Kernel-based quadrature applied to offshore wind turbine damage estimation
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Kernel-based probabilistic integration

Industrial context & Problem statement

- EDF Renewables operates ~10 000 MW of wind turbine (WT) worldwide
- New technologies (e.g., offshore floating WT), wind farms reaching end-of-life
  ➔ Need probabilistic tools to optimize safety margins and asset management

1. Select integration nodes ➔ \( E[g(X)] \approx \frac{1}{N} \sum_{i=1}^{N} g(x^{(i)}) \)

Candidate set: \( \mathcal{S} \) is a fairly dense finite subset of \( \mathbb{R}^n \) with size \( N \gg n \) that emulates the target distribution (e.g., a large Sobol’ sequence, available data as in Fig.4).

2. Compute optimal weights for integration ➔ \( E[g(X)] \approx \sum_{i=1}^{N} w_i g(x^{(i)}) \)

Optimal weights for quadrature ➔ for a given DoE \( X_n \) and a given kernel \( k \)

\[
 w_i = P(X_i | K_n) \]

with potentials \( P(X_n) = \left\{ \int k(x, x^{(i)}) f(x) dx \right\} f(x) dx \)
and variance-covariance matrix \( \left[ K_n \right]_{ij} = k(x^{(i)}, x^{(j)}) \)

Conclusions & Perspectives

- Combining kernel herding with optimal weights is an efficient integration method
- This method is sensitive to the chosen kernel and its hyper-parameters

Environmental measured data

SCADA data collected over a period of four years at the Teesside (UK) offshore wind farm

Numerical results: DEL estimation by kernel herding

References


