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INTERNSHIP 2021

DESIGN BY AI OF OPTIMAL ARCHITECTURES FOR ULTRALIGHT METAMATERIALS RESISTANT TO FRACTURE AND DEFORMATION

Microlattice developed by Boeing

The quest toward high-performance materials combining lightness and mechanical strength gave rise to a flurry of activity: desire to reduce CO2 emissions and develop fuel-efficient vehiclesin the transport industries for instance. In this context, meta-materials or architectured materials offer considerable potential (e.g. micro-lattice invented at Caltech and produced by Boeing) and significant progresses have been achieved recently.

The routes explored so far have mainly focused on periodic architectures, inspired from crystals. Maxwell's criterion makes it possible, from the number of struts and joints present in a basic cell, to predict whether the structure deformation will stretching- or bending-dominated, and consequently to estimate overall metamaterial stiffness and its its variation with material density. Conversely, the architecture materials observed in nature (bone, cellular structure in bark...) present random architectures optimized to respond to a certain stress of the environment or fulfill a specific function.

The idea proposed here is to use the tools of artificial intelligence (AI) and topological optimization to strengthen architectures without presupposing them. The intership is mainly numerical and theoretical. We will start from a beam model recently developed in the lab. The final objective is the development of an algorithm to define optimal architectures in terms of mechanical stiffness and cracking resistance, under constraints of density conditions and mechanical isotropy, with the help of tools to be defined: cost function and associated weights, gradient descent for minimization, neural network etc. An experimental component may be included, with the 3D-printing of the metamaterials designed numerically and their mechanical characterization on the experimental setups developed in our lab.

This intership takes place astride AI, Engineering Mechanics, and Materials Science. The candidate will have the opportunity to use, - and to familiarize himself with -, the techniques developed in these three fields. It is part of a collaboration between two laboratories at CEA: SPHYNX at SPEC and LIONS at NIMBE.

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