Distribution-free P-box processes: definition and simulation

M. G. R. Faes [1,2], M. Broggi[2], K.-K. Phoon[3], M. Beer[2]

[1)]KU Leuven, LMSD division, B-2860 St.-Katelijne-Waver, Belgium
[2)]Institute for Risk and Reliability, Leibniz Universität Hannover
[3)]National University of Singapore, Department of Civil & Environmental Engineering

Keywords: Non-Gaussian random field; distribution-free p-box; imprecise probability.

Abstract

Typically, non-deterministic models of spatial or time dependent uncertainty are modelled using the well-established random field framework. However, while tailored for exactly these types of time and spatial variations, stochastic processes and random fields currently have only limited success in industrial engineering practice. This is mainly caused by its computational burden, which renders the analysis of industrially sized problems very challenging, even when resorting to highly efficient random field analysis methods such as EOLE. Apart from that, also the methodological complexity, high information demand and rather indirect control of the spatial (or time) variation has limited its cost-benefit potential for potential end-users. This data requirement was recently relaxed by the author with the introduction of imprecise random fields, but so far the method is only applicable to parametric p-box valued stochastic processes and random fields. This paper extends these concepts by expanding the framework towards distribution-free p-boxes. The main challenges addressed in this contribution are related to both the non-Gaussianity of realisations of the imprecise random field in between the p-box bounds, as well as maintaining the imposed auto-correlation structure while sampling from the p-box. A case study involving a dynamical model of a car suspension is included to illustrate the presented concepts.

References

Faes, M. and D. Moens. Imprecise random field analysis with parametrized kernel functions. Mechanical Systems and Signal Processing, 134:106334, 2019.