Chapter 13

Robust Fault Detection Based on State Observers for Networked Control Systems

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ABSTRACT

With the development of network and control technology, networked control systems (NCS) have been widely studied recently, especially in the area of complex industrial systems. The system model and states observer based approach is very important for the fault detection (FD) and diagnosis of NCS. This chapter focuses on robust fault detection methods based on states observer. States observers on NCS with short time-delay and uncertain time-delay are both discussed and designed without changing the structure of the systems. The corresponding theorems are systematically given and proved. The methods of robust fault detection on NCS are proposed and some typical examples are demonstrated to test the presented methods.

INTRODUCTION

In many complicated control systems, serial communication networks are employed to exchange information and control signals between spatially distributed system components, like supervisory computers, controllers and intelligent I/O devices (e.g., smart sensors and actuators). Each of the system components connected directly to the network is denoted as a node. Control systems communicating with sensors, controllers, and actuators over communication networks are named networked control systems (NCS) (Figure 1). With respect to the traditional control, NCS have many advantages such as low cost, reduced weight and power requirements, simple installation and maintenance, and high reliability.

There are many examples in which placing a network to interconnect control applications is convenient. A typical example is the case of aircraft control. In this case, different sensors and control

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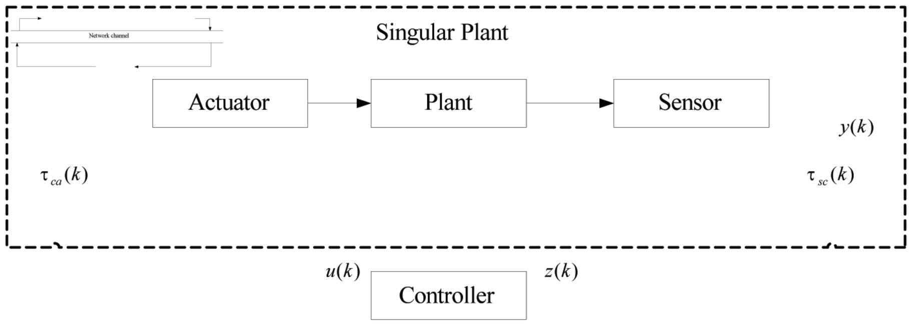
Figure 1. Networked control systems



surfaces among other control components are distributed over the aircraft. Another example is the case of manufacturing factories where it is a common practice to implement data acquisition systems along the process path. Dozens of sensors are deployed over critical points to make important information about the process available to quality control engineers. Most of the times, these sensors will transmit the collected information to a central computer using an industrial network. More than often the need to create new control loops appears as quality or industrial engineers analyze the data retrieved by the acquisition network. In this case, it seems natural to attach the controllers and actuators to the already existent network and share the data already provided by the deployed sensors. In general, the use of a network on a control system is desirable when there is a large number of distributed sensors and actuators (Montestruque & Antsaklis, 2001).

NCS have also been used in the process control systems widely. For example, the implementation of distributed control can be traced back at least to the early 1970s when Honeywell distributed control system (DCS) was introduced. Control modules in a DCS are loosely connected because most of the real-time control tasks (sensing, calculation, and actuation) are carried out within individual modules. Only on/off signals, monitoring information, alarm information, and the like are transmitted on the serial network. Today DCS has been widely used in process control systems. Current candidate networks for NCS implementations are DeviceNet, Ethernet, and Firewire with their own protocols. In industry process control systems, these NCS implementations are also inducted widely.

However, the insertion of the communication network in the feedback control loop makes the analysis and design of an NCS complex. The usage of network cables inevitably makes the analysis and design of the NCS complicated. The limited bandwidth of the communication channel brings new issues such as network-induced time delay, data missing and quantization effect, which constitute potential sources of instability and poor performance of NCS. Methods developed from conventional control theory are no longer applicable for the analysis and design of the NCS and should be modified to account for the additional complexity (Zhang et al, 2001).

With the development of network and control technology, NCS have attracted more and more attention in recent years. As a new research area with many open issues, NCS have been discussed comprehensively, which mostly focus on modeling, scheduling, stability analysis, online delay-evaluating and control schemes. Compared with the conventional point-point control systems, the structure of NCS is more complex and the actuators, sensors and plants are farther from the controller. It is often much more difficult to test the signals of NCS. These problems make FD of NCS more challenging.