

Health monitoring by statistical learning and physical modelling

15 October 2019

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Overview

Leverage artificial intelligence and digital twins to

- 1. uncover the intricate structures of data sets,
- 2. produce meaningful maps,
- 3. design monitoring and prognosis devices.

Two case studies

- Nuclear safety: diagnose steam generator clogging
- Offshore facilities: monitor fatigue of risers and mooring

1. Steam generator clogging



Clogging phenomenon



Effect of clogging



: Evolution before chemical cleaning

Effect of clogging



- ↗ : chemical cleaning

Digital twin (Modelica)



Predicting clogging from pressure signals is an ill posed inverse problem.

Unsupervised dimension reduction

- Deviation from average behaviour of pressure signal can be approximated by the sum of
 - ▶ a "slope" component (95.5% information)
 - and a "curvature" component (4.4 % information)



Supervised dimension reduction

- ► The slope component can predict a single global clogging index.
 - Inversion (slope \rightarrow clogging index) is now straightforward
- The curvature component does not improve the diagnosis
- Empirical severity scale:



Diagnoses examples 1/2



Healthy steam generator.

Diagnoses examples 2/2



Plant shutdown induced by tube crack.

2. Offshore fatigue

Offshore facilities sustain continuous swell induced motion.



Target: predict component lifespan for extending operating period

Note: a lot of the following results from collaboration with (Jean-Philippe Roques).

Example of application:

mooring line fatigue



Classical prognosis method



Innovation: use in situ measurements



We are interested into the boat, not waves!

Innovation: use in situ measurements



• Example of 3 hour motion episode.

From complex signals to goal oriented map



Dimension reduction is adapted to prognosis.

Probability-damage map



Continuous processing of motion and update of lifespan prognosis

Take home message

► Low dimensional structures of complex data can be mapped.

Our stance to artificial intelligence aims at

- reliable generalisation,
- high interpretability,
- compatibility with small samples.

 The output a 10+ years of R&D is now available to your industry.

Thanks for your attention.

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