Abstract

This work presents a design exploration of underactuated robotic hands for enveloping and fingertip grasps. In design exploration, we compare the grasping performance of various hand designs to find the best design from the point of view of a large workspace or greater strength of the grasp. Parametric geometric design of the hand is considered and different combinations of the design parameters generate the candidate hand designs for comparison.

For a tripod fingertip grasp with a three-fingered hand, we choose the position and orientation workspace of the hand object system as the performance criterion. Results suggest that for a fully-actuated hand, hand designs with finger base locations placed closer are better for grasping small objects. For grasping large objects, hand designs with finger base locations farther apart are better. However, for an underactuated hand, designs with finger base locations placed farther apart give better performance for both large and small objects.

For enveloping grasps, we perform the design exploration of an underactuated finger to obtain a large number of configurations in which it can apply a positive grip on an object. The ratio of the radius of the pulleys at the joint and the link length are chosen as the design parameters. Performance criteria are a large feasible configuration and a large force applied by the finger on the object towards the palm. Results show the optimum radius ratio for every link-length. The link-length can be chosen based on the largest object that is required to be grasped using a tool that we present in the result.

For enveloping grasp with two-fingered hands, we define the strength of the grasp in terms of the grasp stiffness. Results show that an optimum value of the joint pulley radius ratio maximizes the grasp stiffness. The grasp, however, is non-immobilizing. We have explored the utility of joint limits for creating immobilizing grasps. We also found that reducing the base distance between the fingers and increasing the joint limits increases the range of object sizes immobilized. We have designed a fabricated a two-fingered and a five-fingered hand and performed grasp demonstrations on various objects.

Keywords: grasping performance; underactuated hands; design exploration; fingertip grasps; enveloping grasps