Real-time fault detection and diagnosis using sparse principal component analysis - DTU Orbit (05/05/2019)

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With the emergence of smart factories, large volumes of process data are collected and stored at high sampling rates for improved energy efficiency, process monitoring and sustainability. The data collected in the course of enterprise-wide operations consists of information from broadly deployed sensors and other control equipment. Interpreting such large volumes of data with limited workforce is becoming an increasingly common challenge. Principal component analysis (PCA) is a widely accepted procedure for summarizing data while minimizing information loss. It does so by finding new variables, the principal components (PCs) that are linear combinations of the original variables in the dataset. However, interpreting PCs obtained from many variables from a large dataset is often challenging, especially in the context of fault detection and diagnosis studies. Sparse principal component analysis (SPCA) is a relatively recent technique proposed for producing PCs with sparse loadings via variance-sparsity trade-off. Using SPCA, some of the loadings on PCs can be restricted to zero. In this paper, we introduce a method to select the number of non-zero loadings in each PC while using SPCA. The proposed approach considerably improves the interpretability of PCs while minimizing the loss of total variance explained. Furthermore, we compare the performance of PCA- and SPCA-based techniques for fault detection and fault diagnosis. The key features of the methodology are assessed through a synthetic example and a comparative study of the benchmark Tennessee Eastman process.

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