FUNDAMENTALS — FAULT DIAGNOSIS AND FAULT TOLERANCE —

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Lecture 1.2
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LECTURE SUMMARY

What are we going to talk about today ?

> A taxonomy of different kind of **FD approaches**

> A taxonomy of different kind of **FT approaches**

FAULT DIAGNOSIS

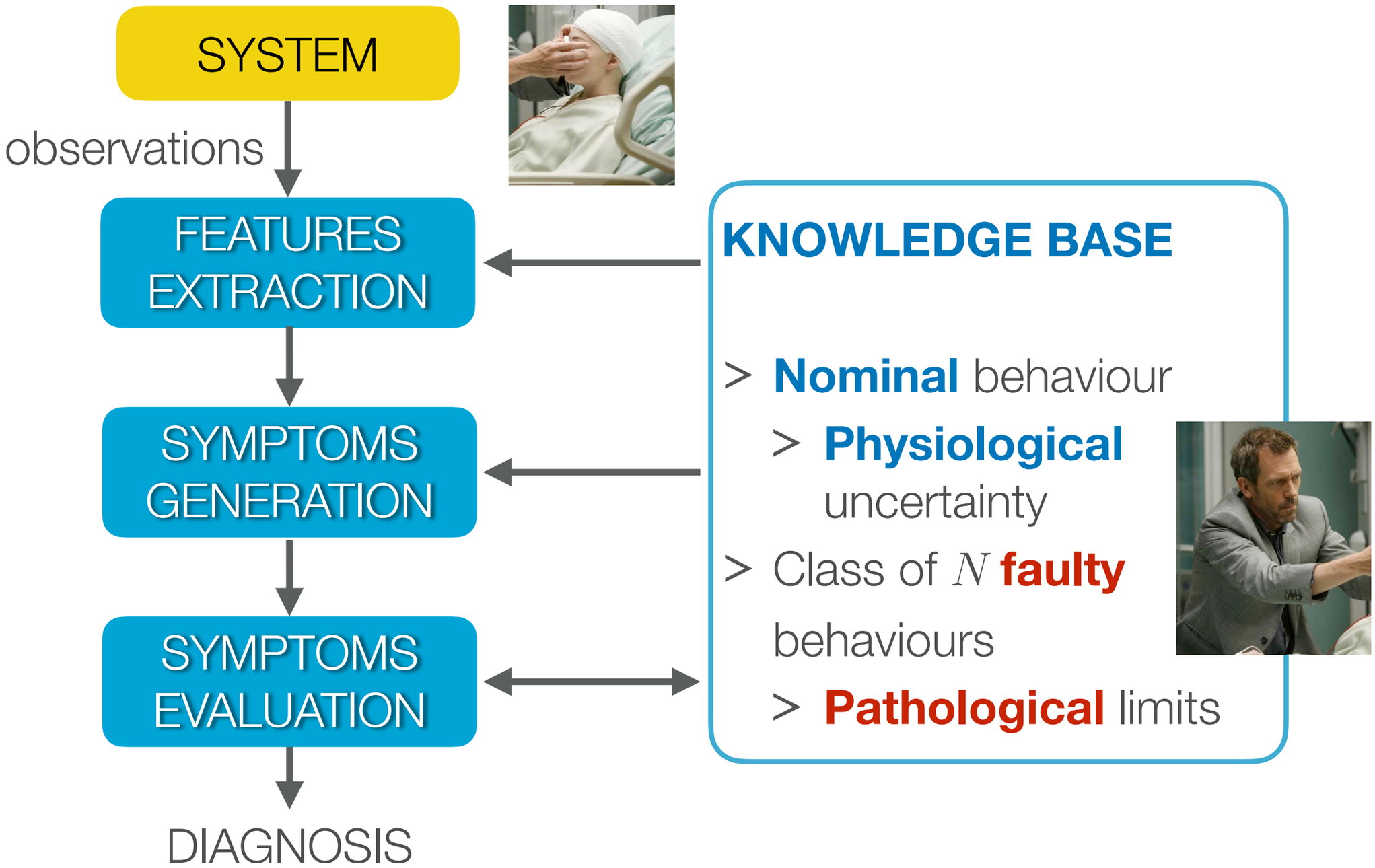
An overview of different approaches

FAULT DIAGNOSIS

It is not that much different from medical diagnosis!

