Digital Quality Assessment of Composite Structures Using 3D Surface Scanning

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Abstract

Composite structures are increasingly used in lightweight engineering applications where reliable inspection methods are required to ensure structural integrity during manufacturing and testing. Due to their complex geometries and heterogeneous material architectures, composite components require advanced approaches capable of capturing spatial information about surface condition and deformation. Conventional inspection methods often rely on localized measurements or require dedicated laboratory equipment, making the rapid evaluation of complex composite components challenging and more expensive than necessary.
A digital inspection workflow based on 3D surface scanning was developed to enable non-contact evaluation of composite structures. The approach combines 3D surface acquisition with quantitative analysis of the acquired data, allowing the measurement of geometric deviations, surface changes, and deformation patterns following mechanical testing. The generated digital surface models provide a basis for objective evaluation of structural changes and support data-driven quality assessment.
The workflow was experimentally validated on composite structures with different levels of complexity, including textile-reinforced composite specimens, impact-tested samples, and composite overwrapped pressure vessels (COPVs). The measurements enabled the quantification of geometry changes, deformation patterns, and impact-induced damage features, demonstrating the potential of 3D surface scanning for digital quality assessment of composite structures.
The results demonstrated that the proposed workflow enables quantitative assessment of geometric changes, deformation patterns, and impact-related surface damage in composite structures. The generated surface models provide full-field information about deformation and damage evolution, allowing a more comprehensive evaluation compared to localized measurement approaches. This highlights the capability of 3D surface scanning to support digital inspection and quality assessment of composite components.
The proposed approach demonstrates the potential of 3D surface scanning as a flexible tool for digital quality assessment of composite components. By providing objective three-dimensional surface data without contact, the workflow supports future data-driven inspection strategies for composite manufacturing and quality assurance applications.

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