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MULTISCALE FE DIGITAL IMAGE CORRELATION AND MATERIAL PARAMETER IDENTIFICATION

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Connection between simulation and full-field measurement was originally a critial task. With the advent of finite element based digital image correlation methods [9, 2, 4], it is now possible to bridge efficiently both of them with a common language: a unique finite element mesh [6]. However, choosing an appropriate mesh and / or resolution may be quite tricky because of the resolution / uncertainty compromise [3], even if FE DIC approaches may significantly reduce the measurement uncertainties as they assume the continuity of the displacement field [5]. In addition, this choice is also constrained by hardware limitations. Moreover, in the context of mechanical parameter identification, the resolution is often limited because the field of view generally needs to include the boundaries of the specimen [8]. At the same time, a high resolution is required in the regions where the displacement is sensitive to the parameter to identify. And in some cases, these region are very small.

To circumvent these issues, it is proposed to exploit images shot at distinct scales. As a first step, in the simple case presented herein, a two scale approach is presented. A FE DIC is performed at the scale of the structure (far-field) and a second one in a (much) smaller region (near-field). The idea is to measure accurately the displacement field in a region where the sensitivity of the displacement field to the sought parameters is significant. An automatic estimation of the near-field / far-field transformation is obtained by a dedicated DIC based method, in order to bridge precisely the measurement performed at both scales. Measurement uncertainties are evaluated using multi-resolution speckle pattern synthetic and unbiased images based on the mechanical analytical field used in [7].

The multiscale measurements are then used for the identification of material parameters thanks to a finite element model updating technique [7, 1]. The FEMU procedure is first validated using synthetic test cases. The technique is eventually applied to real images acquired during a test performed on a laminated glass / epoxy coupon made of woven plies. Except for the transverse modulus Et (in practice, the displacement field is hardly sensitive to this parameter), the identified values are very close to those identified in a classical way.

The results show that the proposed multiscale method greatly improves both measured displacements and identified parameters. It is shown that even with a ratio of 5 between the image resolutions, the measurement and identification uncertainties can be reduced by one decade. Not only the uncertainties are reduced, but it is shown that the proposed method is also more robust with respect to image noise by approximately one decade. This noise robustness can be further reduced by using a weighted **M**-norm as in [6].

REFERENCES

[1] S. Avril, M. Bonnet, A.-S. Bretelle, M. Grédiac, F. Hild, P. Ienny, F. Latourte, D. Lemosse, S. Pagano, E. Pagnacco, and F. Pierron. Overview of identification methods of mechanical parameters based on full-field measurements. *Experimental Mechanics*, 48(4):381–402, 2008.

[2] G. Besnard, F. Hild, and S. Roux. finite-element displacement fields analysis from digital images: Application to portevinle chtelier bands. *Experimental Mechanics*, 46(6):789–803, 2006.

[3] M. Bornert, F. Brémand, P. Doumalin, J.-C. Dupré, M. Fazzini, M. Grédiac, F. Hild, S. Mistou, J. Molimard, J.-J. Orteu, L. Robert, Y. Surrel, P. Vacher, and B. Wattrisse. Assessment of digital image correlation measurement errors: methodology and results. *Experimental Mechanics*, 49(3):353–370, june 2009.

[4] J. Fehrenbach and M. Masmoudi. A fast algorithm for image registration. *Comptes Rendus Mathématique*, 346(9-10):593–598, 2008.

[5] F. Hild and S. Roux. Comparison of local and global approaches to digital image correlation. *Experimental Mechanics*, 52(9):1503–1519, 2012.

[6] H. Leclerc, J.-N. Périé, S. Roux, and F. Hild. Integrated digital image correlation for the identification of mechanical properties. *Lectures Notes in Computer Sciences*, 5496:161–171, 2009.

[7] J. Molimard, R. Riche, A. Vautrin, and J. Lee. Identification of the four orthotropic plate stiffnesses using a single open-hole tensile test. *Experimental Mechanics*, 45(5):404–411, 2005.

[8] J. Réthoré, Muhibullah, T. Elguedj, M. Coret, P. Chaudet, and A. Combescure. Robust identification of elasto-plastic constitutive law parameters from digital image using 3d kinematics. *Int. J. Solids and Structures*, 50:73–85, 2013.

[9] Y. Sun, J. Pang, C. K. Wong, and F. Su. Finite element formulation for a digital image correlation method. *Applied Optics*, 44(34):7357–7363, 2005.