FAULT DIAGNOSIS

Whatever approach you use, this is the common structure of FD



FAULT DIAGNOSIS

Feature extraction is different according to the FD approach

Signal based

Model based

FAULT DIAGNOSIS

Feature extraction is different according to the FD approach

Signal based

- Raw signal
- Mean or std over moving window
- Peak values
- Fourier transform, STFT, Wavelet, ...
- Cepstrum
- Curtosis
- ...

Model based

- (Kalman) observer estimation error
- Parity relations error
- Model parameters estimate

E.g. $\ddot{x} = -\underline{k}x - \underline{b}\dot{x}$

FAULT DIAGNOSIS

Symptoms generation

> From Wikipedia (sorry, but they actually have a good definition)

"*A* **symptom** *(from Greek σύμπτωμα, "accident, misfortune, that which befalls", […]) is a* **departure** *from* **normal** *function or feeling*"

> In FD, a **symptom** is a measure of the **difference** between **actual** value of **features** extracted from observations, and **nominal** ones

Signal based

Model based

FAULT DIAGNOSIS

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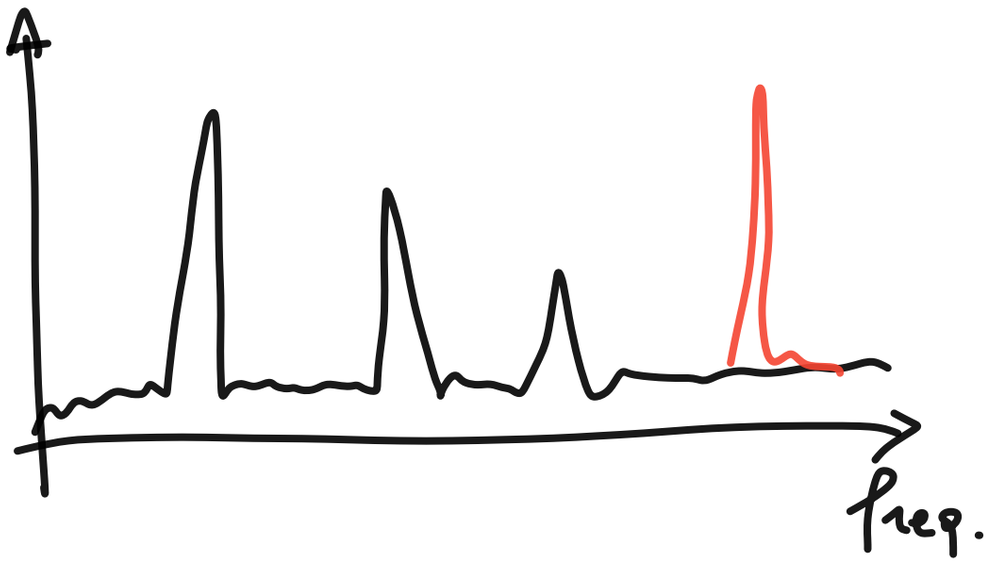
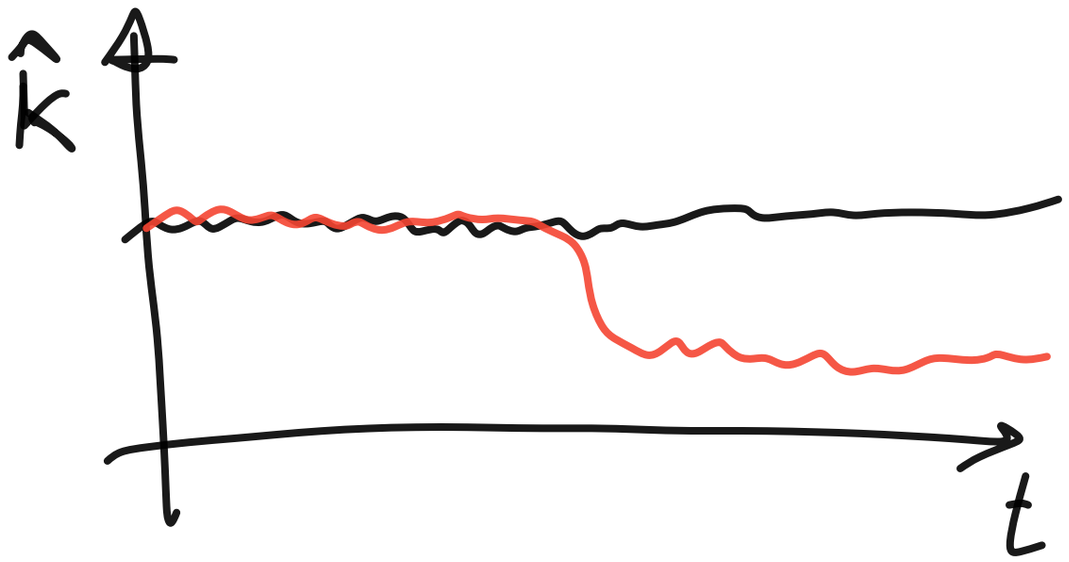
Signal based



