
Signs of Trouble: Exploring the Observability of Failures in System Behavior

Master's Thesis

Designing methods to identify fault symptoms using system connectivity and instrumentation

Motivation

In modern process industries, the ability to detect and interpret faults quickly is essential for safe and efficient plant operation. Control room operators rely heavily on sensor readings and visual cues to identify the source of problems. For training systems that aim to realistically simulate such fault scenarios, it is important to understand how failures manifest as observable “symptoms” in the system. This thesis explores whether such symptoms can be derived purely from the structural layout and equipment types of a plant — without relying on historical data or complex simulations.

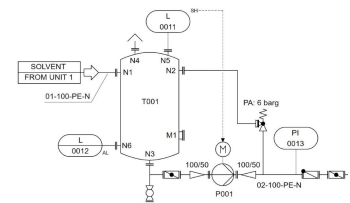


Figure 1: Exemplary P&ID

Goals

This thesis investigates how failures in process systems, such as a stuck valve or a pump malfunction, can be linked to observable symptoms in sensor data. The focus lies on exploring whether such symptoms can be derived from structural information of a process system, modeled as a graph that reflects instrumentation and connectivity typically found in P&IDs.

Key tasks include:

- Reviewing literature on fault modeling, symptom inference, and graph-based representations of process systems.
- Exploring and comparing different approaches (e.g., rule-based, AI-supported) for identifying symptom locations based on system structure.
- Designing and implementing a prototype to validate the developed methods using selected fault scenarios (e.g. through lab experiments or a simplified simulation model)

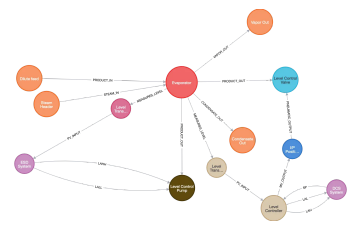


Figure 2: Exemplary P&ID graph representation

Helpful Background and Interests

- 🔧 Interest in automation systems, fault diagnosis, and process engineering
- 📚 Curiosity about AI methods or rule-based reasoning for technical problem-solving, as well as graph-based modelling
- 💻 Experience with programming or modeling environments (e.g., Python, Modelica) is beneficial
- 👤 Participation in courses such as Cyber-Physical Modeling



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Tags: automation systems, fault diagnosis, process engineering, graph-based modeling, AI methods, rule-based reasoning