Evaluation of the Thesis: "System Supervision and Abnormality Detection through Multivariate Statistical Methods" by Bálint Levente Tarcsay

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The thesis by Bálint Levente Tarcsay, titled "System Supervision and Abnormality Detection through Multivariate Statistical Methods," presents a comprehensive study on fault detection (FD) and isolation (FDI) in industrial processes using advanced statistical methods. This research addresses the increasing need for reliable FD systems due to the growing complexity of industrial processes and the associated risks of faults and abnormalities. The chosen topic is focusing on a very current problem, which is a critically important issue in the industry.

The literature review is thorough and well-structured, covering quantitative model-based methods, qualitative model-based methods, and process history-based methods. The author provides a detailed comparison of these methods, highlighting their strengths and weaknesses. The review sets a solid foundation for the research, demonstrating a deep understanding of the current state-of-the-art in FD and FDI.

The methodology section is divided into three main parts, each addressing a specific research objective:

1. Fault Isolation Using Principal Component Analysis (PCA) and Trajectory Distance Metrics:
   - The author proposes a novel method combining Dynamic PCA (DPCA) with the discrete Fréchet distance metric for fault isolation.
   - The method is validated using a three-tank benchmark problem, demonstrating its robustness and accuracy.
   - The use of trajectory similarity metrics for fault isolation is innovative and shows significant potential for real-time fault diagnosis.
2. Integration of Risk Factors into Fault Detection:
   - The author integrates Bayesian Networks (BN) with Failure Mode and Effect Analysis (FMEA) to develop a risk-based FD method.
   - The method is tested on a three-tank benchmark system and a dehydrogenation reactor, showing a reduction in superfluous alarms and improved operator decision-making.
   - The approach effectively combines statistical methods with risk assessment, providing a more comprehensive FD framework.
3. Reduced Models for Training Fault Detection Methods of Distributed Parameter Systems:
   - The author develops a method to create compartment models (CM) from Computational Fluid Dynamics (CFD) results, reducing computational load while maintaining accuracy.
   - The method is validated using a mixing tank experiment, demonstrating its applicability for training FD methods in DPS.
   - The approach addresses a critical challenge in FD for DPS, offering a practical solution for real-time system supervision.

The results are presented with high quality. clearly and systematically, with each section providing detailed analysis and validation of the proposed methods. The author uses appropriate

metrics, such as False Alarm Rate (FAR), Missed Alarm Rate (MAR), and the macro-averaged F1 score, to evaluate the performance of the methods. The discussion is insightful, highlighting the strengths and limitations of the research.

The thesis concludes with a summary of the key findings and contributions. The author successfully demonstrates the applicability and effectiveness of the proposed methods in various scenarios. Overall, the dissertation contributes to the field of industrial process safety by proposing innovative methods for fault detection and isolation, integrating risk analysis.

The thesisbook chapter, is compherensive, well written and the dissertation is supported by five publications.

As a summary, Bálint Levente Tarcsay's dissertation makes notable contributions to the field of fault detection and isolation in industrial processes. Through the development of novel data-based methods, integration of risk analysis, and addressing challenges in distributed parameter systems, the research enhances the safety and reliability of complex industrial technologies. The formal and technical language used is appropriate for the academic audience, and the clear structure facilitates a comprehensive understanding of the research.

Concluding all above the P.h.D. thesis work of Bálint Tarcsay called "System supervision and abnormality detection through multivariate statistical methods" complies to the rules of ResearResearch Centre for Biochemical, Environmental and Chemical Engineering Department of Process Engineering. I would like to express my support to accept the thesis points of Bálint as new scientific results, therefore i propose for Bálint to grant the academing title Ph.D.

Possible questions (if needed):

- Can you elaborate on the challenges you faced while integrating Bayesian Networks with FMEA for risk-based fault detection? How did you address these challenges?
- What were the main limitations you encountered during the validation of the compartment models using experimental data? How did you mitigate these limitations?
- Based on your findings, what are the potential areas for future research in fault detection and isolation using multivariate statistical methods?
- How do you envision the practical implementation of your proposed methods in real-world industrial settings? What are the key factors for successful deployment?
- How do your proposed methods compare with other state-of-the-art techniques in terms of computational efficiency and fault detection accuracy?

Páty, 10.09.2024.

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