Studies in Robotics Grasping

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Grasping of an object by computer-controlled manipulator is an important, but poorly understood operation. The planning of successful grasping as well as the reliable consequences of an attempted grasping is unpredictable. Therefore, the present work is intended to extend research how articulated hands can be used to securely grasp objects and also, apply arbitrary forces and small motions to these objects. Further, robotic manipulators are competent only in the simplest application domains such as spray-painting and welding etc. There are many instances when complex relationships between parts arise, such as in assembly tasks, or when the task environment is an unpredictable, robots are found waiting. To understand manipulation, we have to understand how objects move during touching and pushing. When contact occurs between two bodies, the relative motion between them will depend upon the geometric and friction properties of the contact. Therefore, some of the fundamental issues in multifingered cooperative manipulation have been discussed in thesis.

Screw theory has been used as a powerful tool to investigate the geometry of the force allocation problem in multiple contact situations. A natural set of vectors visualized as zero pitch wrenches and the span of homogeneous solution set have been shown in the thesis. The dimensionality of the homogeneous solution space along with techniques to find a minimum spanning set has been established. The force geometry of three-point contact has been characterized by a set of two parallel planes, three cones, three conic section and three vector directions. For the three point of contact case, it has also been shown that the force system can be described completely in a two dimensional Euclidean plane. The two dimensional description can be used to make useful qualitative judgments about the grasp state.

Manipulation with three fingers in frictional contact is known to be an under-specified problem. A discussion of the achievement of a grasp of maximum possible stability under a set of contact and loading conditions is found in the literature. Here, an attempt has been made by modification of a technique in linear algebra known as the minimum norm solution. Using the methods discussed therein, numerical analysis and optimization of the forces influencing the system is carried out.

The equilibrating forces and interaction forces as well as the optimization for q_i are recomputed for each interval of 1° and the analysis of the results showed the variation of q_1, q_2, and q_3 as the value of a varied through its range. Optimum grasp, for a nominated set of contact points and loading condition, is when the maximum of the friction angles at the contact points is minimized. A numerical computation of the friction angles offers solidity to the theory behind the entire analysis.

The simulation has been developed on 3-dS Max software for two hypothetical objects i.e., a sphere and a cube. Only kinematic simulation has been developed, using horizontal and vertical positions for finger manipulation, at this stage. The possibility of executing finger motions for certain class of objects has also been simulated. A re-oriented task of a sphere and a cube has been considered to show the validities for a robotic hand with four fingers, each of which has four joints, where the z-axis defines the joints' axes of rotation. The standard specifications of the hand and object have been considered in study. The initial joint configurations of the fingers are arbitrarily chosen. The orientation of reference and the body coordinate frames are initially taken to be coincident. The grasp simulation studied here, is helpful in stability and equilibrating force analysis.