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FRICTIONLESS CONTACT OF ELASTIC BODIES: COMPARISON OF TREATMENT IN FINITE ELEMENT ANALYSIS AND ISOGEOMETRIC ANALYSIS

J. Kopačka, R. Kolman, D. Gabriel, J. Plešek *

Abstract: *Artificial oscillations in contact force due to non-smooth contact surface are treated by isogeometric analysis (IGA). After brief overview of B-splines and Non-Uniform Rational B-Splines (NURBS) representation, the mortar-based contact algorithm is presented in the frictionless small deformation regime. Contact constraints are regularized by penalty method. The contact algorithm is tested by means of contact patch test.*

Keywords: ***Isogeometric analysis, Contact analysis, NURBS***

The main difficulty in contact analysis is non-smoothness. It arises from inequality constraint as well as the geometric discontinuities inducted by spatial discretization. Contact analysis based on traditional finite elements utilizes element facets to describe a contact surface. The facets are C^0 continuous so that surface normal can experience jump across facet boundaries leading to artificial oscillations in contact force.

There were attempts to treat the geometric discontinuities by smoothing the contact surfaces using splines interpolation. These remedies introduce an additional geometry on the top of the existing finite element mesh. This adds an additional layer of data management and increasing computational overhead. Details and further references can be found in Wriggers (2006).

Another remedy to the geometric discontinuity provides isogeometric analysis (IGA). The fundamental idea is to accurately describe a physical domain of interest by proper representation (e.g. NURBS) and then utilize the same basis for analysis. This is in contrast with the classical finite element method where the basis is given in advance by the element type and so that the physical domain could be approximated inaccurately. More detailed description could be found in Cottrell et al. (2009).

Isogeometric NURBS-based contact analysis has some additional advantages: preserving geometric continuity, facilitating patch-wise contact search, supporting a variationally consistent formulation, and having a uniform data structure for the contact surface and the underlying volumes.

Geometric basis and formulation for frictionless isogeometric contact has been given in Lu (2010). Sharp corners or C^0 edges that can exist on the interface of patches present a challenge to contact detection. A strategy to seamlessly deal with sharp corners has been proposed in this reference. Herein, the contact constraints are regularized by penalty method and contact virtual work is discretized by finite strain surface-to-surface contact element. Both one-pass and two-pass algorithm are tested.

In Temizer et al. (2011), finite deformation frictionless quasi-static thermomechanical contact problems are considered. Two penalty-based contact algorithms are studied herein. The former is called knot-to-surface (KTS) algorithm. It is the straightforward extension of the classical node-to-surface (NTS) algorithm. Since NURBS control points are not interpolatory, contact constraints are enforce directly at the physical points of the quadrature points. It is shown in this reference that this approach is over-constrained and therefore not acceptable if a robust formulation with accurate tractions is desired. The latter is called mortar-KTS algorithm. In this algorithm a mortar projection to control pressures is employed to obtain the correct number of constraints.

*Ing. Ján Kopačka, Ing. Radek Kolman, Ph.D., Ing. Dušan Gabriel, Ph.D., Ing. Jiří Plešek, CSc.: Institute of Thermomechanics AS CR, v.v.i., Academy of Science of the Czech Republic, Dolejškova 1402/5; 182 00, Prague 8; CZ, e-mail: {kopacka,kolman,gabriel,plesek}@it.cas.cz

The penalty-based mortar-KTS algorithm has been extended to frictional contact in Lorenzis et al. (2011) and Temizer et al. (2012). The mortar-KTS algorithm has been also studied in conjugation with augmented Lagrangian method in Lorenzis et al. (2012). Isogeometric frictionless contact analysis using non-conforming mortar method in two-dimensional linear elasticity regime has been presented in Kim (2011).

In this paper, we present mortar-based frictionless isogeometric contact algorithm in small deformation regime. The main contribution of this work is to prepare an implementation of the IGA procedures for further investigation. The robustness of the algrithm is chacked by means of contact patch test according to Taylor and Papadopoulos (1991).

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