Public Abstract
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Graduation Term:FS 2012
Department:Mechanical & Aerospace Engineering
Degree:MS
Title:THEORY AND DEVELOPMENT OF A CAMERA-BASED NONCONTACT VIBRATION MEASUREMENT SYSTEM

Dramatic advancement in technologies for high-speed high-resolution digital cameras in recent years enables the development of camera-based full-field noncontact measurement systems for vibration testing of flexible multibody systems undergoing large rigid-body motion and elastic/plastic deformations. A few of such systems exist in todayâ€™s metrology market, but they are inconvenient for use and prohibitively expensive. Most seriously, they are not really appropriate for structural vibration testing because their measurement accuracy is low due to several technical reasons, including inappropriate setting of cameras and experimental setup because of userâ€™s innocence of video-grammetry, non-precise corner detection and other problems of image processing techniques, and inaccurate modeling and calibration of cameras. This thesis develops and puts together a complete set of necessary techniques for the development of a camera-based noncontact full-field vibration measurement system using inexpensive off-the-shelf digital cameras. An optimal combination of appropriate methods for corner detection, camera calibration, lens distortion modeling, and measurement applications is proposed and numerically and experimentally verified. Moreover, we derive/improve some image processing methods and 3D reconstruction algorithms to improve vibration measurement accuracy.
To examine the proposed methods and their combined effects against high measurement accuracy, two Canon EOS-7D DSLR cameras are used for theoretical studies and experimental verifications. Numerical and experimental results show that the recommended methods together with our improved image processing techniques is feasible for the development of a camera-based noncontact full-field vibration measurement system with high precision and low cost. This camera-based measurement instrument has the potential for developing new structural testing techniques and can open new possibilities for research and development in mechanical and aerospace engineering, computer science, animal science, and many other fields.