Exploring Slipping-Rolling Transitions of Rigid Bodies by the Analysis of Nonsmooth Vector Fields

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Nonsmooth phenomena from contacting bodies lead to interesting issues. In case of dry friction, the friction forces depend discontinuously on the variables of relative velocity, and a static – sticking or rolling – contact state can be initiated. The resulting transitions between slipping and sticking pose a usual challenge in analysing and simulating mechanical systems with dry friction. The main idea of the talk is that in the case of a class of friction models including the Coulomb model and the Stribeck model, the sticking-slipping transitions are purely described by the qualitative behaviour of the slipping vector field in the vicinity of the discontinuity set in the phase space. This property can be easily seen in the planar frictional case leading to piecewise-smooth systems, but becomes intricate in the spatial case, where there are continuously many normal directions at the higher codimensional discontinuity set. Based on recent results, the talk presents the cases of a single spatial contact point, multiple spatial contact points, a finite spatial contact region, and more complicated cases involving rolling. The analysis focuses on the existence of the limit directions, which are organizing lines at the discontinuity set, showing the possible directions of sticking-slipping transitions.