Model based



FAULT DIAGNOSIS

Symptoms evaluation

> **Physiological** changes shall be **ignored**, but **pathological** changes are **evaluated** in the next step

> A **measure** of a **symptom** is so **compared** against a known **pathological threshold**

> In general, this is a **change detection problem** (more in upcoming lectures)

FAULT DIAGNOSIS

Once symptoms evaluation is done, diagnosis entails:

- STEP 1: **DETECTION**
  - Testing the **null hypothesis**:

$\mathcal{H}_0$: "*Is the system behaving in a **nominal** way?*"

- STEP 2: **ISOLATION**
  - Testing N **faulty hypotheses**:

$\mathcal{H}_i$: "*Is the system behaving as if the **i-th fault** is present?*"

- STEP 3: **IDENTIFICATION/ESTIMATION**
  - If $\mathcal{H}_0$ and every but one $\mathcal{H}_i$ are falsified ⇒ **estimate** parameters of i-th fault
  - If $\mathcal{H}_0$ and every $\mathcal{H}_i$ are falsified ⇒ **identify** model of a new fault

FAULT TOLERANCE

FAULT TOLERANCE

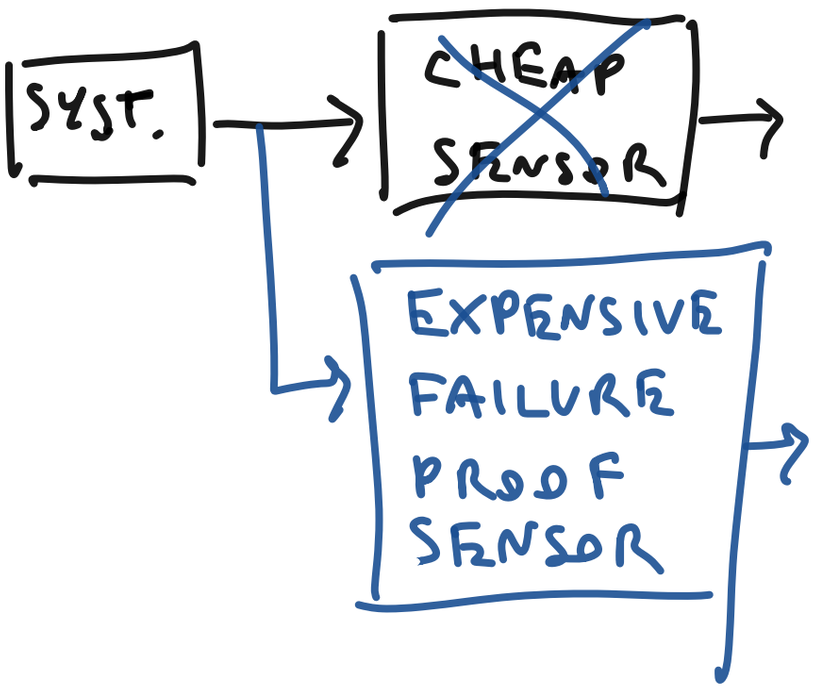
Different approaches to fault tolerance

By design	Switching	Adaptive

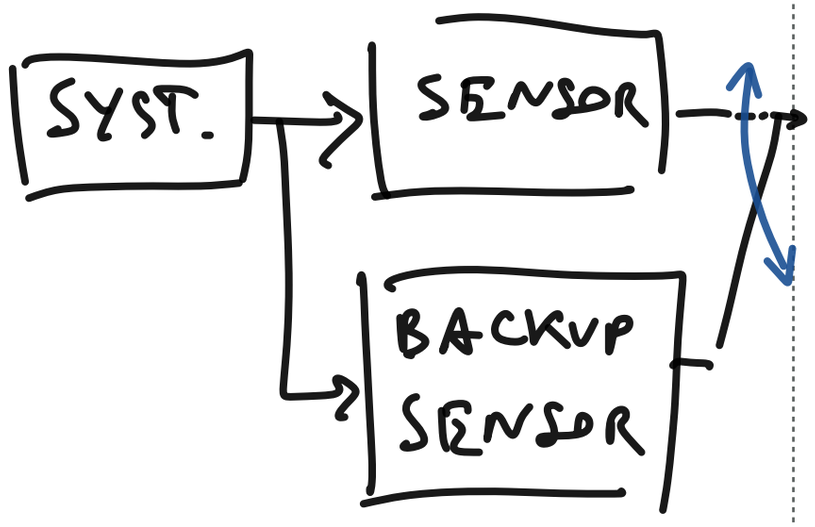
FAULT TOLERANCE

Different approaches to fault tolerance

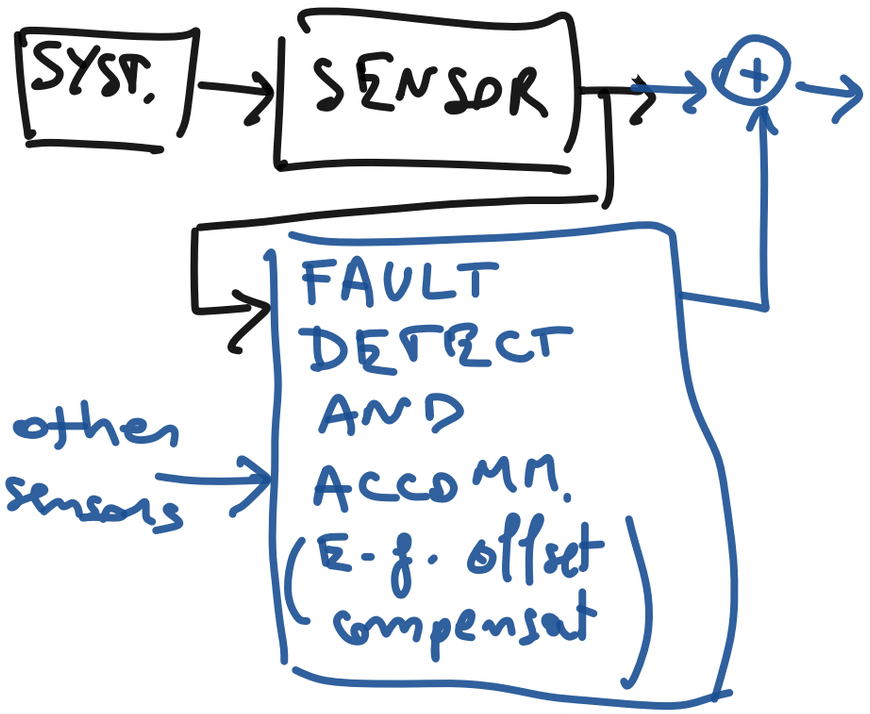
By design



Switching



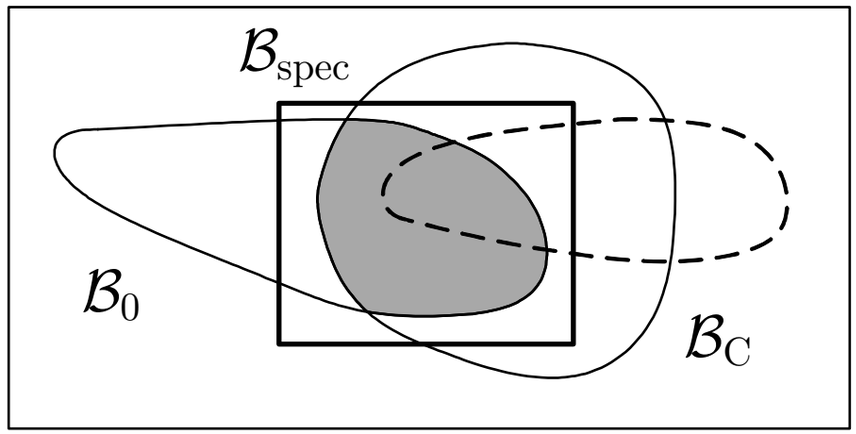
Adaptive



FAULT TOLERANCE

