Archives of Computational Methods in Engineering
2020

Stochastic Oblique Impact on Composite Laminates: A Concise Review and Characterization of the Essence of Hybrid Machine Learning Algorithms

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Abstract: Due to the absence of adequate control at different stages of complex manufacturing process, material and geometric properties of composite structures are often uncertain. For a secure and safe design, tracking the impact of these uncertainties on the structural responses is of utmost significance. Composite materials, commonly adopted in various modern aerospace, marine, automobile and civil structures, are often susceptible to low-velocity impact caused by various external agents. Here, along with a critical review, we present machine learning based probabilistic and non-probabilistic (fuzzy) low–velocity impact analyses of composite laminates including a detailed deterministic characterization to systematically investigate the consequences of source- uncertainty. While probabilistic analysis can be performed only when complete statistical description about the input variables are available, the non-probabilistic analysis can be executed even in the presence of incomplete statistical input descriptions with sparse data. In this study, the stochastic effects of stacking sequence, twist angle, oblique impact, plate thickness, velocity of impactor and density of impactor are investigated on the crucial impact response parameters such as contact force, plate displacement, and impactor displacement. For efficient and accurate computation, a hybrid polynomial chaos based Kriging (PC-Kriging) approach is coupled with in-house finite element codes for uncertainty propagation in both the probabilistic and non- probabilistic analyses. The essence of this paper is a critical review on the hybrid machine learning algorithms followed by detailed numerical investigation in the probabilistic and non-probabilistic regimes to access the performance of such hybrid algorithms in comparison to individual algorithms from the viewpoint of accuracy and computational efficiency.

Link: https://link.springer.com/article/10.1007/s11831-020-09438-w