Impact of Body-Fitted Finite Element Discretizations for Moving Interfaces Applied to Microstructural Evolutions

Sebastian Florez*, **Thomas Toulorge**† **Marc Bernacki***

* Centre de Mise en Forme des Matériaux (CEMEF)
Mines ParisTech, Université de recherche Paris-Sciences-et-Lettres (PSL)
1 Rue Claude Daunesse, 06160 Sophia Antipolis, France
e-mail: sebastian.florez@mines-paristech.fr, web page: http://www.cemef.mines-paristech.fr/

† Centre de Recherche en Aeronautique (Cenaero)
Rue des Frères Wright 29, 6041 Gosselies, Belgium
e-mail: thomas.toulorge@cenaero.be - Web page: http://www.cenaero.be/

ABSTRACT

The Level-set (LS) method has been shown to be a powerful approach to model dynamic interfaces in the context of large deformations. The LS method has been applied to the simulation of microstructural evolutions as Grain Growth (GG) and Recristallization (ReX) at the mesoscale [1]. Interfaces between grains are then implicitly described in a Eulerian framework, as the zero-isovalue of the LS fields and their evolution is governed by convective-diffusive partial differential equations (PDEs).

In the context of the Finite Element Method (FEM), the LS approach circumvents the notoriously difficult problem of generating interface-conforming meshes for geometries subject to large displacements and to changes in the topology of the domains. However, in order to maintain high accuracy, moving interfaces are generally captured by a locally refined FE mesh with the help of mesh adaptation techniques. In a microstructual problem, the large number of interfaces and the fine mesh required in their vicinity make the mesh adaptation process very costly in terms of CPU-time, particularly in 3D [2].

In this work, a different adaptation strategy is used. It maintains the benefits of the classical Eulerian LS framework, while enforcing at all times the conformity of the FE mesh to implicit interfaces by means of local remeshing operations [3]. With this approach, geometrical data such as interface normals and curvatures can be computed directly from the body-fitted mesh using the position of the interface nodes only, instead of relying on the costly and inaccurate approximation of the LS field derivatives. Changes in properties between grains, such as the dislocation density, can also be represented by a genuinely discontinuous jump at the interface, instead of resorting to a smoothed field.

We will illustrate how the new method decreases the requirement in mesh density while maintaining the accuracy at the interfaces, hence reducing the computational cost of the simulations.

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