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Editorial

Special Issue on Advances in Digital Image Correlation (DIC)

Jean-Noël Périé * and Jean-Charles Passieux *

Institut Clément Ader (ICA), Université de Toulouse, CNRS-INSA-UPS-Mines Albi-ISAE, 31400 Toulouse, France

* Correspondence: jean-noel.perie@iut-tlse3.fr (J.-N.P.) and passieux@insa-toulouse.fr (J.-C.P.)

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1. Introduction

Digital Image Correlation (DIC) has become the most popular full field measurement technique in experimental mechanics. It is a versatile and inexpensive measurement method that provides a large amount of experimental data. Because it can take advantage of a huge variety of image modalities, the technique allows covering a wide range of space and time scales. Stereo extends the scope of DIC to non-planar cases, which are more representative of industrial use cases. With the development of tomography, Digital Volume Correlation now gives access to volumetric data. It makes it possible to study the inner behavior of materials and structures.

However, the use of DIC data to quantitatively validate models or accurately identify a set of constitutive parameters is not yet straightforward. One of the reasons lies in the tricky compromises between measurement resolution and spatial resolution. Second, the question of the boundary conditions is still an open question. Another reason is that the measured displacements are not directly comparable with usual simulations. Finally, the use of full field data leads to new computational challenges.

2. Advances in DIC

In reviewing the 16 articles published in this special issue, it is interesting to see that they cover some of the current challenges and relevant topics facing the international Digital Image Correlation community. Applications of DIC to various scales of space and time or for the inspection of mechanical phenomena involving different types of materials (composite, metals, earth, biological tissues, etc.), in possibly complex environments. The question of large strains is also addressed. The papers address full-field measurements, their use for validation of mechanical models and for the identification of delicate mechanical properties. The coupling of DIC with other techniques is also an burning issue discussed in the special issue. Concerning the DIC variants, 2D DIC, stereo DIC and 3D Digital Volume Correlation (DVC) are also covered. Finally, the collection of articles also addresses algorithmic issues and questions related to efficient implementation.

More precisely, with regards to applications, in [1], transient kinematic measurements are performed with DIC for the inspection of the in-situ manufacturing of thermoplastic composite materials. The response of copper plates subjected to impulsive loading in complex fluid-structure environment, studied in [2] using high-speed stereo-DIC, illustrates the wide range of time scales that can be addressed by DIC. Along the same line, high-speed camera based DIC was used in [3] to observe ruptures during stick-slip motions of a simulated earthquakes. Still in the field of geomechanics, paper [4] measured earth surface dynamics and investigated the issue of application of DIC under severe environmental and lighting conditions and at very large space scales. The question, addressed in [5], of the thermal environment is also central for the (thermo-)mechanical analysis of materials, and it raises a whole set of experimental problems (texture, acquisition, filtering, etc.). Regarding an atypical application, balloons, the authors of [6] recall that the field of (very) large deformation is still wide open and depending on the use case, special specific experimental configurations may help. It is also a theme addressed by [7] where calibrated targets were used to evaluate measurement uncertainties in this large deformation regime. The possibility to bridge more intimately measurements and models is highlighted in [8] where experimental measurements are combined to a model to extract mechanical fields with a certain mechanical admissibility close to a shear crack at bi-material interface. A little further on in the coupling between models and measurements, [9] proposed an interesting methodology to quantitatively characterize mechanical (interlaminar) properties reputed to be difficult to identify using finite element model updating techniques. Among current topics, the coupling of DIC with other types of instrumentation techniques or more generally data fusion is discussed in Article [10]. A comparative analysis based on DIC and Accoustic Emission techniques is helpful to comprehend the characteristics of concrete fracture process zones. In addition to the classic 2D DIC, several variants are also illustrated in this special issue. For example, stereo-DIC is an ally of choice for the validation of models on complex or large poly-instrumented structures. The issue of calibrating several independent benches using valuable CAD information is discussed in [11]. Conversely, when non-planar tests are to be instrumented at small scales or in conditions of difficult access, stereo can be used with a single camera by adapting the mounting with, for example, prisms and mirrors [12]. Another variant of DIC, which is still in its infancy, relies on X-ray based digital volume imaging. Increasingly, the measurement of 3D fields in material bulk (DVC) is leading mechanical engineers to rethink the way they conduct tests, developing, in addition to new image correlation algorithms, special machines that allow in-situ testing. This trend is illustrated in article [13]. Volume measurement with X-ray tomography is not the only volume imaging method of interest in mechanics. For example, Optical Coherence Tomography (OCT) allows this kind of investigation to be carried out and is particularly interesting for biological materials. The results obtained, combined with identification techniques, make it possible to estimate some mechanical properties [14]. Last but not least, the last part concerns algorithmic issues. The choice of correlation metrics itself is still under investigation. For instance, in [15], the authors present different metrics based on the gradients of the image rather than on the grey level. The above-mentioned question of large deformations implies, in addition to experimental constraints, particular complexities from an algorithmic point of view. Initialization in the large deformations framework of the correlation algorithm is also a topical issue [16].

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