Assessment of Alarm Systems for Mixture Processes and Intermittent Faults

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Abstract.

Alarm systems are utilized in the process industries to notify operators and other plant staff of abnormal process conditions or equipment faults. Alarm system, as an essential part of distributed control systems (DCS), assists operators in safely operating the process under normal and abnormal situations. The alarm system must be appropriately constructed to maximize the possibility of safe and efficient operation. Nowadays, advanced industrial monitoring systems such as Supervisory Control and Data Acquisition (SCADA) and Centralized Monitoring System (CMS) are equipped with an enormous number of sensors, thanks to the rapid growth in sensing technologies. As an advantage, the number of alarm tags in a plant grows noticeably and makes it possible to monitor the whole industrial plant with more details. As a drawback, the number of alarms may confuse the operator to originate the faults. Chattering alarms are also another disruptive phenomenon in modern alarm systems. Poor alarm system rationalization is the primary source of the aforementioned issues. As a reason for poor alarm rationalization, the behavior of the faulty process variable is not taken into consideration in alarm system design, and again this will bring many meaningless alarms and no-alarms states to the operator. As an attempt to solve this problem, we tried to propose a model to reflect the behavior of an intermittent fault and utilize it to design alarm systems more specifically to the fault type. The Time-variant Finite Mixture Model is utilized to model the behavior of an Intermittent Fault (IF), which is a fault that alternates between faulty and non-faulty behavior at discrete random intervals. Time-variant finite mixture models could be a helpful tool for modelling complex data collections whose statistical properties change over time. A finite mixture model is a convex combination of two or more probability density (or mass) functions (PDF(PMF)). By combining the properties of the individual PDFs, mixture models are capable of approximating any arbitrary distribution.

Our work's contribution is twofold. First and foremost, since intermittent faults are the most difficult to diagnose and are one of the leading causes of No Fault Found, we attempted to present a model that can easily be modified to mimic different behaviors of an IF simply by changing the value of model parameters in order to design an alarm system that can find an IF in the shortest amount of time.

Second, for a process affected by an IF, we established three different zones of operation: Normal operating zone, Rising zone, and Fault zone. Furthermore, we considered the two last zones to be the operation's Abnormal condition. The Indices are estimated for both normal and abnormal conditions (including Fault zone and Rising zone). Because we considered that the process in the Rising zone is non-stationary, the MAR_t is defined as a time-

variant index that measures the designed alarm system's missed alarm rate with time. This tv index allows for better performance of the designed alarm system than in the past since it gives more details about the alarm system's performance in addition to the information provided by the time-variant FMM model.

Keywords: Alarm system, Intermittent faults, Finite mixture models, non-stationary process, Averaged alarm delay (AAD), False alarm rate (FAR), Missed alarm rate (MAR)