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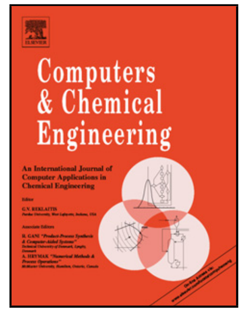

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A deep belief network based fault diagnosis model for complex chemical processes

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Abstract: Data-driven methods have been regarded as desirable methods for fault detection and diagnosis (FDD) of practical chemical processes. However, with the big data era coming, how to effectively extract and present fault features is one of the keys to successful industrial applications of FDD technologies. In this paper, an extensible deep belief network (DBN) based fault diagnosis model is proposed. Individual fault features in both spatial and temporal domains are extracted by DBN sub-networks, aided by the mutual information technology. A global two-layer back-propagation network is trained and used for fault classification. In the final part of this paper, the bench marked Tennessee Eastman process is utilized to illustrate the performance of the DBN based fault diagnosis model.

Keywords: fault diagnosis; deep belief network; feature extraction; early warning; alarm management.

1. Introduction

Modern chemical processes are highly automatic due to the contribution of advanced process control systems. However, accidents still happen and have caused tremendous casualties, environmental and economic losses. For example, the BP Texas City refinery explosion accident and the PetroChina's Jilin chemical plant explosion accident in 2005 (Shu, et al., 2016). Even though human factors are usually involved in chemical accidents, abnormal situation management (ASM) still heavily relies on human operators to handle a large amount of alarms. Therefore, how to detect abnormal situations early enough and help operators make timely and reliable decisions is vital for preventing accidents. As a central component of ASM, process fault detection and diagnosis (FDD) has drawn increased attention from academia and industry over the last three decades.

The FDD methods can be classified into three parts: quantitative model based, qualitative model based and process history based methods (Venkatasubramanian, et al., 2003a, b, c). Among these methods, the quantitative process history based methods or data-driven methods possess more potential to be applied in the chemical processes. One set of data-driven methods are statistical methods such as principal component analysis (PCA) (Kresta, et al., 1991; Russell, et al., 2000; Cho, et al., 2005; Ge, et al., 2009; Fan & Wang, 2014; Rato, et al., 2016), partial least squares (PLS) (Piovoso & Kosanovich, 1994), independent component analysis (ICA) (Kano, et al., 2003; Jong-Min Lee, et al., 2007), fisher discriminant analysis (FDA) (Chiang, et al., 2000), subspace aided approach (SAP) (Ding, et al., 2009) and correspondence analysis CA (Detroja, et al., 2007). Yin et. al. performs an interesting comparison study with the above methods and their derivatives in the benchmark Tennessee Eastman (TE) process (Downs & Vogel, 1993). The comparisons show that different FDD methods correspond to distinct fault diagnosis rates and the average fault diagnosis rate of all 21 faults based on TE data sets is about 73.8% to 84.4% (Yin, et al., 2012). A framework of Bayesian diagnosis is proposed by Huang (2008). Based on Gaussian mixture model and optimal principal components, a Bayesian diagnosis system is developed for multimode processes (Jiang, et