Networked Control Synthesis Using Time Delay Approach: State Feedback Case

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Abstract: Networked Control Systems (NCS) is a control system in which the sensors, controllers, and the actuators are connected via communication network. The use of communication network will lead to intermittent losses or delays of the information and may decrease the performance and cause instability. This paper presents the design of H_∞ state feedback controller for NCS. The NCS is modelled as a time delay system. Two network features are considered: signal transmission delay and data packet dropout. Our objective is focused on the design of state feedback controller which guarantee asymptotic stability of the closed-loop systems. The proposed methods are given in the terms of Linear Matrix Inequality (LMI). Finally, we consider an unstable system for numerical example. It is shown that the state feedback controller proposed here make the closed-loop system stable with or without input disturbance.

Keywords: Networked Control Systems (NCS), Signal Transmission Delay, Data Packet Dropout, State Feedback Controller

1. Introduction

In modern control systems, physical plant, controller, sensors and actuator are difficult to be located at the same place, and hence these components need to be connected over network media. When feedback control system is closed via a communication channel, then the control system is classified as a Networked Control System (NCS) [1,2]. NCS has been attracted much attention due to significant advantages, such as reduced installation and maintenance cost, increased system agility, and so on [3]. There have many researcher to conduct research on the topic of NCS. To mention a few, [4] addressed the problem of quantized feedback control. Result on state feedback control could be seen in [5,6]. Stability analysis, and stabilization of NCS are investigated in [2, 3] and the references therein. There are some parameters that arise when using communication network in NCS such as packet dropouts and signal transmission delay. The presence of these parameters can degrade the performance of the system and could lead to instability.

When information or energy is physically transmitted from one place to another, there is a delay associated with the transmission [7]. It is well known that the presence of time-delay is a source of instability [8]. Xia et al. [9] presents some basic theories of stability and synthesis of systems with time-delay, in the form of $\dot{x}(t) = Ax(t) + A_d x(t - \tau(t))$, where $\tau(t)$ represents time-varying delay. Wu et al. [10] presents a method referred to as the free-weighting-matrix (FWM) approach for the stability analysis and control synthesis of various classes of time-delay systems. In [11], a new model for time delay systems is proposed, that is $\dot{x}(t) = Ax(t) + A_d x(t - \tau_1(t) - \tau_2(t))$. The new model is motivated by practical situation in Networked Control Systems (NCSs), where $\tau_1(t)$ is the time-delay from sensor to the controller and $\tau_2(t)$ is the time-delay from controller to the actuator. Based on such a system

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