A frictional contact formulation for planar mechanisms

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Frictional contact plays a crucial role in the dynamic behavior of mechanical systems, influencing energy dissipation, motion stability, and force transmission [1, 2]. Accurate modeling of tangential interactions remains a challenge, particularly when combined with flexible body dynamics. This work extends a recently proposed area-based contact formulation [3] to include frictional effects. The original method relies on the penalty approach to compute the normal contact force between two planar bodies by exploiting the geometric overlap: the force magnitude is proportional to the intersection area through a penalty coefficient, its direction is obtained from weighted projection vectors, and it is applied at the centroid of the overlapping region. For flexible bodies, this global force is decomposed into nodal contributions that satisfy both force and moment equilibrium. The present contribution introduces tangential forces through a regularized Coulomb friction model. The relative sliding velocity at the contact centroid is evaluated considering both translational and rotational motion of the contacting bodies. A sigmoid function ensures a smooth transition between sticking and sliding regimes, avoiding numerical instabilities at near-zero velocities. The resulting friction force, proportional to the normal force magnitude, is then distributed among the contact nodes while preserving static equivalence with respect to the global tangential force. As shown in Fig. 1, both the normal and tangential global forces are decomposed into nodal contributions acting on the contact interface. The extended formulation has been validated on planar mechanisms involving flexible bodies, demonstrating stable behavior and accurate force transmission under dynamic frictional contact conditions.

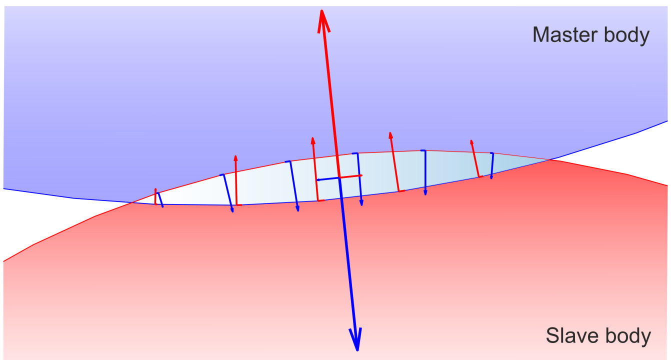

Figure 1: Normal and tangential global forces at the contact centroid with the corresponding nodal decomposition.

References

[1] P. Wriggers. *Computational Contact Mechanics*, 2nd ed., Springer, 2006.

[2] T. Laursen and J.C. Simo, A continuum-based finite element formulation for the implicit solution of multibody, large deformation frictional contact problems, *Int. J. Num. Meth. Engng.*, 36:3451–3485, 1993.

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