PhD position at IFP Energies nouvelles (IFPEN)
Mathematics

Chance constraint optimization of a complex system Application to the design of a floating offshore wind turbine

Among the new marine sources of energy under development, the floating offshore wind turbine (FOWT) solution offers a panel of advantages : a stronger and sustained wind, less usage conflicts than onshore or fixed offshore wind turbine. Nonetheless its feasibility demonstration is complex and the reliability of the FOWT must be guaranteed with respect to the whole set of environmental loads likely to occur in a ten-year period. The reliability of the structure is in particular insured by the anchoring system of the floating support which restrict the wind turbine motion. The design of the anchoring must avoid the ruin caused by a failure of the anchoring lines under extreme stress, or as a consequence of accumulated damage during the lifespan of the structure. These constraints inherit the random characteristics of the FOWT behavior when submitted to the random marine environment. The lack of consideration of this uncertain aspect can lead to unexpected ruin caused by a non-robust optimal design. . Moreover the determination of an optimal design will be decisive for the economic feasibility of the studied FOWT technology.
This problem can be mathematically stated as the search for an optimal configuration minimizing the manufacture, maintenance and installation costs while satisfying probabilistic constraints of threshold exceedance type. Solving this type of problem is a mathematical challenge combining reliability (statistic/probability) and constrained optimization. Mathematically we seek for the solution of the problem :

$$(P) \quad \begin{cases} \min_d c(\boldsymbol{d}) \\ g(\boldsymbol{d}) < 0 \\ Prob(\ G(\boldsymbol{d}, \boldsymbol{U}) < 0\ ) \geq\ p \end{cases}$$

with $\boldsymbol{d}$ the vector of design parameters, c the cost function, g and G the functions defining the constraints, $\boldsymbol{U}$ the vector of stochastic parameters and p the level of acceptance probability required.

Apart from the important and judicious choice of the optimization method for the acquisition of a feasible solution, the difficulty lies as well in the need to estimate a probability at each step of the optimization loop. This estimation is all the more costly that

$$(H) \quad \begin{cases} \text{the constraint function } G \text{ is nonlinear and expensive to evaluate,} \\ \text{the dimension of the uncertain parameters } \boldsymbol{U} \text{ is large,} \\ \text{the level of acceptation of the probabilistic constraint } p \text{ is high.} \end{cases}$$

The objective of the thesis is therefore the development of an adequate methodology enabling the resolution of the probabilistically constrained optimization problem (P) under hypothesis (H). Indeed the literature has so far came with practical solution for simplified versions of (H) such that linear/differentiable/convex constraint functions, small dimension of the uncertain parameters and/or a not to high level of acceptation.

Keywords: Optimization, Probability, Statistics, Reliability,

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Duration and start date	3 years, starting preferably on 1st september/october 2018
Employer	IFP Energies Nouvelles, Rueil-Malmaison, France
Academic requirements	Master degree in Probability/statistic or/and Optimization
Language requirements	Fluency in French or English, willingness to learn French
Other requirements	Programming skills in R, Python, Matlab, Scilab, C prefered

For more information or to submit an application, see theses.ifpen.fr or contact the IFPEN supervisor.

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