Robust Identification of Modal Parameters of Nonlinear and Time Variant Systems

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BACKGROUND

The identification of modal parameters of systems under ambient or operational vibrations is termed Operational Modal Analysis (OMA). One of the basic assumptions in OMA is that the system being analysed is linear, and time invariant. This limits the applicability of OMA.

The Centre for Oil and Gas – DTU is working on extending the life time of the off-shore oil and gas platforms in the North Sea, through structural health monitoring. This is done by monitoring the vibrations of the structures, which is relevant for fatigue, wear, and possibly damage detection. One of the analysis steps in structural health monitoring is OMA. The off-shore platforms are generally considered nonlinear systems. The main concern is the nonlinearity that come from the friction in the sliding bridge bearings on the bridges connecting the platforms, see figure 1. The topside weight of the platforms is constantly varying due to emptying and filling of storage tanks. This means the platforms cannot be considered time invariant, which is another limitation regarding the application of OMA. These challenges in applying OMA on these structures gives reason to improving the existing OMA tools, that allow a robust identification of modal parameters, when the system includes nonlinearities and is not considered time invariant.

Figure 1: Platforms in the North Sea, located in the Danish oil field called Gorm.

OBJECTIVES

The overall objective of the project is to improve existing OMA techniques such that the modal parameters of the platforms can be identified under the above-mentioned conditions. The work will include fully controlled numerical examples (simulations) and small-scale tests, and, if possible, tests in larger scale, at a near shore test centre. The project will focus on system identification for systems that are nonlinear and time variant.

The analysis technique, Random Decrement (RD), can be applied to specific amplitudes, and produce RD signatures that represents the dynamic properties of the mechanical system vibrating with the amplitude that is being investigated. An example is given in Figure 2.

The primary goals of the PhD project:

- To investigate how Random Decrement signatures can be used for investigating nonlinear and time varying systems.
- Developing methods for identifying the type of nonlinearity and its location.
- A state-of-the-art wavelet-based parameter estimation algorithm will be developed and compared to other methods.

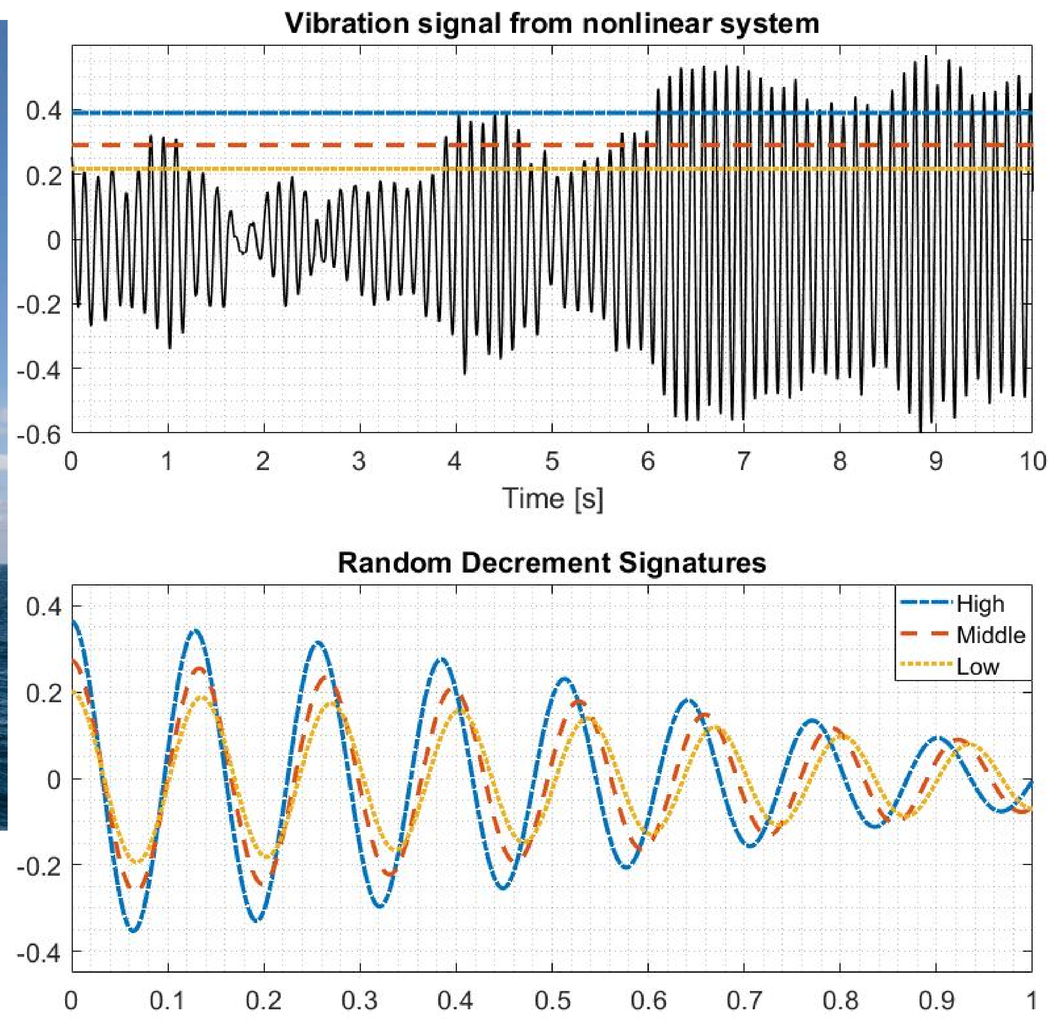

Figure 2: Top: Vibration signal analysed at 3 different amplitudes. Bottom: Random Decrement signatures from corresponding amplitudes.

COLLABORATION

This PhD project is part of a larger project, consisting of two PhD projects, where the second PhD student is Tobias Friis, located at The Technical University of Denmark (DTU) in Lyngby. Rune Brincker, which is co-supervising this PhD project, is the main supervisor of Tobias Friis. A close collaboration with Tobias will be carried out through the entire project.

Center for Olie og Gas - DTU
The Danish Hydrocarbon Research and Technology Centre