Department of Engineering, Mathematic, and Physics Presents

The EMAP 2009 Colloquium

Wednesday, October 28th

4:30-5:30pm

Room: LBV 208
Free and Open to Public

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Robust and Reduced Order H_∞ Filtering via LMI Approach and Its Application to Fault Detection

Abstract

Filters that estimate the state variables of a system are important tools for control and signal processing applications. Early work in the area assumed that the system dynamics were known and external disturbances were white noise with known statistical properties. In contrast to traditional Kalman filters, H_∞ filters do not require knowledge of the statistical properties of the noise. H_∞ filters are more robust to disturbances and modeling uncertainties than Kalman filters. Thus, in practical applications where disturbances may not be known exactly and system uncertainties may appear in modeling, the H_∞ technique is often used.

The first objective of this work is to provide a practical methodology for designing full and reduced order H_∞ filter for plants with polytopic model uncertainty. Because the polytopic model description is convex, it is

amenable for a Linear Matrix Inequality (LMI) formulation. Reduced order filters are desirable in applications where fast data processing is necessary. To improve robustness to model uncertainties, this paper reformulates an H_2 filter design technique as a reduced order H_∞ filter design methodology. Lyapunov functions are replaced with parameter-dependent Lyapunov functions to provide less conservative results. As the problem is formulated as an LMI, an admissible filter with suitable dynamic behavior can be obtained from the solution of a convex optimization problem. The advantages of this approach over earlier approaches are highlighted in a simple computational example.

The second objective of this work is to demonstrate how this filtering technique can be used for fault detection filter design. As the reliability and security of complex systems becomes more important, on-line monitoring of faults that occur during the operation of a dynamic system is necessary. In this study, estimator based fault detection methods will be the focus. The key to estimator based fault detection is to generate a fault indicating signal (residual) using input and output signals from the monitored system. However, there is always a model-reality mismatch between plant dynamics and the model used for the residual generation. In this work, the design of a fault detection filter that is robust to this uncertainty is formulated as a multi-objective H_∞ optimization for a polytopic uncertain system. The order of the filter is reduced using LMI techniques, and the detection performance is compared with the full order filter. An adaptive threshold is used to reduce the number of false alarms. An example is presented to illustrate effectiveness of the order reduction.

Keywords: Robust filtering, Linear Matrix Inequalities, Fault detection filter design, Order reduction.

Refreshment Starts at 4:00pm

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