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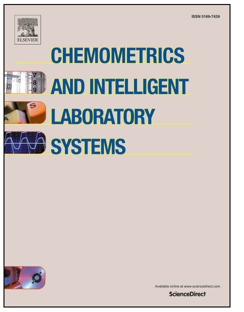

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Abstract

Principal component analysis (PCA) is largely adopted for chemical process monitoring and numerous PCA-based systems have been developed to solve various fault detection and diagnosis problems. Since PCA-based methods assume that the monitored process is linear, nonlinear PCA models, such as autoencoder models and kernel principal component analysis (KPCA), has been proposed and applied to nonlinear process monitoring. However, KPCA-based methods need to perform eigen-decomposition (ED) on the kernel Gram matrix whose dimensions depend on the number of training data. Moreover, prefixed kernel parameters cannot be most effective for different faults which may need different parameters to maximize their respective detection performances. Autoencoder models lack the consideration of orthogonal constraints which is crucial for PCA-based algorithms. To address these problems, this paper proposes a novel nonlinear method, called neural component analysis (NCA), which intends to train a feedforward neural work with orthogonal constraints such as those used in PCA. NCA is a unified model including a nonlinear encoder and a linear decoder. NCA can adaptively learn its parameters through backpropagation and the dimensionality of the nonlinear features has no relationship with the number of training samples. Extensive experimental results on the Tennessee Eastman (TE) benchmark process show the superiority of NCA in terms of missed detection rate (MDR) and false alarm rate (FAR). The source code of NCA can be found in https://github.com/haitaozhao/Neural-Component-Analysis.git.

Keywords: Process monitoring, Fault detection, Feedforward neural network, Autoencoder

1. Introduction

Monitoring process conditions is crucial to its normal operation [24]. Over last decades, data-driven multivariate statistical process monitoring (MSPM) has been widely applied to fault diagnosis for industrial process operations and production results [22, 27]. Due to the data-based nature of MSPM, it is relatively convenient to apply to real processes of large scale comparing to other methods based on theoretical modelling or rigorous derivation of process systems [10, 8].