Surface-to-surface continuum beams contact dynamics using the complementarity problem approach

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EXTENDED ABSTRACT

1 Introduction

Complementarity problem approaches (CP) have recently been adopted to enforce contact constraints in large deformation contact dynamics problems in the framework of the two-dimensional absolute nodal coordinate formulation (ANCF) continuum beams [1]. However, with the three-dimensional cross-section-deformable beam elements, the line-to-line contact formulation in conjunction with the CP approaches as introduced in [1], is not sufficiently general and robust. Therefore, the CP approach in [1] needs to be adopted to impose the contact constraints on the actual surfaces.

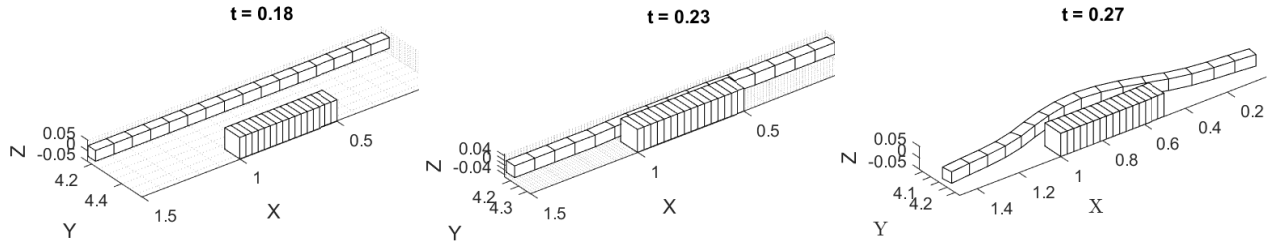
2 Applied methods

The computational advantage of the CP approach over the penalty-based methods was first discussed in [1] for the line-to-line beam contact problems. Later, in [3], the CP approaches were equipped with a robust optimization procedure to solve flexible multibody contact problems using a point-wise contact formulation. Therefore, to impose the contact constraint based on the distributed contact force, over beam's fully interpolated surface, the CP approach is preferred over the penalty method. The interpolation scheme to approximate an arbitrary cross-section in ANCF beams [5] that was applied with the penalty-based surface-to-surface formulation, introduced in [2], is utilized to define the cross-section of the ANCF beams in this study.

3 Results

For the validation of the CP approach, we investigate an academic contact problem as shown in Figs. 1a-1c that show the configurations of two beams with different geometrical dimensions made of a Neo-Hookean material model before, within and after contact.

Fig. 2 shows the logarithmic values of the inf-sup with increasing of integration segments on the contact surface. After a slight increase of β_{hs}, it is almost bounded overhead with a small rise. Therefore, the inf-sup test is passed. Contrary to the penalty method, there is no need for the refining of the contact discretization using any segmentation techniques to alleviate the interpenetration [2] with the CP approach. This is an important computational advantage of this scheme.



(a) Before contact (b) During contact (c) After contact

Figure 1: Surface-to-surface contact between two parallel beams with non-conformal beam discretization when the discretization of 16 ANCF elements is used.

4 Conclusions

The contact surface between beams with the highly deformable cross-sections can be effectively constrained with the CP approach. The CP approach has been tailored for an efficient numerical integration over the beams' contact surfaces in the case of non-conforming mesh with the contacting beams using a nonlinear material model.

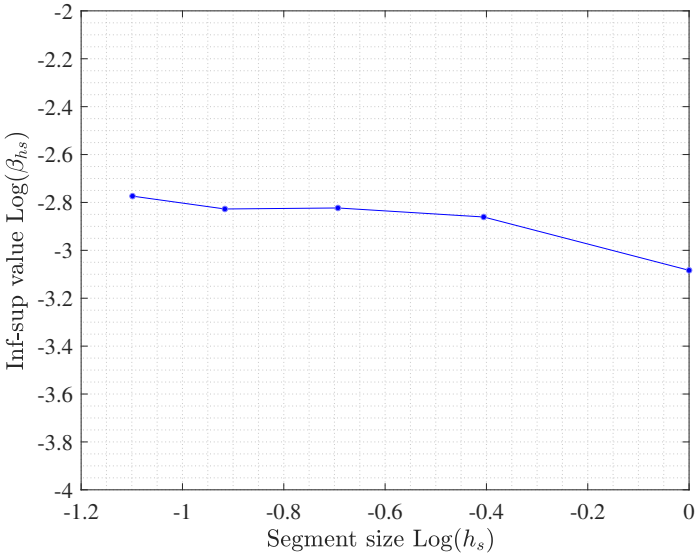


Figure 2: Inf-sup values for the contact patch test for increasing number of elements (integration segments). The results are based on the discretization of 16 ANCF elements.

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