Advancing NDE 4.0: Optimal 6-DOF Robot Arm Scanning for Eddy Current Array Testing

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This study explores the integration of advanced Industry 4.0 technologies, particularly computer vision, within the field of Nondestructive Evaluation 4.0 (NDE 4.0) for optimal robotic NDE data acquisition and digitization. Our research focuses on the implementation of autonomous Eddy Current Array (ECA) scanning for objects characterized by intricate geometries. The presented work demonstrates the effectiveness of a robotic arm system with a surface reconstruction device, enabling visualization of the workspace containing the test specimen. A novel path planning approach using ray-triangle intersection arrays is employed to manipulate the ECA probe along the curved surfaces of the sample. High accuracy reconstruction and robotic manipulation facilitates close and consistent lift-offs without contact between the probe and specimen even on curved surfaces. This paired with array scanning enables strong and expeditious detection of defects, even for shallow defects such as corrosion on steel using high frequency probes. The proposed robotic arm NDE scanning systems would be useful as a "robotic carwash," where a vehicle under inspection enters the scanning zone and is evaluated autonomously, and have significant implications in the NDE 4.0 realization. This work may also be extended to mobile systems where manipulation of the probe is dependent on the dynamic location of the NDE scanning platform