Solving Frictional Contact Problems in Space and Time at Scale

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We present an non-linear parallel solution method for frictional contact problems, which uses ideas from multiscale as well as domain decomposition methods. Our method is inherently non-smooth and allows for the massively parallel solution of frictional contact problems at scale.

Taking the locality of the (Coulomb) friction law and of the non-penetration con- straints into account, we first "separate" the non-smooth interface processes from smooth reaction of the material bulk by means of a multi-scale decomposition. Within this multiscale decomposition, the non-smooth frictional effects at the interface are located on the finest scale. They can be dealt with locally by means of non-smooth solution approaches, thereby allowing for a highly accurate identification of the stick/slip regime. The smooth response of the bulk, however, is associated to the coarser scales of the model. In contrast to the fine scale effects, here global interaction has to be taken into account during the solution process. This is done efficiently by means of a modified multi-level basis inspired by linear multigrid methods. For the scale separation we employ a constrained Newton-like linearisation, which allows to "remove" the sticky node and to restrict the linearisation to where the underlying energy functional is differentiable.

We then show how our multi-scale approach can be combined with domain decomposition ideas, leading to a massively parallel solution methods for frictional contact problems.

In our presentation, we will explain the design of our multi-scale decompositon in detail and discuss its convergence properties. We will show that our approach is flexible in the sense that it also allows for the solution of, e.g., thermomechanical problems. We will furthermore exploit our method in the framework of a fully implicit time discretisation scheme for frictional contact problems, which is based on our stabilised Newmark method. Numerical examples will illustrate the performance and scalability of our method. We will in particular compare to standard approaches, such as active set strategies, and show that our approach is significantly faster.

References

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[2] R. Krause, M. Walloth, A time discretization scheme based on Rothe's method for dynamical contact problems with friction, *Computer Methods in Applied Mechanics and Engineering.*, 1-19,2209.