Internship position

Context and goals of the Internship

Finite element mesh constrained repartitioning using open-source libraries for HPC applications

DIGIMU industrial chair, handled by ARMINES MINES ParisTech and co-funded by ANR and an industrial consortium formed by ArcelorMittal, AREVA, ASCOMETAL, AUBERT & DUVAL, CEA and SAFRAN, deals with the **D**evelopment of an **I**nnovative and **G**lobal framework for the Model**I**ng of **M**icrostr**U**ctural evolutions involved in metal forming processes. DIGIMU® is also the name of the resulting software developed by the company TRANSVALOR project partner.

The optimization of the vital metal parts of many materials around us requires a knowledge of matter and the changes to its properties during forming operations. In addition to understanding the underlying metallurgical phenomena, thanks to the continuous improvement of experimental means, there is also now a growing interest for increasingly finer and more predictive simulations of these mechanisms. In this emerging context of «digital metallurgy», the DIGIMU Chair and consortium have two main objectives. The first one concerns the development of an efficient multiscale numerical framework adapted to the resolution of these questions. The second one is related with the optimization of these techniques in terms of numerical cost and their validation by the industrial expertise at the heart of the DIGIMU consortium.

Within this context of high performance computing in metallurgy, this internships (which can then open the road to a PhD position) is dedicated to improving our current mesh partitioning strategy implementation. Within the aforementioned context of a finite element library (FE) using unstructured meshes, partitioning algorithms are used in order to distribute the elements among the available CPUs and solve partial differential equations using the parallel computing. Sometimes the FE mesh must be adapted. This adaptation is achieved through the steps of remeshing. In the present approach, each processor remeshes its partition using a sequential algorithm without modified the borders of the partition. The computational domain is then "re-partitioned" so that the old partition borders are strictly placed within the new partitions [a] as the 2D example shown in the Figure (this can be seen as constrained repartitioning operations). New partitions are remeshed again, and repeating these operations multiple times, a mesh can be adapted in parallel.

Expected developments

The strategy adopted today has some limitations that we would like to remove. To this end, open-source partitioners (Metis, Scotch, ...) will be tested and compared to the existing strategy on large meshes. The idea is to build a multi-partitioners interface that taking into account the specific weaknesses/strengths of each partitioner.

[a] Coupez, Thierry, Hugues Digonnet, and Richard Ducloux. "Parallel meshing and remeshing." Applied Mathematical Modelling 25.2 (2000): 153-175.

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Partners

Keywords

Partitioning - Repartitioning - Mesh - Finite elements - HPC - C++.

Profile – Skills

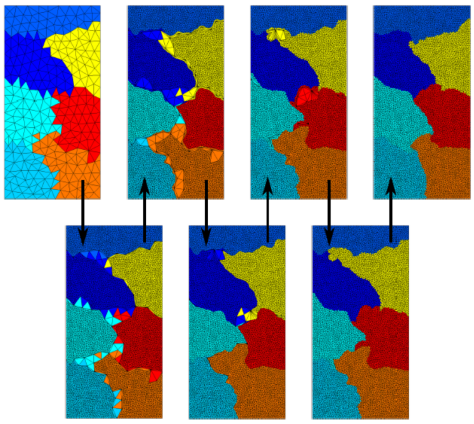
C++ - MPI - CMake - Partitioning/Repartitioning

Place

The Internship will take place at Cemef at "Ecole des Mines de Paris" in Sophia-Antipolis.

Team and type of project

Internship within the context of a pre-doctoral year, MSc or MTech with a maximum duration of 6 months paid at the French minimum wage (SMIC). The internship will take place in the team MultiScale Modeling – MSM under the direction of M. Bernacki, D. Pino Muñoz, S. Kraria and T. Toulorge.



2D Example of the strategy used for remeshing (downwards arrows) and repartitioning (upwards arrows)[b]

[b] H. Digonnet, L. Silva, and T. Coupez. "Massively parallel computation on anisotropic meshes". In: 6th International Conference on Adaptive Modeling and Simulation, ADMOS, 2013, pages 199–211.