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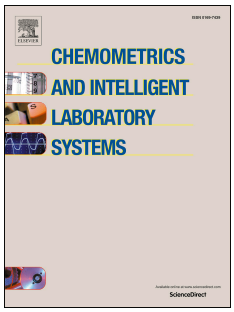

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A Visualization Approach for Unknown Fault Diagnosis

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Abstract

Since visualization can provide useful information to control engineers about the state of the process, visualization has become an dispensable item in the condition monitoring toolbox. The objective of this paper is to propose a visualization approach and apply it to unknown fault isolation. First, the data-driven parity space (PS) technique is used to identify the stable kernel representation (SKR) of a linear time invariant dynamic system. Then, the signature directions (SDs) and the current directions (CDs) are defined, based on which the detection and isolation rules are proposed for diagnosing both the known faults (KFs) and the unknown faults (UFs). Finally, a visualization approach is provided for projecting high-dimensional fault information onto a lower dimensional and drawable space. This approach maintains the fault isolability so that engineers will be able to diagnose the faults more reasonably. The proposed visualization approach is applied to a vertical take off and landing (VTOL) aircraft model and a glass tube manufacturing process.

Keywords: Fault diagnosis; Visualization; Parity space; Unknown fault; Rank reduction.

1. Introduction

With the rapid growth in high-dimensional data, visualization has become an important component of modern condition monitoring (Shardt et al. (2012, 2015)).

Why is visualization necessary? Visualization allows the operators and engineers the ability to see the data for diagnosis. As is shown in Swayne et al. (1998), research on visualization has successfully brought together researchers from computer science, user interfaces, psychology, perception, and statistics. For example, the contribution plot (Westerhuis et al. (2000); He et al. (2005); Van den Kerkhof et al. (2013); Alcala and Qin (2009)) is an important visual tool for process engineers to perform fault isolation. Visualization is an interactive and dynamic method and it can provide the engineers with visual insight into the monitored data. Based on their prior knowledge, engineers may be able to visually identify faults.

Fault detection and isolation (FDI) modules usually focus on diagnosing the known faults (KFs). However, in real operations the set of KFs are not complete and some unknown faults (UFs) may occur. UFs have been defined as faults that are neither anticipated nor encountered previously (Brotherton and Johnson (2001); Yue and Qin (2001); Zhang et al. (2011); He et al. (2012); Wang et al. (2013)). For example, if only univariate and time-invariant faults are considered, then multivariate or time-varying faults are UFs. Compared with KFs, prior information about the UFs is scarcer, thus they are more difficult to diagnose. Visualization can partly cope with the diagnosis of UFs, because some space information, e.g., the location or direction distribution, is available in the visual plot, which hopefully will help the diagnosis expert to identify the faults.

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