A Model-Based Damage Identification using Guided Ultrasonic Wave Propagation in Fiber Metal Laminates

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ABSTRACT

Fiber metal laminates (FML) are lightweight hybrid structural materials that combine the ductile properties of metal with high specific stiffness of fiber reinforced plastics. These advantages led to a dramatic increase in such materials for aeronautical structures over the last few years. One of the most common and vulnerable defects in FML is impact-related delamination, often invisible to the human eye. Guided ultrasonic waves (GUW) show high potential for monitoring structural integrity and damage detection in thin-walled structures by using the physical phenomena of wave propagation interacting with the defects [1].

The focus of this research project is on describing an inverse solution for the detection and characterization of defect in FML. Model-based damage analysis utilizes an accurate finite element model (FEM) of GUW interaction with the damage. The FEM is developed by project partners from mechanics at Helmut-Schmidt-University in Hamburg, Germany, and will be treated as a black-box for further analysis. A Bayesian approach (Markov chain Monte Carlo) is employed to characterize the damage and quantify its uncertainties. This inference problem in a stochastic framework requires a very large number of forward solves. Therefore, a profound investigation is carried out on different reduced-order modeling (ROM) methods in order to apply a suitable technique that significantly improves the computational efficiency.

The proposed method is well illustrated on a simpler case study for the damage detection, localization and characterization using 2D elastic wave equation. The damage in this case is modeled as a reduction in the wave propagation velocity. The inference problem utilizes a parameterized projection-based ROM coupled with a surrogate model [2] instead of the underlying high-dimensional model. This research is funded by the Deutsche Forschungsgemeinschaft Research Unit 3022 under grant LO1436/12-1.

REFERENCES
