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Multiscale uncertainty quantification in friction interfaces for structural nonlinear dynamics

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Abstract.

Many nonlinearities and uncertainties emerge from friction interfaces present in large structural assemblies. They impact significantly the dynamic response and require specific attention. Usually, a macroscopic modelling of the contact surface is employed, coupled with a contact friction law. The latter depends only on a few parameters experiencing large variability leading to uncertain predictions of the dynamic response. Many works have been dedicated to the uncertainty propagation and quantification in friction interfaces using macro-scale modelling. But, it appeared from recent works that the macroscale modelling is not able to capture the physics taking place at the friction interface and that the micro-scale contact model must be considered. Therefore, it is required to develop an efficient multi-scale modelling approach to propagate friction contact uncertainties from the mesoscale to the macro-scale to improve the prediction of the full nonlinear dynamic response. In this context, this work aims to investigate the interest in multi-scale uncertainty quantification for nonlinear dynamic systems with friction interfaces. The focus of this work is to quantify and link the uncertainties from friction interfaces at different scales to the nonlinear dynamic response of the structure.

The test case is based on a fan blade root test rig setup, illustrated in Fig. 1(a). The friction interfaces are at the function between the blades and the discs. The nonlinear dynamic response is characterised by the computation of the nonlinear normal modes (NNM) of the mechanical structure. First, the pressure and gap distributions at the contact interfaces are obtained accurately introducing mesoscale considerations. Then, using these real pressure and gap distributions, the NNMs are computed. Uncertainties on mesoscale parameters controlling the surface shape are considered. This uncertainty is propagated through the different scales to obtain the random contact gap and pressure distribution as well as NNMs. Multiscale PCE is exploited in this work for this propagation and is compared to kriging. Results show that such an approach allows getting deep insights into the system understanding for a reduced numerical cost compared to Monte Carlo simulations.

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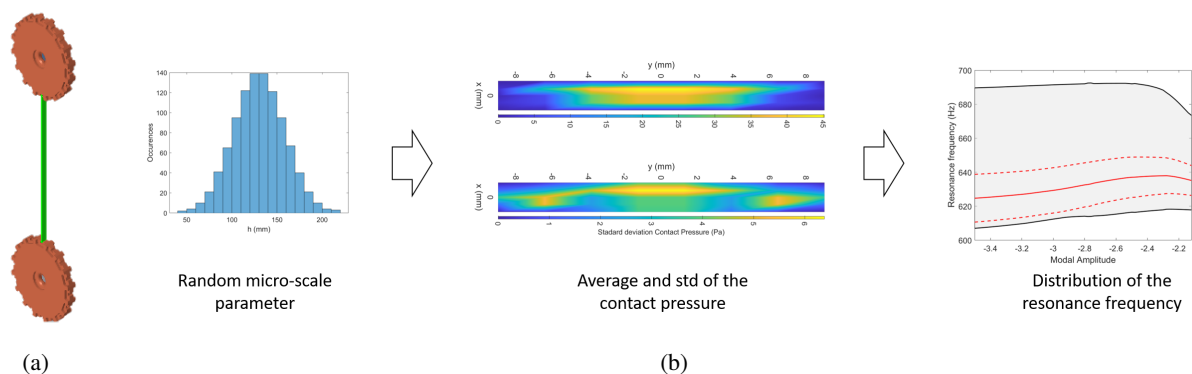


Figure 1: (a) FE model of the Dogbone rig (b) Multi-scale UQ process illustration