

Hybrid control of networked embedded systems

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Abstract

Hybrid systems that involve the interaction of continuous and discrete dynamics have been an active area of research for a number of years. In this paper, we start by briefly surveying the main theoretical control problems that have been treated in the hybrid systems setting and classify them into stabilization, optimal control and language specification problems. We then provide an overview of recent developments in four of the most prominent areas where these hybrid control methods have found application: Control of power systems, industrial process control, design of automotive electronics and communication networks.

1 Introduction

The term hybrid systems is used in the literature to refer to systems that feature an interaction between diverse types of dynamics. Most heavily studied in recent years are hybrid systems that involve the interaction between continuous and discrete dynamics. The study of this class of systems has to a large extent been motivated by applications to embedded systems and control. Embedded systems by definition involve the interaction between digital devices and a predominantly analog environment. In addition, much of the design complexity of embedded systems comes from the fact that they have to meet specifications such as hard real-time constraints, scheduling constraints, etc. that involve a mixture of discrete and continuous requirements. Therefore, both the model and the specifications of embedded systems can naturally be expressed in the context of hybrid systems.

Control problems have been at the forefront of hybrid systems research from the very beginning. The reason is that many important applications with prominent hybrid dynamics come from the area of embedded control. For example, hybrid control has played an important role in applications to avionics, automated highways, communication networks, automotive control, air traffic management, industrial process control, manufacturing and robotics.

The Network of Excellence HyCon [1] aims to consolidate and promote research on hybrid systems throughout Europe. The network provides the means to coordinate the research of 23 European research institutions in the areas of modeling, analysis and control of hybrid systems with applications to power management, automotive control, industrial processes and communication networks. In addition to research integration, the activities of the HyCon network also include collaborative efforts in the teaching of hybrid systems, the development of a virtual library of hybrid systems literature, the establishment of a hybrid systems tool repository, and the establishment of common benchmarks on which to test novel hybrid systems methods.

In this overview paper we review recent results emerging from research currently being conducted under the HyCon umbrella. We concentrate on results dealing with novel hybrid control methods and their applications.

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References

- [1] Network of Excellence HyCon. Taming heterogeneity and complexity of networked embedded systems. European Commission, FP6-IST-511368. www.ist-hycon.org.