Nowadays, Robots are common to manipulate different objects and perform sophisticated tasks. They lift up massive soft and hard objects, plan the motion with specific speed, and repeat complex tasks with high precision. However, without carefully control, even the most sophisticated robots would not be able to perform a simple operation.

Robot grasping of deformable objects is an under-researched area. The difficulty comes from both mechanics and computation. First, deformation caused by the grasp operations changes object’s global geometry. Second, the torques exerted by the grasping fingers vary, in contrast with rigid body grasping whose torques are invariant under forces.

Collision is a common phenomenon in robot manipulation, as observed in the games of marbles, billiards, and bowling. To make the robot purposefully take advantage of impact to become better at certain tasks, a general and computationally efficient model is needed for predicting the outcome of impact. And also, tasks to alter the trajectory of a moving object are also common in our daily life, like batting a baseball, playing ping-pong ball. A motion planning strategy based on impact is necessary for the robots to accomplish these tasks.

The thesis investigates problems of deformable grasping and impact-based manipulation on rigid bodies. The work contains deformable grasping on 2D and 3D soft objects, multi-body collision modeling, and motion planning of batting a flying object.

In our previous work, in 2D space an algorithm is proposed to characterize the best resistance by a grasp to an adversary finger which minimizes the work done by the grasping fingers. An optimization scheme is offered to handle the general case of frictional segment contact. And also, a strategy is introduced for a two-finger robot hand to grasp and lift a 3D deformable object resting on the plane.

Next, an n-body impulse-based collision model that works with or without friction was studied. The model could be used to determine the post-collision motions of any number of objects engaged in the collision. Making use of the impact model, we investigated the task of batting a flying object with a manipulator in both 2D and 3D cases with or without friction.