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A Model-based, Bayesian Solution for Characterization of Complex Damage Scenarios in Aerospace Composite Structures

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Ultrasonic damage detection and characterization is commonly used in nondestructive evaluation (NDE) of aerospace composite components. In real materials and structures, the dispersive waves result in complicated behavior in the presence of complex damage scenarios. Model-based characterization methods utilize accurate three dimensional finite element models (FEMs), using PZFlex, of guided wave interaction with realistic damage scenarios to aid in defect identification & classification. This work builds on the results and methods in [1] and describes an inverse solution for realistic composite damage characterization by comparing the wavenumber- frequency spectra of experimental and simulated UT inspections. The FEM is parameterized with the damage model described in a companion presentation [2], capable of describing the complex damage typical of low impact strikes in composites (Figure 1). The damage is characterized through a stochastic solution, enabling uncertainty quantification surrounding the characterization. Typical Bayesian methods, such as Markov chain Monte Carlo (MCMC), are computationally costly and cannot be easily parallelized. In this work, we present a Sequential Monte Carlo (SMC) scheme in which the complex damage parameterization is formulated as a set of random variables, propagated using importance sampling and MCMC-based rejuvenation mechanisms to characterize the composite damage and quantify the uncertainty surrounding those estimates. SMC enables increasing FEM fidelity during the solution, allowing for fast optimal global localization and subsequent damage characterization refinement.

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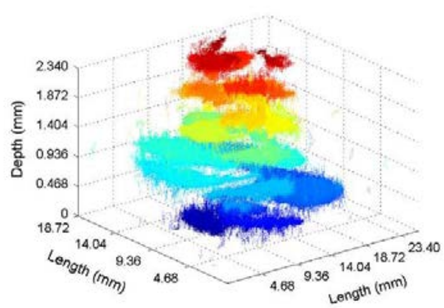

Figure 1. 3D delamination data map created from microCT image data [1]

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