching sequence is arbitrary. It is supposed that there is no jump in the state at switching instants, and there is no Zeno behavior, i.e., there is a finite number of switches on every bounded interval. For the analysis of deterministic switched systems, the multiple Lyapunov functions are used, and the global exponential stability is proved. The exponentially stable equilibrium of systems is relevant for practice because such systems are robust to perturbations.

**Key words** switched system, multiple Lyapunov function, global exponential stability

**Chinese Library Classification** O322

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### 1 Introduction

Hybrid systems describe the interaction between software, modeled by finite state-systems such as finite-state machines, and the physical world described by differential equations. The several key verification and control synthesis results for hybrid systems, guided by the concept of bisimulation, are outlined in Ref. [1]. From the classical control theory point of view, the hybrid systems can be described as a switching control between analog feedback loops<sup>[2–3]</sup>. For example, the systems with quantization are the examples of switched systems with state dependent switching.

The main motivation for studying such kinds of systems is a fact that there exist a large class of nonlinear systems, which is possible to be stabilized by switching control schemes, but cannot be stabilized by any continuous static state feedback control<sup>[4]</sup>. The overview of the most recent developments in the field of the stability and stabilizability of switched systems is presented in Refs. [5] and [6].

In Ref. [7], a framework was established for the stability analysis of deterministic and stochastic switched systems by combining the method of multiple Lyapunov functions with the comparison principle. It is shown that nonlinear deterministic switched systems are globally uniformly asymptotically stable. Reference [8] considers the stability of deterministic linear switched systems. The problem is based on the determination of a minimum dwell time by means of a

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