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Estimation de la probabilité de défaillance d'une turbine d'éolienne

Contexte du projet

Offshore wind farms are gaining considerable interest because the generally superior wind speed makes them more efficient than their onshore equivalents. For water depths greater than 50 m, floating foundations are considered. These floating supports are submitted to wave and wind loads resulting in extreme mechanical responses that can lead to structural failure. Assessment of the failure probability is then necessary to evaluate the robustness for a given life cycle.

The non-linear and time dependant response of the wind turbine is usually derived from a finite element computer code that takes as inputs the wind and wave loads which are usually modelled as Gaussian processes. A discrete representation of the two stochastic inputs is traditionally obtained through a spectral model. An outcrossing rate analysis based on the FORM algorithm can then be performed as in [Jensen, 2009], [Perdrizet and Averbuch, 2011], yielding the failure probability. However, the computational complexity of the FORM procedure is closely related to the number of harmonics in the spectral model which can be quite high. It is therefore desirable to use a random process discretization with the lowest possible dimension.

In this talk, the Karhunen-Loève (KL) expansion method is compared with the spectral model via the evaluation of the outcrossing rate in stationary conditions. For the spectral model, an approximation using only one design point computation is available [Koo et al., 2005]. For the KL expansion however, it is necessary to use either a functional formulation of Phi-2 method which implies two design point computations. In the case of KL expansion, we give an outcrossing rate estimator similar to Koo's formula by deriving a first order approximation of the design point at time t + □t given the a design point at time t. We then discuss and examine the return periods using both stochastic expansions.

We also investigate the efficient implementation of an importance sampler since approximations solely based on design points computations do not come with confidence intervals. The idea is to find a subspace of lower dimension such that the response dependence on the inputs can be accurately described by the projection of the inputs on this subspace. The motivation is the ability to design a surrogate model for the mechanical simulator based on significantly fewer random inputs. Once this metamodel is obtained, it is used to build an proposal distribution close to the optimal importance distribution as in [Dubourg and Sudret, 2011]. A discussion on how to infer a basis of the dimension reduction subspace is obtained through different methods such as sliced inverse regression [Li, 1991], mean average variance estimation [Xia et al., 2002] and Kernel Dimension Reduction [Fukumizu et al., 2009].

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