Nested objective functions for frictional contact

Diego Hurtado, Lars Beex
Department of Engineering; Faculty of Science, Technology and Medicine, University of Luxembourg, Luxembourg
E-mail: *diego.hurtado@uni.lu, lars.beex@uni.lu*

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Quasi-static mechanical simulations of rate-independent deformable solids can often be expressed in an incremental objective function. Whereas Newton's method is a commonly used approach to solve this optimization problem thanks to its speed, other minimization methods are not restricted by singular stiffness matrices. Thus, a wider range of quasi-static rate-independent mechanical models can be solved if they are considered as an optimization problem.

If the solution of quasi-static rate-independent deformable solids can indeed be formulated as the minimizer of some objective function, this also remains the case if the solids undergo frictionless contact. The problem of interest here is that this is not the case if the solids undergo frictional contact [1].

A somewhat limited number of works have proposed nested objective functions for frictional contact. Whereas frictionless contact can be included in the original objective function describing the mechanical deformation of the solids, nested objective functions write the frictional contact problem in terms of more than one objective function, whose minimizer depends on the minimizer of another objective function.

An example of such an approach is the work mentioned in [2]. In this work, four nested optimization problems are proposed. This is believed to be a relatively large number of embedded objective functions, which may come with substantial simulation times.

In the presentation, an alternative approach is presented that is based on two nested objective functions. The goal of the outer minimization problem is to compute the current projection of the active slave nodes onto the master surface. On the other hand, the inner minimization problem simply solves the objective function that describes the mechanics, where the slave-to-master projections suggested by the outer minimization problem are included as equality constraints.

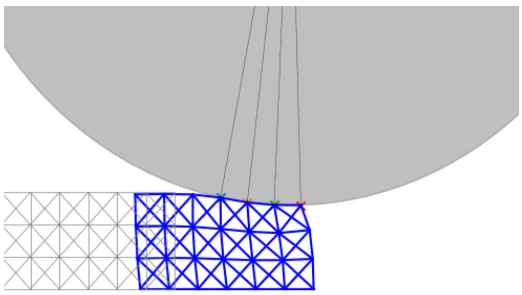

Figure 1: The embedded objective functions are currently investigated for a 2D configuration involving a deformable body and a rigid circle.

The presentation will explain the different contributions of the objective functions in a step-wise manner. The bottleneck (of the simulation times) will then be revealed and an alternative approach will be presented. The alternative describes the problem in terms of three embedded objective functions, but the result is a computational speed-up in fact.

The framework is presented for a 2D node-to-surface case as illustrated in Fig. 1, where the surface is the outer surface of a rigid body. In the future, however, the approach is scheduled to be investigated for 3D deformable-to-deformable cases (node-to-surface), where the mechanical problem cannot be solved using Newton's method.

References

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