PhD position

Context and goals of the PhD

New 3D Finite-Element meshing/remeshing approach for large-scale dynamic polycrystals

DIGIMU is an ANR 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. This Chair deals with the **D**evelopment of an **I**nnovative and **G**lobal framework for the ModelIng of MicrostrUctural evolutions involved in metal forming processes. DIGIMU® is also the name of the resulting software developed by the company TRANSVALOR as a project partner. Countless products involved in our every-day life rely on vital metal parts. Optimizing these parts requires a knowledge of how material properties change during forming operations. Although the understanding of the underlying metallurgical phenomena has improved thanks to the continuous progress of experimental facilities, the interest for increasingly fine and predictive simulations has been recently growing. In this emerging context of "digital metallurgy", the DIGIMU Chair and consortium have two main objectives. The first one is to develop an efficient multiscale numerical framework specifically designed to tackle such problems. The second one is to bring the corresponding numerical methods to an industrial level of maturity, by decreasing significantly their computational cost and by validating them against the industrial expertise existing in the DIGIMU consortium.

In order to accurately describe the 3D evolution of polycrystals (recrystallization, phase transformations...), full-field methods such as the phase-field or the level-set methods have to be employed. Despite the recent introduction of HPC techniques in metallurgy, the main weakness of these methods still lies in their computational cost. Optimized 3D meshing and remeshing strategies are an interesting alternative for overcoming this problem, as illustrated in the figure below. Nevertheless, it seems that state-of-the-art methodologies involving unstructured Finite-Element (FE) meshes will remain incapable of carrying out large-scale computations ($\sim$ 10000 to 100000 grains) with reasonable computational facilities.

In the proposed PhD project, a new 3D mesh adaptation technique that combines explicit meshing of interfaces and implicit level set (LS) description will be investigated to reach this objective. Front-capturing approaches based on the plain LS method can suffer from spurious deformations of inter-grain interfaces due to numerical diffusion, particularly during the remeshing operations required to follow the interface motion. Comparatively, the new technique has been shown to drastically reduce the volume loss at remeshing[a] in the context of biphasic materials, with a beneficial impact on the overall computational cost. This quite prospective approach will be complemented with a more classical investigation of anisotropic mesh adaptation procedures driven by new geometric error estimators that are specific to 3D polycrystals. Finally, the resulting developments will be applied to industrial-scale cases and prepared for integration in the DIGIMU® software package.

[a] M. Shakoor, P.-O. Bouchard, and M. Bernacki. An adaptive level-set method with enhanced volume conservation for simulations in multiphase domains. International Journal for Numerical Methods in Engineering, 2016, In press.

Mines ParisTech
CEMEF rue Claude Daunesse CS 10207 06904 Sophia Antipolis, France
marc.bernacki@mines-paristech.fr
thomas.toulorge@mines-paristech.fr
+33 (0)4 93 67 89 23

Partners

ANR – ARMINES – MINES ParisTech – AUBERT&DUVAL – cea – AREVA – ArcelorMittal – ASCOMETAL – SAFRAN – TRANSVALOR

Keywords

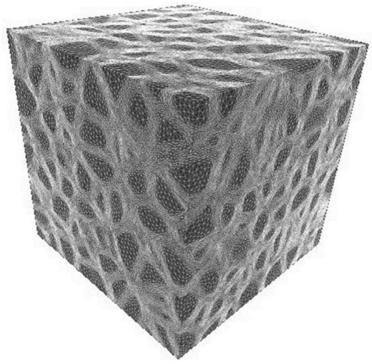
FE Method – Meshing – HPC – Metallurgy – C++.

Candidate profile and skills

Degree: MSc or MTech in Applied Mathematics, Mechanics or related discipline, with excellent academic record. Skills: Finite Element Method, C++ programming, proficiency in English, ability to work within a multi-disciplinary team.

Offer

The PhD will take place in CEMEF, an internationally-recognised research laboratory of MINES ParisTech located in Sophia-Antipolis, on the French Riviera. It offers a dynamic research environment, exhaustive training opportunities and a strong link with the industry. The PhD student will receive a 3-year fellowship. She/He will join the MultiScale Modeling (MSM) and the Metallurgy Structure Rheology (MSR) research teams under the supervision of M. Bernacki and T. Toulorge.



Example of a 3D polycrystal non-conforming FE mesh[b]

[b] M. Bernacki et al. Finite element model of primary recrystallization in polycrystalline aggregates using a level set framework. Modelling and Simulation in Materials Science and Engineering, 17(6):064006, 2009.