

A NEW METHODOLOGY FOR FAST LIFESPAN PREDICTION OF OFFSHORE STRUCTURES.

September 2021, 20th

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Partnership





Principia, expert in offshore structures, digital twin development and tools integration.

Phimeca, expert in reliability, data science, dimension reduction and emulation.

Predictive maintenance of offshore structures



- to predict potential failures and take preventive actions.
- ▶ to protect environment from consequences of a failure.
- to reduce maintenance cost.

Predict lifespan : classical method



Issue 1: We are not interested in waves, but in structure's motion.

Innovation 1: in situ measurements



Issue 2: Damage model (digital twin) is accurate but expensive and time-consuming.

Innovation 2: dimension reduction and emulator

Goal: find a new model of D'(motion), to emulate the digital twin.

Problem: a set of episods contains thousands variables.



D' can be estimated by regression methods based on the low-dimension map.

Summary

- **1.** Digital twin : an accurate model is based on site data to predict specific outputs (e.g. damage).
- **2.** Emulator : a meta-model is trained on a concise representation of motion-damage relationship.
- **3.** Prognosis : new motions from sensors are processed to update the lifespan.

Use case : Oil & Gas Industry

Fatigue life of steel catenary risers.



Figure 1: Floating Production, Storage and Offloadling (FPSO) unit on AKPO field (Nigeria).

Motions and damages

- almost 25000 20-min-episodes, during years 2009 and 2010.
- damages computed with a digital twin for a specific riser.
- training on 2009 data, to predict 2010 damages.



Figure 2: Damage evolution during 2009 and 2010

Dimension reduction

Only 2 dimensions are sufficient to represent the motion-damage behavior !



Figure 3: Concise representation of maximal damages in 2009 along the riser

Emulation

- Emulator trained on the concise representation on data of 2009.
- ▶ Maximal error on lifespan prediction on 2010 data: 5%.
- Uncertainty quantification: predictions can be rejected if too uncertain.
- ▶ Predictions performed faster (~1s) than the digital twin (~1h).

Emulation

This emulator produces a slightly conservative prediction of cumulative damage compared to measurements.



Integration

- emulator and engine integrated into a monitoring tool.
- installed directly into the FPSO.
- ► fast lifespan prediction.
- updatable with new episods of motion.

Ongoing research: floating wind-turbines





Figure 4: FEDER project AFFIDA

Conclusion

- Innovative method combining digital twin and advanced machine learning methods;
- Complex data reduced and summarized by 2 or 3 variables;
- Fast emulator for offshore structure lifespan monitoring;
- Embedded into the structure itself and updatable.

Thanks for your attention.

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