PhD Dissertation Defense Announcement
Mechanical and Aerospace Engineering Department
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DEEP LEARNING-ENHANCED X-RAY COMPUTED TOMOGRAPHY FOR DEFECT DETECTION IN COMPOSITE STRUCTURES

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Abstract

Structural health monitoring plays a pivotal role in the maintenance of aerospace structures. A crucial component of structural health monitoring is nondestructive inspection (NDI). Among various NDI techniques, X-ray Computed Tomography (CT) is distinguished by its unparalleled fidelity, leading to extensive applications. Although X-ray CT provides high-fidelity defect detection, its application to large aerospace components is restricted by the size limitations of test specimens. Inclined CT (ICT) mitigates these constraints by positioning the X-ray source and detector on opposite sides of a stationary test specimen. This system geometry, however, results in limited angular data for 3D reconstructions, leading to significant artifacts that may inaccurately represent defects. This study illustrates that deep learning (DL) techniques, specifically the fine-tuned Segment Anything Model (SAM), can enhance defect recognition from ICT data. The methodology involves fine-tuning SAM with various sizes of datasets. Validation of the fine-tuned model on an as-built aluminum test specimen serves as a proof-of-concept, achieving over 70% accuracy for defect detection and 98% accuracy for overall shape detection. Further validation on carbon fiber reinforced polymer specimens with Teflon inserts provided improved results compared to ICT reconstruction methods, indicating promising practical applicability. The findings suggest that DL-enhanced ICT can attain detection capabilities comparable to full CT while maintaining ICT's compatibility with large structures, making it a valuable NDI method for aerospace industry applications.