"Generation of Statistical Design Allowables of Composite Laminates using Theory-Guided Machine Learning"

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This work represents the first study towards the application of machine learning techniques in the prediction of statistical design allowables of polymer composite laminates used in aircraft structures. Building on data generated analytically using Finite Fracture Mechanics based models developed at the length scale of the laminate, four machine learning algorithms are used to predict the notched strength of composite laminates and their statistical distribution, associated to material and geometrical variability.

Excellent representations of the design space (relative errors of around ±10%) and very accurate representations of the distributions of notched-hole strengths and corresponding B-basis allowables are obtained. The Gaussian Processes models proved to be the most reliable, considering their continuous nature and fast training process. This work serves as basis for the prediction of first-ply failure, ultimate strength and failure mode of composite specimens based on non-linear finite element simulations, providing further reduction of the time required to virtually certify the next generation of composite aerostructures.