4-Dimensional mapping method based on angular pulse-echo ultrasonic propagation imaging system

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Research on the NDE(Non-destructive Evaluation) technique using laser ultrasonic waves is being actively conducted in structural health monitoring as laser ultrasonic testing can inspect from a long distance and does not require a separate contact medium. Among them, ultrasonic wave propagation imaging (UWPI) is a popular technique for visualizing defects by mapping ultrasonic data into the three dimensions of space (height x width) and time to visually show the changes during the propagation of ultrasonic waves. However, the 3D (H x W x T) mapping approach of UWPI has inherent limitations. Firstly, to match the defect location identified on the UWPI with its actual position, there's a necessity to separately store information about the scanned location. Secondly, mapping onto an H x W plane restricts the effective representation of complex shapes. In this study, ultrasonic data acquired using the angular pulse-echo ultrasonic propagation imaging technique are mapped onto a 4-dimensional framework, comprising 3D spatial coordinates (X x Y x Z) and Time (T). A targeting algorithm is developed, utilizing a galvanometric scanner system to steer laser beams based on point cloud coordinates acquired from a LiDAR camera. Through this approach, laser beams for excitation/sensing are steered to each point to collect ultrasonic data. The acquired data are spatially mapped, enabling a 4D visualization of the data changes over the time axis. This method allows for the visualization of ultrasonic data in the actual shapes and provides detailed spatial context for the scanned locations.