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SELF-REPAIRING AND ADAPTIVE CONTROL OF MIMO SYSTEMS WITH FAULTY SENSORS

Masanori Takahashi

Department of Mechanical Systems Engineering
Tokai University
9-1-1 Toroku, Kumamoto, 862-8652, Japan
masataka@ktmail.tokai-u.jp

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Abstract. *This paper presents a design method for a self-repairing control system (SRCS) for multi-input multi-output systems with sensor failures of a stuck-type. Based on dynamic redundancy, the SRCS can replace the faulty sensors with the healthy ones. Exact fault detection can be attained with use of an auxiliary signal and an integrator, and so no diagnostic observer is used. Furthermore, a switched high-gain controller is introduced to cope with uncertainties and disturbances. Thus, for the plants with complex and unknown structures, one can construct the simple SRCS and achieve fault detection.*
Keywords: Fault detection, Sensor failures, Adaptive Control, Switched systems

1. **Introduction.** Fault detection has played an important role in safety and reliability of control systems. The difficulty of fault detection arises in dealing with multi-input multi-output (MIMO) systems. For MIMO systems, we should not only find occurrence of faults but also specify their locations. Hence, many deterministic approaches have exploited diagnostic observers and estimators under the assumption that the plant models are available [1, 2, 3]. However, because their structures depend on the structures of the plants, the resultant systems may become complex for plants with complex structures. In addition, exact fault detection cannot be guaranteed if the plants have uncertainties.

Measured signals sometimes get stuck due to sensor failures. This type of failure is called *a stuck-type*. Such a sensor failure cuts a feedback-loop and makes the control system unstable. Unfortunately, it is extremely hard to find the stuck sensors when the measured signal is stuck on just an ideal or admissible value.

To accommodate the stuck sensor, a new self-repairing control system (SRCS) has been developed in an alternative way of fault detection [4]. The SRCS can detect the sensor failure and switch from the failed sensor to the healthy one using on dynamic redundancy. The fault detector in the SRCS exploits an auxiliary signal and an integrator. The auxiliary signal is well designed so that the output of the integrator hits a decision threshold if the measured output of the plant is stuck. Therefore, to find the failure, the fault detector only has to check whether the output of the integrator hits the threshold or not. This deterministic detection algorithm needs neither observer nor estimator. Thus, one can construct the simple SRCS whose structure does not depend on the order of the plant, and also can achieve exact fault detection even if the plant has uncertainty.

However, for MIMO plants, the above-mentioned self-repairing control problem has not been solved yet. Also, injecting the auxiliary signal might degrade stability and tracking performance. As a remedy, this paper presents the SRCS for MIMO plants, in which a high-gain PI adaptive controller [5] with the switched feedback gain is introduced to cope with uncertainty and disturbance including the auxiliary signal for fault detection.