Nitsche Methods for Frictional Contact: From Mathematical Analysis to Large-Scale Elastoplastic Industrial Applications

Cédric Pozzolini*, **Moise Pignol*, Yves Renard†, Bruno Souloumiac***

Framatome, 2 Rue Professeur Jean Bernard, 69007 Lyon, France
cedric.pozzolini@, moise.pignol@, bruno.souloumiac.ext@framatome.com
† Université Lyon 1 / INSA Lyon, ICJ – LaMCoS, Villeurbanne, France
yves.renard@insa-lyon.fr

ABSTRACT

Over the past decade, Nitsche-based formulations have emerged as a powerful alternative to classical penalty and Lagrange-multiplier methods for contact mechanics. By enforcing interface constraints weakly, these methods provide consistent discretizations without introducing additional contact unknowns or imposing compatibility conditions between contacting meshes. This talk reviews recent developments in the mathematical analysis, numerical treatment, and industrial application of Nitsche methods for frictional contact problems. Particular attention will be given to large-scale three-dimensional simulations involving Coulomb friction, elastoplastic constitutive laws, and non-matching high-order finite-element discretizations. The presentation will first examine recent theoretical results concerning the well-posedness, stability, and convergence of Nitsche formulations for unilateral contact and frictional problems. The algorithmic challenges associated with nonlinear constitutive updates, semismooth Newton methods, projection operators, and monolithic solution strategies will then be discussed. In particular, the interaction between local constitutive integration schemes and global contact solvers remains a central issue for the robustness and efficiency of large-scale computations. A significant part of the talk will focus on industrial applications and numerical results obtained for challenging three-dimensional contact configurations. The discussion will emphasize convergence properties, robustness with respect to mesh non-conformity, and comparisons with classical penalty and augmented-Lagrangian approaches. Finally, the talk will outline several perspectives toward a rigorous mathematical and algorithmic framework for coupling Nitsche contact formulations with nonlinear elastoplastic constitutive operators.

REFERENCES

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[2] F. Chouly, P. Hild, V. Lleras, Y. Renard, *Nitsche method for contact with Coulomb friction: existence results for the static and dynamic finite element formulations*, Journal of Computational and Applied Mathematics, Vol. 416, 2022.