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INTELLIGENT DETECTION AND PREDICTION OF INTERNAL DAMAGE IN COMPOSITE STRUCTURES USING ARTIFICIAL INTELLIGENCE

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ABSTRACT

Composite materials are increasingly employed in mechanical engineering and aerospace applications due to their high strength-to-weight ratio and excellent specific mechanical properties. However, composite structures are susceptible to internal damage mechanisms, including matrix cracking, delamination, and porosity, particularly under low-velocity impact loading. Such damage can significantly reduce structural integrity and mechanical performance while remaining difficult to detect through conventional visual inspection.

Non-Destructive Testing (NDT) techniques, such as ultrasonic inspection and infrared thermography, are widely used to detect and characterize internal damage without compromising the integrity of composite structures. Nevertheless, the analysis and interpretation of the large and complex datasets generated by these techniques remain challenging and often require substantial expert intervention. To address these limitations, this work investigates the integration of Artificial Intelligence (AI) with experimental mechanical testing and NDT data for the automated detection, characterization, and prediction of internal damage in composite structures.

The proposed methodology combines low-velocity impact testing, non-destructive inspection, image-based damage characterization, and AI-based predictive modeling to establish relationships between measurable damage features and the resulting degradation of mechanical properties. The developed approach aims to improve the accuracy and efficiency of internal damage assessment while reducing reliance on manual interpretation. The results highlight the potential of AI-based methods for intelligent damage detection and prediction, with promising applications in structural health monitoring and predictive maintenance of composite structures.

Keywords: Composite materials; Low-velocity impact; Internal damage; Non-Destructive Testing; Artificial Intelligence; Damage prediction; Structural health monitoring.