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A multiscale a priori reduced-order modelling method for problems with multiple frictional contact interfaces

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Despite continuous progress in computational contact mechanics, simulating a complex structure with multiple frictional interfaces still requires a large computational time due to multiple sources of non-linearity: contact and friction status change with deformation, frictional dissipation, and possible rotations in the transformation. This cost may induce limitations for industrial cases involving architected materials [1], like spiral strand wire ropes used in offshore engineering which motivated this work [2].

A well-known strategy to circumvent such limitations is to project the full-order problem on a reduced-order basis (ROB) of the original problem through various reduced-order modeling (ROM) strategies. Classical ROM approaches with contact conditions remain limited to a-posteriori methods for parametric problems, mainly limited to frictionless contact [3, 4]. Their application to frictional problems with the change in contact conditions remains an open question, specifically for the cases involving the propagation of sliding/adhesion fronts.

The considered resolution strategy is based on the LATIN (Large Time Increment) solver combined with the a priori ROM based on the Proper Generalized Decomposition (PGD). The LATIN is a non-incremental solver that features a robust treatment of contact conditions with two alternating search directions and a global space-time approach that enables the use of ROM on the fly during the computations. Spiral strand wire rope mechanics are marked by local solutions at wire contact interfaces with shorter wavelength when compared to the characteristic rope length. A well-suited strategy is thus adopted, with a multiscale domain decomposition method (DDM) based on the LATIN method [5].

Simple 1D and 2D problems will be presented to illustrate the concepts of the strategy and its performance. To ensure accurate prediction of the local solution on several frictional interfaces, it is crucial to control the local error with an appropriate convergence indicator. The convergence rate of the method also strongly depends on the search directions of the LATIN solver. The method efficiency also depends on the size and quality control of the ROB that is progressively built with PGD, so as on the choice of DDM coarse scale problem. With adapted choices, it is possible to get a significant computational gain for the same accuracy.

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