Geometrical Constraint in Grasping

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***Abstract*— Geometrical constraint in grasping, which is as known as caging, gives some advantages over conventional force-controlled grasping. For the difficulty of achievement of complete caging from the limitation of DOF of the hand, we propose partial caging, where the object is partly surrounded by the hand but it is allowed to escape from the hand. Some experiment shows that partial geometrical constraint is often enough to hold an object, taking the posture of the hand into account.**

I. Introduction

Caging is a method of geometrical constraint, where a position-controlled robot hand surround an object loosely and make it inescapable from the "cage" [1]. Caging grasps in the real scene have some advantages over conventional grasping. For example, caging grasps provide more reachability for humanoid robots and manipulators because of indeterminacy of contact points between the objects and the robots [2]. Moreover they can allow small errors in measurements of, for example, posture, size and even shape of objects.

Complete caging such above, however, is not easily achieved because of the limitation of DOF of the robot hand. Then we propose *partial caging*, in which the objects are partly geometrically constrained.

II. Partial Caging

Partial caging can be defined as that an object is geometrically constrained by robots but it has paths to escape from the partial confinement (We call "escape paths"). Although the object can escape through the escape paths, but it can be difficult, especially in the following two cases: 1) The escape paths are too constricted (Fig. 1); 2) Some forces are applied to the object to prevent it from escaping (Fig. 2). For robot hands whose size is almost same as humans hand, the limitation of DOF of the hand should be considered when the hand captures daily use equipments.

The idea of partial caging can be applied to conventional grasping because geometrical constraint provides fail-safe or more reliable strategies in grasping. In addition, caging may be applied to dynamic catching motion, instead of grasping. The robot only has to move the cage-shaped hand so that the thrown object comes into the cage.

In our research, we consider partial caging for some objects by a prosthetic hand, which is as large as a human hand and has same number of fingers and joints.

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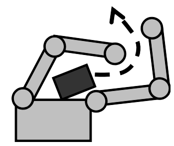


Fig. 1. The escape path is too constricted for the object to escape.

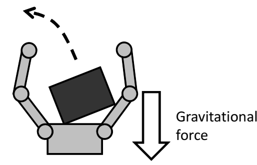
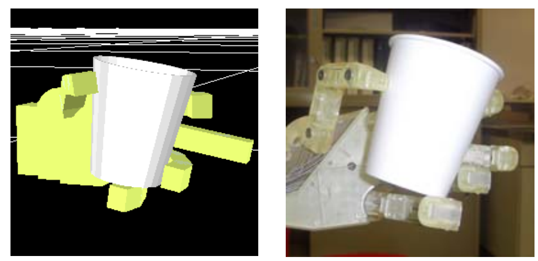


Fig. 2. The gravitational force prevent the object from escaping.



(a) In a simulation (b) In a experiment

Fig. 3. Partial caging for a paper cup

III. Experiment

A prosthetic hand used in the experiments is almost same size as that of an adult human. All the joints of the hand has 1 DOF for flexion/extension, and the CM joint of the thumb and the MP joint of other four fingers additionally has another DOF for adduction/abduction. We use no force sensors and force control, and show an experimental result for a paper cup in this paper.

To put a paper cup on the flexed little finger and locate other fingers along the side face of the object, we can achieve partial caging for the paper cup (Fig. 3). Although the cup is allowed to escape only from above, the gravitational force prevents it from escaping. Of course, it falls down when the hand rotates upside down, but we can hold the cup in gravity without rigid grasping or complete caging.

IV. Conclusions

In this paper, we proposed "partial caging", which is based on geometrical constraint by robot hands, and tested the methodology for one of objects with a prosthetic hand.

References

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