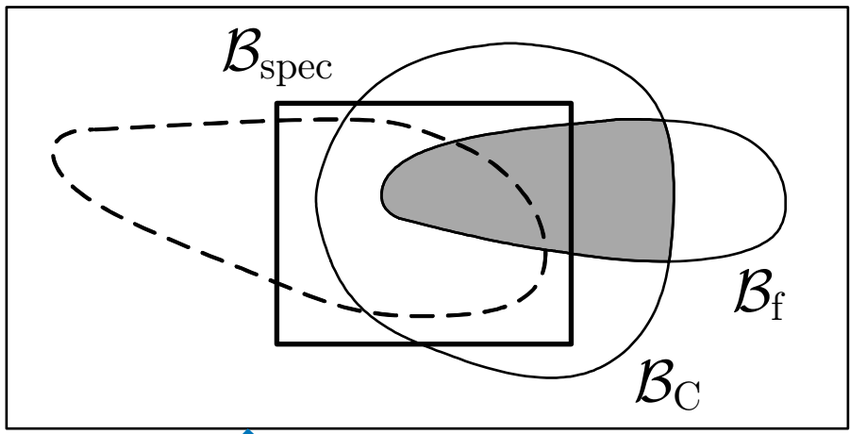
Fault accommodation: remember the behaviour diagram?

Control of the faultless system

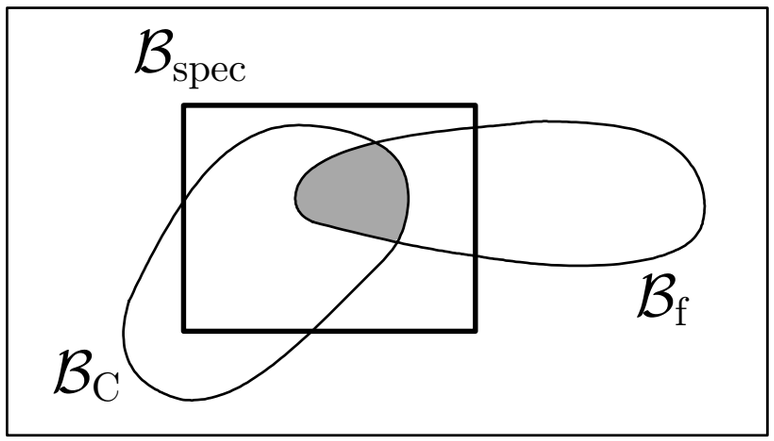


FAULT

Control of the faulty system



ACCOMMODATION



CONCLUSION

Recap of this lecture and plan for next

> **TODAY**

> We introduced an **overview** of FD and FT

> We introduced **definitions**

> We provided some **taxonomy** of existing approaches

> **TOMORROW**

> **System structural analysis and components and services model**

CONCLUSION

Thank you for your attention !

For further information:

Course page on Brightspace

or

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