Available online at www.sciencedirect.com
ScienceDirect
Mathematics and Computers in Simulation 82 (2011) 414–427
MATHEMATICS AND COMPUTERS IN SIMULATION
www.elsevier.com/locate/matcom

Feedforward control of a class of hybrid systems using an inverse model

Gorazd Karer *, Gašper Mušič, Igor Škrjanc, Borut Zupančič

Faculty of Electrical Engineering, University of Ljubljana, Tržaška 25, 1000 Ljubljana, Slovenia

Received 28 January 2010; accepted 14 October 2010
Available online 26 October 2010

Abstract

In this paper we describe the design of a control algorithm for MISO systems, which can be modelled as *hybrid fuzzy models*. Hybrid fuzzy models present a convenient approach to modelling nonlinear hybrid systems.

We discuss the formulation of a hybrid fuzzy model, its structure and the identification procedure. This is followed by a derivation of the inverse model and its implementation in the control algorithm. The control scheme we are discussing splits the control algorithm in two parts: the feedforward part and the feedback part. In the paper, we deal with the feedforward part of the control algorithm, which is based on an inverse of a hybrid fuzzy model. Next, a batch-reactor process is introduced. The modelling of the batch reactor is tackled and the results of the simulation experiments using the proposed control algorithm are presented. The experiments involved controlling the temperature of a batch reactor using two on/off input valves and a continuous mixing valve.

The main advantage of the proposed approach is that the feedforward part of the control algorithm can bring the system close to the desired adjusted feasible trajectory, which avoids the need for a very complex feedback part of the algorithm. Therefore, the control algorithm presents a low computational burden, particularly comparing to the standard model predictive control algorithms. These usually require a considerable computational effort, which often thwarts their implementation on real industrial systems. Nevertheless, we show that using the proposed control approach the hybrid fuzzy model framework presents a convenient option for modelling complex systems for control purposes in practice.

Keywords: Hybrid fuzzy model; Inverse-model-based control; Hybrid systems; Nonlinear systems; Batch reactor

1. Introduction

Dynamic systems that involve continuous and discrete states are called *hybrid systems*. Most industrial processes contain both continuous and discrete components, for instance, discrete valves, on/off switches, logical overrides, etc. The continuous dynamics are often inseparably interlaced with the discrete dynamics; therefore, a special approach to modelling and control is required. At first this topic was not treated systematically [20]. In recent years, however, hybrid systems have received a great deal of attention from the computer science and control community.

The principle of *model predictive control* (MPC) is based on forecasting the future behavior of a system at each sampling instant using the process model. The complex hybrid and nonlinear nature of many processes that are met

* Corresponding author.
E-mail address: gorazd.karer@fe.uni-lj.si (G. Karer).

0378-4754/$36.00 © 2010 IMACS. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.matcom.2010.10.015