Master Project

Fault Detection, Isolation and Estimation for High-End Industrial Printers

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Context

Canon Production Printing, a subsidiary of Canon based in Venlo, the Netherlands, specializes in the development, manufacturing, and sales of high-end industrial printers, as shown in Figure 1. The company is strongly invested in research and development ($R\&D$) to continually enhance print quality. To achieve this, Canon engages in partnerships with academic institutions, where specific projects, like this master's thesis, as a second master thesis play a key role.

Figure 1: Canon's Printer

A critical component of Canon's printers is the printhead, which is the focus of this master's thesis and is illustrated in Figure 2. Ensuring the printhead functions properly is essential, as various issues can arise, including air bubbles, nozzle blockages, or ink drying. These faults can lead to diminished image quality and reduced printer performance.

This master's thesis builds upon the previous thesis, which proposed a hybrid model and a data-based fault detection and isolation filter. The aim is to further develop the filter, expanding its capability to detect and isolate faults, as well as to estimate fault magnitudes.
To design the filter, the state-space matrices of a model that describes the fluid dynamics of the ink in the printhead are presented below:

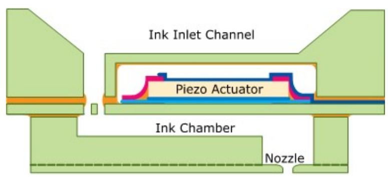

Figure 2: Schematic overview of the printhead

$$\begin{cases} \dot{x}(t) = Ax(t) + B_u u(t) + B_d d(t) + B_f f(t) \\ y(t) = Cx(t) + D_u u(t) + D_d d(t) + D_f f(t) \end{cases} \tag{1}$$

This model is divided into three components: the known part, the unknown part, and the fault part. The filter is designed such that the signals associated with the unknown part—specifically, the internal state x and the disturbance d—do not influence the filter's output. The signals connected to the known part, namely the system's input u and output y, are used as inputs to the filter. The filter's output, known as the residual r, remains zero when no fault signal f is present and becomes non-zero when a fault is detected. To make the filter robust against model mismatches and disturbances, real data is used. The residual generated by the fault detection filter can then be employed to reconstruct the faults in a fault isolation filter. A schematic overview of this process is illustrated in the block diagram in Figure 3.

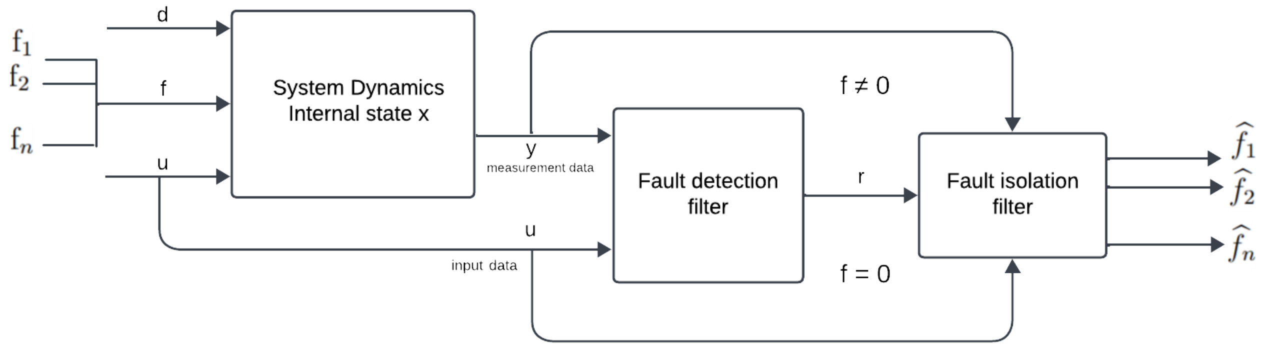

Figure 3: Block diagram of the system and filter

The goal of this thesis is to enhance the fault detection and isolation filter by increasing the number of detectable faults and improving the estimation of fault magnitudes.

Project tasks

This master's thesis project focuses on advancing the fault detection and isolation (FDI) method from the previous project, making it applicable to a broader range of faults and incorporating fault estimation. The key requirements for the method are as follows:

1. Improve the fault detection filter using machine learning techniques;
2. Enhance the robustness of the fault detection filter against model mismatches and disturbances by utilizing real data;
3. Develop the fault isolation filter;
4. Implement the designed FDI scheme on Canon printers;
5. Incorporate fault estimation capabilities.