

Abstract

The methods of non-destructive testing (NDT) and structural health monitoring (SHM) play a pivotal role in predicting the remaining functional life of structures through precise diagnostic and prognostic techniques. Their primary objective is to identify and characterize potential defects that could jeopardize the structural integrity and performance. However, it is noteworthy that advancements in SHM and NDT, particularly those reliant on guided wave-based methodologies, have experienced a slowdown in recent years. This deceleration can be attributed to the limitations associated with traditional signal processing techniques when applied to intricate and the formidable challenge of extracting damage-related features from propagating wave signals.

Conversely, there has been a remarkable acceleration in the domain of artificial intelligence (AI) methods, particularly in deep learning and computer vision, in recent times. This progress has unveiled new avenues for problem-solving and presents opportunities for seamless integration with NDT and, subsequently, SHM methodologies.

The primary aim of this dissertation is to create an innovative AI-driven diagnostic system tailored for the identification of delamination in composite laminates, specifically for carbon fiber-reinforced polymers (CFRP). This endeavor involves exploring the potential of leveraging artificial neural networks (ANNs)-based methods to enhance damage identification through the analysis of Lamb wave propagation. The ANNs-based systems developed in this context employ an end-to-end approach, enabling the direct transformation of propagating Lamb wave animations into comprehensive damage maps.

Moreover, the dissertation addresses the challenge of slow data acquisition inherent in high-resolution full wavefield imaging techniques. To surmount this hurdle, I introduced a deep learning solution designed to reconstruct high-resolution frames depicting Lamb wave propagation, as well as their interactions with delaminations and structural boundaries from low-resolution measurements. This innovative approach promises to expedite the data acquisition process significantly.

Furthermore, another approach of deep learning-based surrogate modeling for solving the inverse problems of delamination identification is also proposed in this study. This surrogate model is able to predict the full wavefield of Lamb waves interacting with delamination in much shorter time than by using traditional finite element method.