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Special Issue on Computer Vision and Scanning Laser Vibrometry Methods

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In recent decades, the use of optical measurement techniques for experimental testing has rapidly been gaining popularity for dynamic measurements. The aim of this special issue of *Experimental Techniques* is to assemble a collection of papers that present recent work on optical measurement techniques, focusing on *computer vision* and *scanning laser Doppler vibrometry* (SLDV) methods and their applications. This collection of papers highlights advancements in the areas of computer vision, laser vibrometry, digital image correlation (DIC), photogrammetry, and other optical techniques, along with applications of these techniques for dynamic measurements, structural dynamics, and structural health monitoring.

During IMAC-XXXVIII held in Houston, TX on February 10–13, 2020, researchers and practitioners from around the world comprising the SEM Technical Division on Computer Vision and Laser Vibrometry (previously the SLDV Application & Methods FG and Optical Methods & Computer Vision for Structural Dynamics FG of SEM) identified the need for this special issue. After undergoing an external peer review, twelve technical papers were accepted for this special issue, covering a wealth of topics concerning computer vision and SLDV methods. Moreover, this special issue gives an international perspective on these topics, with authors from six different countries, including Belgium, China, Netherlands, Poland, UK and USA. The technical papers fall into two broad categories—(1) computer vision and (2) scanning laser Doppler vibrometry—with some overlaps existing among subsets of papers, which are briefly described herein.

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Computer Vision

Eight articles on computer vision are presented in this issue of *Experimental Techniques*. The first three are focused on *digital image correlation*, the next two on *motion magnification*, and the last three on single camera approaches.

DIC

Beberniss and Ehrhardt (1) investigate the presence of light refraction distortions in 3D DIC displacement measurements of a panel specimen during Mach 2 wind tunnel tests. Their study addresses distortions from the optical access window and high-speed flow density gradients, with shock foot distortion posing the greatest challenge but ultimately being deemed acceptably small. Recommendations for DIC optical setups are proposed to mitigate light refraction distortions.

Hu et al. (2) combine 3D DIC and Bayesian operational modal analysis (BOMA) for high-temperature modal analysis of a titanium plate. The plate was prepared with a laser engraved speckle pattern, and a low-cost heating technique combining electromagnetic induction and radiant heating was used. The experimentally measured natural frequencies exhibited a non-monotonic dependence on the temperature, which is hypothesized to be attributed to a non-uniform temperature field and geometric imperfections and is a topic of ongoing investigation.

Witt and Rohe (3) present a framework for performing experimental modal analysis (EMA) using DIC, covering some best practices in the test planning, setup, execution, and post-processing phases. Challenges in DIC-based EMA are identified (e.g., noise floor of the optical data acquisition system and the relatively long data processing time), and recommendations for overcoming these challenges are proposed to promote and improve the use of DIC in EMA.

Motion Magnification

Eitner et al. (4) utilize phased-based motion magnification (PMM) to reduce the signal-to-noise ratio in the output-only modal identification of a polycarbonate's out-of-plane displacement. The technique showed nearly fourfold increase in modal assurance criteria (MAC) values when compared to a finite element model. Recommendations for the selection of the magnification factor and frequency band are given based on a coherence function.

Rohe and Reu (5) introduce a phase-based processing technique for extracting modal parameters directly from the phase quantities. By treating the phase data directly as deformations, closely spaced peaks can be separated and qualitative analyses can be performed on the scaled modal quantities. Parallelization of the computation combined with optimized data storage is shown to greatly decrease the computational time required.

Single Camera

Rohe et al. (6) introduce a novel technique to extract 3D motions from a single camera. The technique uses a finite element model expansion to recover the out-of-plane displacements that have traditionally been inaccessible with a single camera. Both synthetic and experimental sets of 2D images were used to validate the method, which shows promise for future applications with radiographic images.

SoleimaniBabakamali et al. (7) proposed leveraging traffic cameras to extract modal information of the supporting traffic signal mast arm. By using a single traffic camera and a pixel-based photogrammetric technique, modal frequencies and damping ratios could be accurately predicted using covariance-driven stochastic subspace identification. Possible extensions of this proof-of-concept study are described, motivating future research in this area.

Chi et al. (8) propose and validate the use of image compression in infrared thermography (IRT). Compressed images were shown to preserve meaningful features during two experimental tests. The gains in storage space saved from image compression outweigh the accuracy lost in the determination of feature size, which holds promise for future research on more complicate structures.

Scanning Laser Vibrometry

Four articles on scanning laser vibrometry are presented in this edition of *Experimental Techniques*. The first one is under the category of *interferometry techniques*, while the other three are about using laser vibrometry in application of experimental model validation and damage detection. A brief account of the papers is given herein.

Styk and Dziubecka-Bala (9) propose a new investigation about the classical time-averaging interferometry technique, which is widely used for MEMS/MOEMS dynamic behavior investigations. It provides useful information on resonant vibration frequencies and mode shapes in the form of Bessel fringe images. The paper numerically investigates the possibility of reducing Bessel images argument (phase) evaluation error by different phase shifting strategies.

Sever and Maguire (10) propose a new approach to the model validation by exploiting dynamic strain measurements. The paper shows how a 3D SLDV system can derive modal strains from a turbine and compressor blades. The strain fields are then used for performing Modal Assurance Criterion (MAC) correlations, which are typically done by modal displacement vectors. The research demonstrates the augmented accuracy of performing the correlation by modal strain fields.

Tavares et al. (11) propose a novel integration of SLDV measurements and Artificial Intelligence for Non-Destructive Evaluation (NDE). The paper proposes an algorithm for identifying the defects based on the Local Defect Resonance (LDR) concept, which looks to the high frequency vibrations to get a localized resonant activation of the defect. Artificial Intelligence (AI) techniques were implemented with the aim of creating an automatic procedure based on features extraction for damage detection.

Di Maio et al. (12) propose a novel algorithm which processes the spectral sidebands of an amplitude modulated time signal into a damage indicator. The continuous scanning LDV enables the measurement of one deflection shape by a single amplitude modulated time history. The RASTAR algorithm performs an intelligent calculation of the spectral sidebands to derive a deflection shape change between a pristine and damaged test article.

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