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Image Analysis of Full-Field Vibration and Strain Data

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Full-field measurement of vibration and strain data, using techniques such as digital image correlation, automated photoelasticity, electronic speckle pattern interferometry, thermoelastic stress analysis and scanning laser vibrometry are now widely used in university and industrial research laboratories. Subsequent processing of this data for the purposes of determining frequency response functions, finite element model updating, damage detection or the estimation of residual life, requires efficient data storage with noise rejection and minimal loss of information. Techniques from the image processing community, based on moment descriptors, provide the scientific basis of the work. For example, moment descriptors based on Zernike polynomials may be used for the decomposition of plane circular images, whereas Legendre polynomials provide kernels for rectangular images. Engineering structures, however, often have complicated three-dimensional shapes with irregular boundaries. In that case the classical basis functions (e.g. Zernike and Legendre polynomials) are no longer suitable and it becomes necessary to design structure-specific moment descriptors. Adaptive moment descriptors (AGMDs) are based on monomials, subsequently processed using Gram-Schmidt ortho-normalisation to make them suitable for engineering structures of arbitrary shape. In the case of three-dimensional structures, surface parameterization (typically conformal mapping) may be applied to produce an equivalent plane surface, allowing the application of AGMDs. Applications include full-field modal analysis of a car-bonnet liner, finite element model updating of composite structures used in space probes and uncertainty analysis of assembled car wheels.

Keywords: Full-field measurement, image decomposition, moment descriptors, vibration and strain.