Compensation of Spatial Distortion Errors of curved surfaces for LDV based structural wave imaging

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Conventional laser scanning techniques using a scanning laser Doppler vibrometer (LDV) excel in inspecting flat, plate-like structures. On the other hand, they face challenges and encounter errors when examining complex, three-dimensional structures without prior knowledge of the structure's intricate geometry. In this study, we propose a novel approach that integrates LDV with a laser distance meter (LDM) and employs 3D shape estimation and grid compensation techniques to significantly reduce errors caused by spatial distortions. Utilizing LDM and controlled mirrors, this approach facilitates the accurate acquisition of three-dimensional point clouds representing the curved surfaces of structures, thereby outlining their geometry during the 3D shape estimation process. Spatial distortions, which result from difference in curvature and non-uniform point spacings are effectively mitigated. The proposed method not only compensates for these spatial distortions but also establish an optimal, adaptive scan grid tailored for each 3D structure. By ensuring uniform laser scanning point spacing on curved surfaces, this approach reduces potential errors associated with spatial distortions. We anticipate that this innovative technique will prove invaluable in the analysis of various types of structures characterized by a wide range of geometrical differences, ultimately enabling more accurate and efficient structural inspections using scanning LDV-based wave imaging.