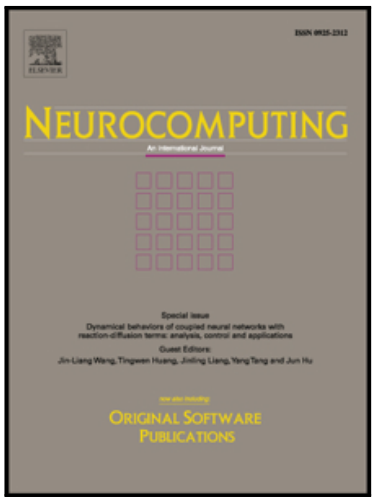

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PII: S0925-2312(18)30271-6
DOI: 10.1016/j.neucom.2018.02.091
Reference: NEUCOM 19401

To appear in: *Neurocomputing*

Received date: 13 May 2017
Revised date: 9 December 2017
Accepted date: 27 February 2018

Please cite this article as: Hanyuan Zhang , Xuemin Tian , Xiaogang Deng , Yuping Cao , Multiphase batch process with transitions monitoring based on global preserving statistics slow feature analysis , *Neurocomputing* (2018), doi: 10.1016/j.neucom.2018.02.091

Multiphase batch process with transitions monitoring based on global preserving statistics slow feature analysis

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Abstract: Most previous studies have shown that the multiphase characteristics of batch processes are critical for process monitoring; however, revealing and utilizing the information of multiplicity in multiphase batch process monitoring remains challenging. In this paper, statistics slow feature analysis (SSFA) is developed to extract slowly varying information at the same sampling time among different batches based on various statistics of the original variables. Then, a new index called the phase recognition factor (PRF), which is based on SSFA, is introduced to automatically achieve phase division. The proposed PRF takes advantage of the time sequence of process phases and does not require predefined parameters. After phase division, global preserving SSFA (GSSFA) is proposed not only to explore the time-varying dynamic information of batch processes but also to consider the mining of global data structure information. Furthermore, a novel process monitoring strategy based on the GSSFA model is developed to monitor batch processes with transitions. In each steady phase, a representative GSSFA model is built for process monitoring; in the transition period, different local GSSFA models are constructed online to monitor the test samples based on the just-in-time learning method. Two case studies, one simple numerical multiphase system and a benchmark fed-batch penicillin fermentation process, are used to demonstrate the effectiveness and superiority of the proposed method.

Key words: multiphase batch process; transition; phase division; slow feature analysis; process monitoring

A summary of the included abbreviations

AMPCA	angle-based multiphase principal component analysis
CPPBM	concurrent phase partition and between-mode
DKSFA	dynamic kernel slow feature analysis
DPRF	differential phase recognition factor
DRF	differential repeatability factor
GSSFA	global preserving statistics slow feature analysis
JITL	just-in-time learning
KDE	kernel density estimation
K-NN	K-nearest neighborhood
LNNM	local neighbor normalized matrix
LVs	latent variables
MDPCA	multiway dynamic principal component analysis

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