Multiscale and multiview DIC for damage detection and quantification

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Experimental data on damage and fracture initiation and growth play an important role for developing and/or validating numerical models. Digital Image Correlation techniques (DIC) [1, 2] provide useful information by measuring full displacement fields and identification means of model parameters, as well as quantitative validation procedures of structural models [3]. When dealing with large-scale structures, using several cameras provides very useful data in different parts of interest with different resolutions and uncertainties. However, the combination of multiscale and multiview approaches remains a delicate task. In particular, it is necessary to couple the scales in the most integrated way possible [4] in order to minimize measurement uncertainties and create seamless procedures between tests and simulations for the characterization and prediction of damage in structures.

A multiscale and multiview DIC (MM-DIC) framework has been developed and validated by performing a three-point flexural test on a notched concrete beam using three different cameras. As opposed to a regular DIC with a single camera, the multiview system required additional steps to be able to express the measurement results in a unique frame, which was that of the virtual FE mesh. Calibration was a necessary step since multiple cameras with different resolutions were used to monitor different zones of the sample surface. A backtracking procedure was also performed to properly overlay the images and the corresponding part of the master mesh and the scale factor between camera frames and the FE model. The computation of the Hessian matrices related to each camera and assembling the global one was required for the MM DIC to be performed. Then, the second member vectors related to each camera and for each iteration were computed and assembled. The nodal displacement increments of each image state were then updated and the measured displacement fields were obtained.

For any measurement to be meaningful, uncertainty quantification is necessary [2]. In the present case, the acquisition noise that affected each camera was analyzed by performing a DIC analysis on sequences of reference images with both mono-camera and MM approaches. Mono-scale analyses were also run and the resulting displacement fields were projected onto the unique global mesh and compared to those measured with MM-DIC. MM-DIC enabled the measurement uncertainties to be reduced, also led to lower registration residuals, thus providing more trustworthy displacement fields for the analysis of damage via crack opening displacement fields.

References

[1] M. A. Sutton, J. J. Orteu and H. Schreier, Image correlation for shape, motion and deformation measurements: Basic Concepts, Theory and Applications, Springer, New York, NY (USA), 2009.

[2] F. Hild and S. Roux, Digital Image Correlation, in: Optical Methods for Solid Mechanics. A Full-Field Approach, Weinheim (Germany), 183-228, 2012.

[3] Avril, S. and Bonnet, M. and Bretelle, A.S. and Grédiac, M. and Hild, F. and Ienny, P. and Latourte, F. and Lemosse, D. and Pagano, S. and Pagnacco, E. and Pierron, F., Overview of identification methods of mechanical parameters based on full-field measurements, Experimental Mechanics (2008) 48 381-402.

[4] J. Passieux, F. Bugarin, C. David, J. Périé and L. Robert, Multiscale displacement field measurement using digital image correlation: Application to the identification of elastic properties, Experimental Mechanics (2015) 55 121-137.