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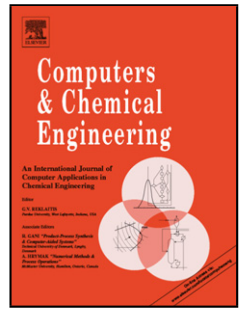

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Author: Yuncheng Du Hector Budman Thomas A. Duever

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Comparison of Stochastic Fault Detection and Classification algorithms for Nonlinear Chemical Processes

Yuncheng Du[1], Hector Budman[2*], Thomas A. Duever[2,3]

[1]Department of Chemical and Biomolecular Engineering, Clarkson University, Potsdam, NY, U.S.A., 13699

[2]Department of Chemical Engineering, University of Waterloo, Waterloo, ON, Canada, N2L 3G1

[3]Department of Chemical Engineering, Ryerson University, Toronto, ON, Canada, M5B 2K3

Abstract: This paper presents a comparative study of two methods to identify and classify intermittent stochastic faults occurring in a dynamic nonlinear chemical process. The methods are based on two popular stochastic modelling techniques, i.e., generalized polynomial chaos expansion (gPC) and Gaussian Process (GP). The goal is to assess which method is more efficient for fault detection and diagnosis (FDD) when using models with parametric uncertainty, and to show the capabilities and drawbacks of each method. The first method is based on a first-principle model combined with a gPC expansion to represent the uncertainty. Resulting statistics such as probability density functions (PDFs) of the measured variables is further used to infer the intermittent faults. For the second method, a GP model is used to project multiple inputs into a univariate model response from which the fault can be identified based on a minimum distance criterion. The performance of the proposed FDD algorithms is illustrated through two examples: (i) a chemical process involving two continuous, stirred tank reactors (CSTRs) and a flash tank separator, and (ii) the Tennessee Eastman benchmark problem.

Keywords: Uncertainty Analysis, Generalized Polynomial Chaos, Gaussian Process, Model Adjustment, Process Monitoring

1. Introduction

Early detection of abnormal events and malfunctions or faults is of great interest, since faults may affect the product quality and lead to economic losses [1]. When the fault is detectable, the fault detection and diagnosis (FDD) algorithm will provide symptomatic fingerprints, which can be used by the FDD scheme to identify the root cause of the anomalous behaviour. Fault diagnosis and fault classification are used interchangeably in this work. Most of the available fault diagnosis algorithms can be broadly classified into three main classes [2, 3]: (i) Analytical methods that are solely based on a first-principle model of a process; (ii) Empirical models that use the historical process data; and (iii) Semi-empirical algorithms that combine the first-principles and empirical models.

Each of these modelling approaches has its own advantages and disadvantages depending on the specific problem [4], but it is recognized that while empirical models are easier to formulate and employ, first-principles models have

[*]Corresponding author: Tel.: +1 519-888-4567 x 36980.
Email address: hbudman@uwaterloo.ca (H. Budman)