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Time-Variant Reliability Analysis Via A Single-Loop Gpr-Based Active Learning Method

Chao Dang[1], **Marcos A. Valdebenito**[1], **and Matthias G.R. Faes**[1]

[1] Chair for Reliability Engineering, TU Dortmund University,
Leonhard-Euler-Straße 5, 44227 Dortmund, Germany
{chao.dang, marcos.valdebenito, matthias.faes}@tu-dortmund.de

Abstract

Time-variant reliability analysis is critical for evaluating the safety degree of engineering structures subjected to both randomness and time-varying factors. Despite its significance, conventional methods often struggle with computational inefficiency, limited accuracy, and practical applicability in real-world scenarios. This presentation will introduce a novel single-loop Gaussian process regression-based active learning (SL-GPR-AL) approach to address these challenges. The method constructs a global Gaussian process regression (GPR) surrogate model for the time-dependent performance function through an iterative active learning process. Key innovations include a tailored stopping criterion to determine when to halt the learning process and two learning functions to strategically select training points for refining the surrogate model. Once trained, the GPR surrogate enables efficient computation of the time-dependent failure probability over a reference time interval via Monte Carlo simulation, while also yielding the evolution of the failure probability over time as an additional outcome. A numerical example will be presented to demonstrate the superior computational efficiency and accuracy of the proposed method compared to several existing approaches.

Keywords: Time-dependent reliability analysis, Active learning, Gaussian process regression, Stopping criterion, Learning function