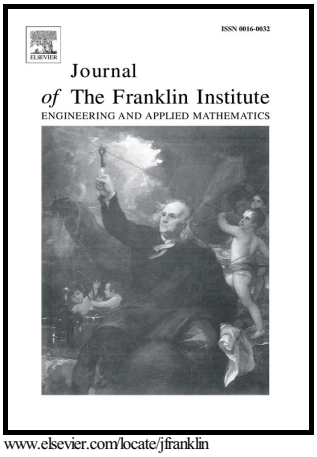

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Fault detection filter design for switched systems with quantization effects

Jian Li and Ju H. Park

Abstract

The problem of fault detection for switched systems with quantization effects is investigated in this paper. The dynamic quantiser introduced here is composed of a dynamic scaling and a static quantiser. Subsequently, a novel fault detection scheme, which fully considers the static quantiser range and quantiser error, is proposed. Furthermore, sufficient conditions for fault detection filter are given in the framework of linear matrix inequality, and the filter gains and the static quantiser range are obtained by a convex optimized problem. Finally, the presented technique is validated by two examples, and simulation results indicate that the proposed method can effectively detect the fault.

Index Terms

Fault detection, switched systems, dynamic quantiser.

I. Introduction

Switched systems are a type of hybrid dynamical systems, consisting of a finite number of subsystems and a logical rule that specifying orchestrates switching among them [1]–[3]. The primary motivation for studying switched systems comes partly from the fact that systems or multi-controller systems are switched. Until now, several approaches have been proposed for the control problem or the filtering problem for switched systems, such as arbitrary switching [4], restricted switching (like dwell time [5] and average dwell time (ADT) [6]), common Lyapunov function method [7], multiple Lyapunov functions method [8], [9] and piecewise quadratic Lyapunov functions [10]. Especially, the ADT approach has been acknowledged to be more flexible and efficient in analysis of switched systems [11]–[13].

On the other hand, fault detection and isolation for dynamic systems are an important topic from the viewpoint of the higher demands for safety and reliability [14], [15]. Many model-based fault detection (FD) results have been obtained in the last decades. The basic idea of these results is to design observers or filters, then generates an residual signal. Comparing the predefined threshold and the value counted by the residual evaluation function, it can be obtained the detection whether the fault has occurred or not. Based on this scheme, many methods have been presented. As one of typical methods, the FD problem is converted into a robust filtering problem [16], [17]. For another method, FD system is directly sensitive to the fault, and, simultaneously, robust to the unknown disturbance [18], [19].

However, the problem of FD design in switched systems schemes is still in the early stage of development and a few results have been reported in literatures [20]–[24]. To the best of authors' knowledge, the FD problem for switched systems with quantization effects, has not been investigated yet. It is worth noting that the FD approaches for switched systems without quantisers are not appropriate for switched systems with quantisers due to the effect of quantiser error. Therefore, a new FD technique is needed to take quantiser error into account. Moreover, since the actual system is established which neglects the transmission requirements, i.e. quantization requirements, the inaccurate mathematics model may reduce the robustness of the actual system, and the results may increase the risk of the false alarm. Thus, as the significance in theory and practice, it is necessary to directly investigate the FD problem for quantized switched system, which motivates us to study this interesting issue.

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