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A fairly priced, unfitted spline image-based model to assist Digital Image Correlation

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With the development of Computed Micro-Tomography (μ-CT), it has become possible to acquire full voxel representations of materials with complex architectures. This facilitates the development of full-field measurement techniques such as Digital Image Correlation (DIC) [1]. This technique allows to estimate the displacement/strain field at the heart of materials in an non-invasive way by comparing voxel data in different load configurations. The DIC problem is ill-posed in Hadamard's sense, namely, it cannot be solved pixel wise without considering some regularization. When images do not exhibit sufficient gray-level gradient values, which is the case of cellular materials for example, the situation meets its most critical level. Our contribution concerns the development of a general DIC algorithm which identifies complex deformations in cellular materials. For that, we adapted an automated and fairly-priced image based mechanical model that accurately describes the mechanical behavior of the complex micro-structure and used it as a regularization of the inverse problem. This technique, inspired from the work by Réthoré et al. [2], consists of penalizing the internal elastic forces of the geometry represented by the image. Provided a level-set description of the material's boundary [4], we show that the Finite Cell Method [3] introduces an interesting computational context for Digital Image Correlation. In fact, when using higher order B-splines as an approximation basis, along with advanced quadrature schemes, it is possible to measure accurate strain fields that could not be obtained using traditional linear finite element DIC algorithms.

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