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Multi-scale identification of elastic properties for anisotropic media through a global hybrid evolutionary-based inverse approach

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Abstract: *One of the main issues of composite materials is related to the difficulty of characterising the full set of material properties at both mesoscopic and microscopic scales. Indeed, classical mechanical tests (traction/compression, 3 or 4 points bending tests, etc.) are not able to provide the full set of 3D material properties of composites. Furthermore, these tests can provide only the in-plane elastic properties of the constitutive lamina (i.e at. the laminate mesoscopic scale). Therefore, in order to go beyond the main restrictions imposed by standard destructive tests, this work deals with the problem of characterising the material properties of a composite plate made of unidirectional fibre-reinforced laminae (at each characteristic scale), through a single non-destructive modal test performed at the macro-scale, i.e. that of the specimen (the laminate).*

To face such a problem a general multi-scale identification strategy (MSIS) is proposed.

The MSIS aims at identifying the constitutive properties at both micro and meso scales by exploiting the information restrained in the macroscopic dynamical response of the laminate (e.g. in terms of its eigenfrequencies). The MSIS relies on the one hand on the strain energy homogenisation technique of periodic media (for determining the effective elastic properties of the lamina as a function of the geometrical and material properties of the microscopic constitutive phases) and on the other hand on a special hybrid algorithm (genetic algorithm + gradient-based algorithm) in order to perform the solution search for the considered problem.

The identification problem is stated as a constrained inverse problem (a least-square constrained problem), where the objective function depends upon both the measured and evaluated (from finite element analysis) natural frequencies of the laminated plate. In this background, the optimisation variables are both geometrical and material properties of the constitutive phases composing the representative volume element (RVE) of the composite.

The effectiveness of the proposed approach will be proven through a campaign of experimental/numerical tests conducted on standard laminates made of unidirectional plies.