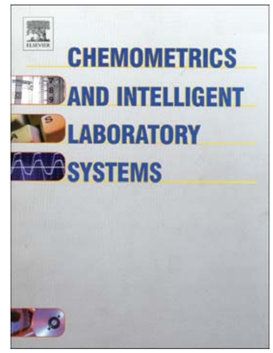
Accepted Manuscript



Fault detection in time-varying chemical process through incremental principal component analysis

Yong Gao, Xin Wang, Zhenlei Wang, Liang Zhao

PII: S0169-7439(16)30167-8
DOI: doi: 10.1016/j.chemolab.2016.07.005
Reference: CHEMOM 3287

To appear in: *Chemometrics and Intelligent Laboratory Systems*

Received date: 8 April 2016
Revised date: 7 July 2016
Accepted date: 12 July 2016

Fault detection in time-varying chemical process through incremental principal component analysis

Yong Gao[1], Xin Wang[2], Zhenlei Wang[1*], Liang Zhao[1]

([1]Key Laboratory of Advanced Control and Optimization for Chemical Processes (East China University of Science and Technology), Ministry of Education, Shanghai, 200237, China;

[2]Center of Electrical & Electronic Technology, Shanghai Jiao Tong University, Shanghai, China

E-mail: wangzhen_l@ecust.edu.cn)

Abstract: Incremental principal component analysis (IPCA) is proposed to improve the detection performance of a slow ramp fault in the time-varying chemical process. Conventional monitoring methods of the time-varying process such as recursive method and moving window strategy, which update the monitoring model and control limit when the newly monitored sample is detected as a normal one, track the slow ramp fault and lose the ability to detect this kind of fault. In this study, the incremental principal components (IPCs) describing time-varying information are proposed to extract the normal time-varying information. This study proposes IPCA method based on IPCs for process monitoring of the time-varying processes. The monitoring model remained unchanged because the normal time-varying information has already been identified by IPCs. The method can distinguish between the slow ramp fault from the normal time-varying process. Two numeric case studies demonstrate the efficiency of the method. Application of the method to an acetylene hydrogenation reactor is also provided.

Keywords: time-varying, slow ramp fault, incremental PCA, fault detection

1 Introduction

Modern industrial processes are large-scale interconnected systems. With the increase in demand for plant safety and product quality, process monitoring has played an increasingly important role in chemical industrial procedures. In past decades, multivariate statistical process monitoring (MSPM) has received significant attention [1–4]. Conventional MSPMs, such as principal component analysis (PCA) and partial least squares (PLS) have been widely applied to process monitoring. These methods can acquire satisfactory results for the time-invariant process with a single steady operation mode [5,6]. However, many process variables are time-varying because several reasons, including deactivation of a catalyst, measurement instrument drifting, and other reasons. In this situation, conventional MSPMs often yield undesirable results.

To date, many complementary MSPM methods have been designed to solve the time-varying problems. Three adaptive monitoring methods have been proposed: recursive, exponential weighting, and moving window methods. Recursive methods absorb the new normal sample into the monitoring model to adapt to the time-varying processes. In [7] and [8], two recursive PCA methods are proposed. Wang developed a recursive PLS method [9]. In [10], a recursive kernel PCA method is further studied to deal with the nonlinear processes. Exponential weighting methods update the monitoring model by absorbing new normal data and forgetting the old data exponentially. In [11], an exponential weighting moving average PCA (EWMA-PCA) method updates the monitoring model by recalculating the mean and variance of the modeling data. EWMA-PCA [12] and EWPLS [13] refresh the monitoring model by updating the covariance matrix. Moving window methods update the monitoring model by discarding the oldest sample and inserting a new normal sample. In [14], a fast moving window PCA