A reduced model for conical contact dedicated to flexible multi-body dynamics

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Abstract. An efficient time integration scheme for flexible multi-body dynamics with frictional impacts dedicated to finite element simulations is presented. Considering bulky compact components the linear theory of elastodynamics may be applied and two separate explicit Newmark integration schemes coupled only by non-linear forces are used for elastic vibration and rigid body dynamics respectively. After a brief study focused on conservation properties, a dedicated rigid-body integration scheme is selected. To avoid contact detection and classical mesh to mesh computation a parameteric study based on static computations is performed to express the reaction forces as analytical functions of few positional arguments. The penalty method is applied and combined with the Coulomb law to modelize impacts between the two colliding bodies. The results are then illustrated on a use case with configuration dependent contact geometry. Finally the global model aims at interpreting experiments on such configurations.

Introduction

Wear is inherent to a large variety of industrial mechanisms including components of water pressurized reactors. Under the action of the cooling fluid two neighboring components may vibrate and collide. In time repeated frictional chocs induce mutual wear and thus a modification of the contact profile between the two bodies.
The present paper focuses on a numerical strategy to simulate about 100 s of structural dynamic with constant contact geometry. Coupling with contact evolution due to wear is considered at a higher time scale. Our case study concerns slender bodies modeled as Timochenko beams yet bulky enough to work in the framework of the Linear Theory of Elastodynamics [**4**]. As a result elastic vibrations and rigid-body motion remain coupled only by non-linear forces. After a brief study on rigid-body dedicated integration schemes (Fig:1.(a)), an explicit Newmark algorithm [**1**] is implemented. A survey over a large panel of rigid-body integration schemes has been performed in [**3**]. For efficiency sake a simple contact model combining the penalty method and the Coulomb law is preferred to avoid impulses. For the most complex contact zones, a parametric study based on static calculus is performed to come up with an analytical formulation of reaction forces (Fig:1.(c)). This allows to dodge time-onerous detection algorithms and mesh to mesh calculation.

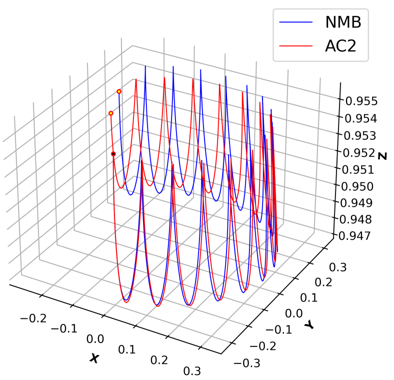

Figure 1.(a): Symmetrical top: center of mass trajectory for the NMB [**2**] & AC2 [**1**] integration schemes

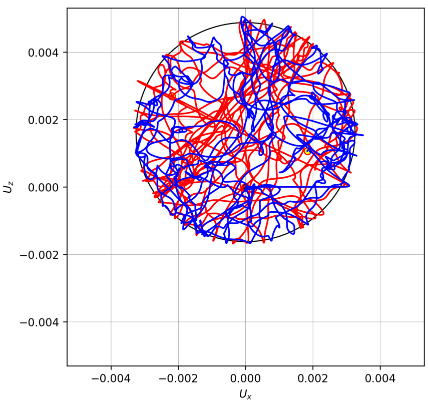

Figure 1.(b): Neutral fiber trajectories on a beam cross section

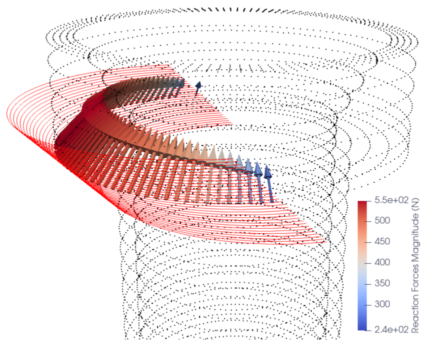

Figure 1.(c): Reaction forces for a circle-cone contact

Results and discussion

Figure **1.** gives a general overview of some of the results obtained with the dynamic model including accurate trajectories and reaction forces on any chosen point (Fig:1.(b)). It is noteworthy that while a simple beam model is used it is still able to keep track of the frictional solicitations on a local scale. The results are validated through comparison with macroscopic experimental observations. The upcoming work will focus on local wear computation using the tangential energy dissipated during collisions.

References

[1] J. C. Simo, K. K. Wong (1991) Unconditionally stable algorithms for rigid body dynamics that exactly preserve energy and momentum. *J. Num. Methods* **31**:19-52.

[2] P. Krys, L. Endres (2005) Explicit Newmark/Verlet algorithm for time integration of the rotational dynamics of rigid bodies. *J. Num. Methods* **62**:2154-2177.

[3] G. Ortolan, A. Saccon (2012) A numerical test of long-time stability for rigid body integrators. *J. Num. Methods* **90**:390-402.

[4] A. A. Shabana (2013) Dynamics of Multibody Systems. Cambridge University Press, NY, pp. 226-227.