12 Months Postdoctoral Position:

Conforming mesh generation for composite materials

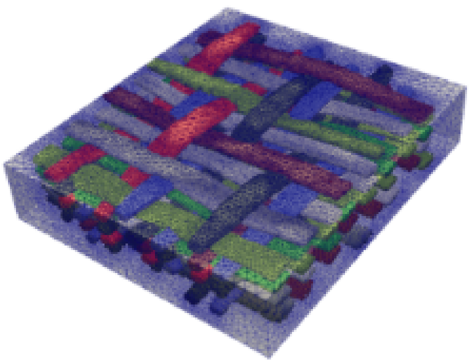
The European Commission has established a target of reducing greenhouse gas (GHG) emissions of the European Union by over 80% by 2050, in comparison to 1990 levels. Additionally, the Commission aims to achieve carbon neutrality by that same year. In the aeronautics industry, one of the ways to achieve these objectives is to reduce the weight of structures, thereby reducing fuel consumption.

In this context and due to their lightweight, composite materials have a huge potential. Depending on its microstructure and manufacturing process, a rather wide range of mechanical properties can be obtained which means that composites could potentially replace multiple metallic components in quest of weight reduction.

However the mechanical behavior of these composite materials, in particular at the mesoscopic scale, is complex. The optimization of the material properties is essential and challenging at the same time. Obtaining in-situ experimental data requires advanced and expensive experimental facilities.

Numerical simulation techniques are nowadays robust enough to predict the mechanical properties of these composites materials provided that the microstructure of the material is properly discretized. One strategy relies on the use of structured grids, that could be based on experimental or synthetic reconstructions of the microstructure, in order to describe the material at the mesoscopic scale. The drawback of this approach is that the different interfaces of the microstructure cannot be discretized in a smooth way.

CEMEF and Safran have collaborated to develop a numerical framework that allows to generate a conforming, non-structured, finite element mesh of the voxelized microstructure. As can be seen in the Figure below, the current framework allows to capture very complex microstructure in a very reliable way.



3D conforming mesh of a woven composite.

Proposed work

A numerical method to assess the quality and the fidelity of the obtained mesh will be developed. Different quantitative approaches will be tested to quantify how accurately the mesh captures the features of the initial microstructure.

Mines Paris
MSR Team & S&P Team webpages
CEMEF 1 rue Claude Daunesse CS 10207
06904 Sophia Antipolis, France
Advisors
daniel.pino_munoz@minesparis.psl.eu
jean-luc.bouvard@minesparis.psl.eu

The mesh generation technique that has been developed runs in sequential. The remeshing algorithms existing at CEMEF run in parallel, but the conforming remeshing approach adds geometrical constraints to the remeshing process that could lead to regions that are present either poor quality or that might even not be conforming to the microstructure. For this reason, an optimization of the current parallel remeshing framework is required in order to reduce the mesh generation time while ensuring good quality and conformity of the mesh. Since the goal is to carry out structural computations using the generated meshes, the quality of the mesh should also be quantified.

Finally, the developed approach will be tested over real composite microstructures. Structural computations will be performed to assess the robustness of the numerical resmeshing framework. The structural computations are expected to contain millions of elements conforming to the microstructure.

The developments will be carried out using the in-house numerical library developed at CEMEF which is written in C++ and uses distributed memory parallelism (MPI).

Candidate description

Dr Shravan Kumar Bhadoria, expert in computational mechanics, high performance computing and material science, has the appropriate profile for this project.

Partner

The project is being conducted as part of a academic/industrial collaborative work between Safran and CEMEF Mines Paris.