Single-image DIC?

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Abstract

Digital image correlation (DIC) and its many variants, such as multi-view stereo-correlation (S-DIC) or digital volume correlation (DVC), have long since demonstrated their power to resolve very fine details of kinematic fields over time series. As a result, DIC has become an essential metrology tool for experimental mechanics. Moreover, the differences between images, after motion correction, the so-called "residual" field, show very conspicuously evolutions that are not purely kinematic and thus give access to information that is often invaluable, such as the appearance of cracks or changes in temperature. In short, the quantitative exploitation of 2D and 3D images has opened up new avenues for challenging our understanding of the mechanical behavior of materials.
A provocative question is thus: can we go beyond and use DIC to challenge our understanding of materials themselves via their microstructure? The idea is no longer to compare several images of the same object but to confront a single image with our apprehension of what it represents. In other words, starting with one "real" image, the idea is to build its ideal version from what we understand about it and gradually refine our understanding and the subtlety of our description by exploiting and reducing the differences (residuals). The ability of DIC to erase kinematics then emphasizes the preservation of topology, which is often an essential property, difficult to restore from local analyses when hampered by the presence of noise, and which gives greater robustness. The same approach is also a way of promoting long-range order and highlighting finer modulations on a smaller scale. Whereas a reference image was the main focus of classical DIC, one can observe a gradual evolution to install as a key reference a 3D object, the set of its individual components, its CAD or numerical model and finally a collection of (topological) properties.

A few applications of this simple idea will be discussed, such as the segmentation of tomographic images of 3D woven fabrics or MET image analysis of multiferroic multilayers.

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