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LaTin method with IsoGeometric Analysis for non-linear simulations with multiple non-conforming contact interfaces

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ABSTRACT

With the development of volume imaging techniques, mechanical models of a material at the microstructure scale can be created from 3D images of a sample. However, the computation of the image-based models still seems unattainable for real mechanical applications. Indeed, these models are associated with massive data and need to incorporate complex constitutive behaviours. The aim of this work is to develop an efficient numerical approach for the computation of solids with multiple non-linear, non-conforming interfaces (contact or delamination). In particular, the simulation of fibre-reinforced composite materials is of interest.

To tackle the geometrical complexity of such multiphase objects, IsoGeometric Analysis (IGA) is used together with immersed boundary approaches [4]. This allows to avoid the delicate meshing phase of such geometrically complex objects and to obtain a better per-degree-of-freedom accuracy through the use of the spline smooth basis functions. Since the non-linearities are located at the interfaces, our purpose is to also take advantage of the so-called Large Time Increment (LaTin) method [3]. Here, the LaTin method separates the non-linear local (i.e. related to the interfaces) and the global linear (i.e. related to the bulk) equations and applies an iterative scheme between both. LaTin-based solvers have recently been applied, for instance, with a FE immersed approach (CutFEM), to model multiple contacts [2]. The present work extends the LaTin to higher-order immersed IGA. The non-conforming coupling is treated by means of Nitsche's approach which has shown optimal convergence behaviour, in particular for global/local analysis [1].

In the proposed method, inspired from [4], two conformal layers are built on the matrix/fibre interface, thus separating the difficulties regarding non-linearity and non-conformity. The layers are coupled by the LaTin method, taking into account the non-linear behaviour. Then, they are coupled through Nitsche's method with the geometrically simple non-conforming matrix or fibre models. In the case of multiple inclusions, the algorithm is naturally parallel. The proposed method has been tested through a series of numerical examples, including multiple unilateral and frictional contacts. Examples with cohesive interfaces will also be presented.

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