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STABILIZATION OF UNSTABLE FIXED POINTS WITH QUEUE-BASED DELAYED FEEDBACK CONTROL

Keiji Konishi[1] and Naoyuki Hara[2]

[1]Department of Electrical and Information Systems, Osaka Prefecture University
1–1 Gakuen-cho, Naka-ku, Sakai, Osaka 599-8531, Japan
Corresponding author email: konishi@eis.osakafu-u.ac.jp

Abstract. We propose a delayed feedback control system using a first-in, first-out queue as the time delay device. The system stability is analyzed on the basis of the semi-discretization technique. The stability regions in a control parameter space, feedback gain vs. delay time, are derived and compared with those of the original delayed feedback control system. The results suggest that for a prototype two-dimensional oscillator, the stability regions become large, even for a low-performance queue with either low sampling frequency or a few buffers.

Keywords. delayed feedback control, unstable fixed point, controlling chaos, FIFO queue, semi-discretization.

AMS (MOS) subject classification: 34H10, 34H15, 93B52

1 Introduction

Control of chaos is an important subject in nonlinear science [6, 37]. In particular, delayed feedback control (DFC), proposed by Pyragas [33], is of considerable interest in the fields of nonlinear science [34] and control theory [13]. This is because a DFC method can stabilize two limit sets, unstable periodic orbits (UPOs) and unstable fixed points (UFPs), without using their locations in its control law. Although stability analysis of DFC systems plays an important role in designing control systems, it requires solving time-periodic linear systems that include a time delay. In recent years, however, several researchers have intensively investigated the stability of DFC systems [8, 21, 30, 32, 35].

The stabilization of UFPs with DFC has also been analytically investigated [5, 7, 16, 23] and used in control theory [15] and laser systems [41]. In experimental situations, a delayed feedback signal for DFC systems is often realized by a bucket brigade delay (BBD) line device, which comprises a series of sample-and-hold circuits [4, 17, 22]. The BBD line device has been used for experimental investigation of nonlinear delay dynamics [25, 36, 42] as well as the experimental implementation of DFC signals. A DFC system with a BBD line device is illustrated in Fig. 1, where the output of the