Title: Vibration-based Structural Damage Detection

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Abstract:

Recent advances in model- and non-model-based damage detection methods using vibration data such as natural frequencies and mode shapes are presented. Two major challenges associated with model-based methods are addressed: accurate modeling of structures and development of a robust inverse algorithm to detect damage, which are defined as the forward and inverse problems associated with model-based damage detection methods, respectively. To resolve the forward problem, new physics-based finite element modeling techniques for fillets in thin-walled beams and bolted joints are developed, so that complex structures with thin-walled beams and/or bolted joints can be accurately modeled with a reasonable model size. To resolve the inverse problem, a robust iterative algorithm that uses Levenberg-Marquardt method is developed to accurately detect locations and extent of damage using a minimum number of measured natural frequencies.

Non-model-based methods that use vibration shapes measured from scanning laser vibrometry, without use of any a priori information of undamaged structures that is usually not available in practice, are introduced. Curvature vibration shapes are compared with those from polynomial fits with proper orders to yield curvature damage indices to identify damage. A new multi-scale differential geometry scheme is developed to calculate curvature vibration shapes. Spatially detailed vibration shapes can be measured by a continuously scanning laser Doppler vibrometer system developed in-house in a rapid and accurate manner. Application of the methodology to detect delaminations in composite plates are demonstrated. Use of operational modal analysis and digital image correlation to detect damage in membranes is also demonstrated.

Biography:

Weidong Zhu is a Professor in the Department of Mechanical Engineering at the University of Maryland, Baltimore County, and the founder and director of its Dynamic Systems and Vibrations Laboratory and Laser Vibrometry and Optical Measurement Laboratory. He received his double major BS degree in Mechanical Engineering and Computational Science from Shanghai Jiao Tong University in 1986, and his MS and PhD degrees in Mechanical Engineering from Arizona State University and the University of California at Berkeley in 1988 and 1994, respectively. He is a recipient of the 2004 National Science Foundation CAREER Award. He has been an ASME Fellow since 2010, and has served as an Associate Editor of the ASME Journal of Vibration and Acoustics and the ASME Journal of Dynamic Systems, Measurement, and Control, and as a Subject Editor of the Journal of Sound and Vibration and Nonlinear Dynamics. His research spans the fields of dynamics, vibration, control, applied mechanics, metamaterials, structural health monitoring, and wind energy, and involves analytical development, numerical simulation, experimental validation, and industrial application. He has published 277 SCI-indexed journal papers in these areas and holds seven U.S. patents. He is a recipient of the 2020 University System of Maryland Board of Regents Faculty Award for Excellence in Research.

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