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Modeling and Robot Grasping of Deformable Shell-like and Planar Objects

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Summary

The robot hand applying force on a deformable object will result in a changing wrench space due to the varying shape and normal of the contact area. Design and analysis of a manipulation strategy thus depend on reliable modeling of the object's deformations as actions are performed. The first part of this talk is concerned with modeling of shell-like objects grasped by a robot hand. We present a formulation of extensional, shearing, and bending strains in terms of geometric invariants including the principal curvatures and vectors, and their related directional and covariant derivatives. A computational procedure is then offered for general parametric shells. Implemented using subdivision surfaces, our method solves a couple of benchmark problems with convergence rates one order of magnitude higher than those of two commercial software ABAQUS and ANSYS. Experiment involves regular and freeform shells grasped by a robot hand, with the results compared against scanned 3-D deformation data (accuracy 0.127mm).

The second part of the talk describes some recent progress on two-finger grasping of deformable planar objects. We derive sufficient and necessary conditions for a successful grasp, which is independent of the applied force under the linear elasticity theory. Numerical algorithms are presented to compute the set of finger placements that would successfully grasp a given object, with small and large deformations modeled by linear and nonlinear elasticity theories, respectively.