

# 1 PM and FDI comparison

The relative arrangement PM and FDI methods representing in following figure 1

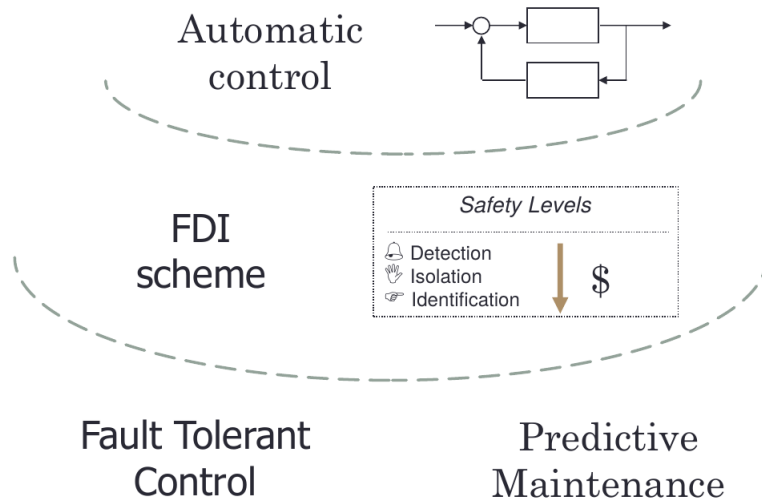


Figure 1: PM and FDI

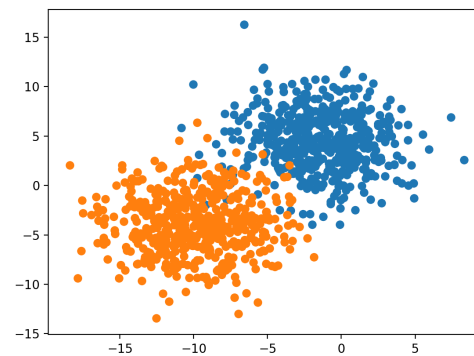
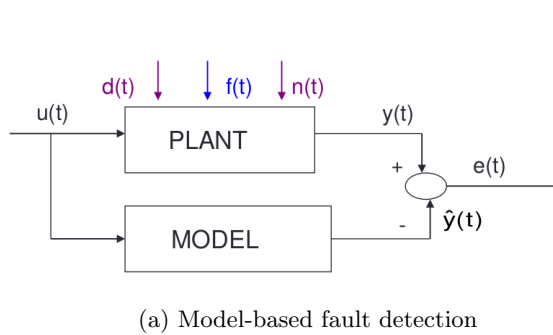
## 1.1 Fault detection and isolation

**Fault diagnosis:**

- Fault detection: Detect malfunctions in real time, as soon and as surely as possible.
- Fault isolation: Find the root cause, by isolating the system components whose operation mode is not nominal.
- Fault identification: Estimation the size and type or nature of the fault.

**There are two common approaches for fault detection 2:**

- Model-based FDI (compare data with healthy-model)
- Signal processing based FDI (using math methods to extract information about the fault from data)



(b) Signal-based fault detection

<sup>0</sup>**Fault** - not acceptable deviation of at least one characteristic or parameter of the system from the standard condition.

Figure 2: Fault detection common approaches

The result of FDI is the detection and identification of faults that occur during the operation of the device. Subsequently data is processed using Fault Tolerance and Predictive maintenance methods.

## 1.2 Fault Tolerance

**Fault Tolerance:** Provide the system with the hardware architecture and software mechanisms which will allow, if possible to achieve a given objective not only in normal operation, but also in given fault situations.

### 1.2.1 Predictive maintenance

**Predictive maintenance** is cost-effective maintenance strategy that predicts time to failure and warns of an anticipated location where this could occur. Predict where, when and what is the reason of failure (identify primary factors).

The are two main goals of Predictive maintenance, RUL (remaining useful life) and identification where the future failure can appear, or what is the reason of decreasing RUL.

**Types of Maintenance:**

- Reactive (fixes than fix)
- Preventative (schedules)
- Condition-based (based on assess of system)
- Predictive (based on model that predict failure)

**Predictive maintenance development sequence:**

1. Collect data (using sensors, math model)
2. Process data (clean up data)
3. Identify condition indicators CI
  - Signal-based CI
  - Model-based CI
4. Fit model (ML techniques)
5. Deploy monitoring and integrate
6. Dashboard (UI)

As a result of PM is RUL representing of number cycles, days, or some time period before fault occurred. And probability where this fault can appear.

## 1.3 Methods

There are couples of signal processing and analysing methods that used in both PM and FDI. For example:

- Spectral Analysis
- Wavelet Analysis
- Wavelet transform
- FFT
- Short Term Fourier Transform

- Gabor Expansion
- Wigner-Ville distribution
- Correlation
- High resolution spectral analysis
- Waveform Analysis
- Time-Frequency Analysis
- PCA
- Machine Learning techniques:
  - kNN
  - ANN