# Development of 3D Scan-based Robot Arm Control Approach for Pulse-Echo Laser Ultrasonic Testing

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Pulse-echo (PE) laser ultrasonic testing (LUT) is a non-destructive inspection technique used to assess subsurface damages in various structures. A Q-switched laser generates the excitation laser, while a laser Doppler vibrometer (LDV) serves as the sensing laser. The internal conditions across the specimen wall thickness can be evaluated based on the propagation of the direct wave and back-wall echo signals. Constant stand-off distance and perpendicular incident angle between the sensing laser and the specimen surface are essential for achieving good signal-to-noise ratio (SNR) in the inspection results. The distance and angle requirements can be maintained by a 6 degree-of-freedom robot arm when provided with the position and rotation required between sensing laser and specimen. This paper proposes an approach to control the movement of the robot arm along a raster scan path for PE LUT using the geometries from 3D scans. First, a handheld 3D scanner is used to capture the inspection surface and produce a triangular mesh file. The geometry data are extracted from the mesh, and scan grids that facilitate a raster pattern are created accordingly. With the surface normal vectors at the grid points and their distances from the LDV, the movement of robot arm can be determined. As the robot arm operates, laser trigger output signals are generated and hence facilitates the execution of PE LUT. The proposed approach aims to streamline scan grid generation using 3D scans, thereby enhancing the applicability of PE LUT for non-destructive inspection in non-planar composite structures.