

Improving material parameter identification using spline-based shape optimization of a test specimen

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ABSTRACT

Characterizing the mechanical behavior of materials is crucial to correctly model structures. It implies choosing an adequate constitutive law and determining the associated constitutive parameters. For this purpose, and to meet the requirements of rigorous certification procedures such as in the aeronautical industry, up to dozens of experimental tests are carried out on mechanical specimens to identify each parameter, thanks to FEMU method applied on full-field displacement measurements obtained by DIC. To improve this time consuming and costly process, Bertin et al. [1] and Feld et al [2] proposed to optimize some shape parameters of the specimen (holes diameter or position) with respect to the sensitivity to a set of constitutive parameters, so as to identify several constitutive parameters at once with low uncertainty. More recently and to obtain completely new specimen geometries, Chamoin et al. [3] used topology optimization to determine one constitutive parameter. However, the ill-posedness of the optimization problem leads to non-physically sound geometries that need to be post-processed.

To tackle this issue and improve the sensitivity to a set of constitutive parameters, we propose to use a smaller yet rich and regular search space for the shape optimization problem, based on splines and the Free-Form Deformation method [4]. This method consists in embedding parts (or features) of the geometry to optimize, described in our case by a FE mesh, into a spline morphing box of which control points pilot the deformation of the geometry. It is then completed by the propagation of the edges deformation to all FE nodes via mesh modification techniques. It results in a non-invasive CAD-based shape optimization that does not necessitate remeshing during the optimization process. A specific care is also paid to the definition of the cost and constraint functions to meet experimental requirements (eigenvalues of the covariance matrix, maximal stress, mass scaling, etc.). The method is then applied to optimize the shape of holes in a traction beam for the identification of all orthotropic linear elastic constitutive parameters.

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