Advanced Robotics, Vol. 13, No. 3, pp. 353–354 (1999)

Grasp and manipulation for multiple objects

MAKOTO KANEKO [1], TATSUYA SHIRAI [2], KENSUKE HARADA [1] and TOSHIO TSUJI [1]

[1] *Cluster II, Faculty of Engineering, Hiroshima University, 1-4-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8527, Japan*

[2] *Graduate Student, Department of Computer Science, Hiroshima University, 1-4-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8527, Japan*

E-mail: kaneko@huis.hiroshima-u.ac.jp

Keywords: Multiple objects; manipulation; constant torque command; grasping.

The goal of this paper is to achieve grasp and manipulation of multiple objects initially placed on a table by using a multi-fingered robot hand. For grasping and manipulating an object, there are two grasp styles, i.e. finger-tip grasp and enveloping grasp. While we can expect a dexterous manipulation through a finger-tip grasp, it may easily fail in grasping multiple objects under a small disturbance. On the other hand, an enveloping grasp may ensure even more robustness for grasping multiple objects than a finger-tip grasp, due to a large number of distributed contacts on the grasped objects, although we cannot expect a dexterous manipulation for enveloped objects. Taking advantage of the robustness of the enveloping grasp, we focus on it for handling multiple objects. Another potential advantage of the enveloping grasp is expected when a hand lifts up two objects placed on a table, as shown in Fig. 1. Even under significant contact friction, a simple pushing motion enables two objects to be lifted up as if they were just connected by mechanical gears. One big problem for manipulating more than two enveloped objects is, however, that the manipulating force cannot be obtained uniquely for a given set of torque commands and it generally spans a bounded space. As a result, each object's motion is not uniquely determined either. Under such an important limitation for manipulating multiple objects in an enveloping manner, we pursue a primitive manipulation where the relative position between objects is changed by a constant torque command.

Figure 2 shows an experiment performed by a human where phase 1–4 denote a series of continuous photos taken when the line connecting the center of each object rotates every 45°. A human can achieve such a manipulating motion easily and quickly. We would note that, in most phases, a slipping contact is maintained between the two objects, while rolling is the dominant motion between each object and the hand. This experiment suggests making the most use of the slipping motion between the objects.

Figure 3 shows an analytical model. For a set of torque commands, we are interesting to know where the total force f_{t1} is. We determine the set of torque commands, so that

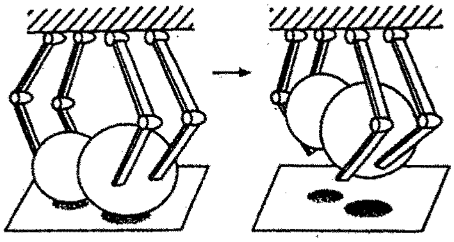

Figure 1. Realization of the enveloping grasp.

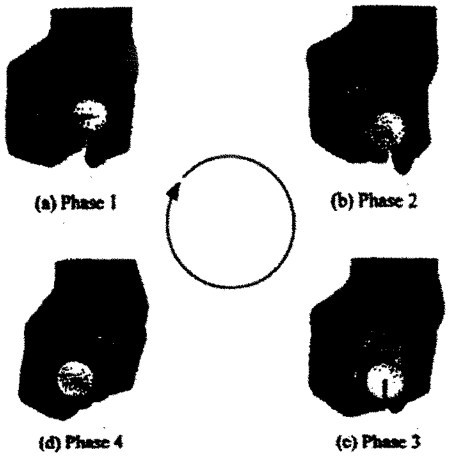

Figure 2. Manipulating two cylinders by a human.

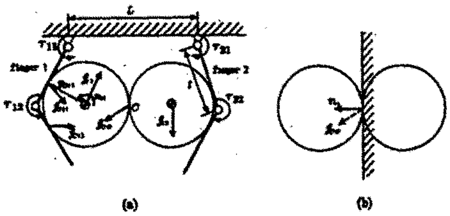

Figure 3. Model of the grasp system.

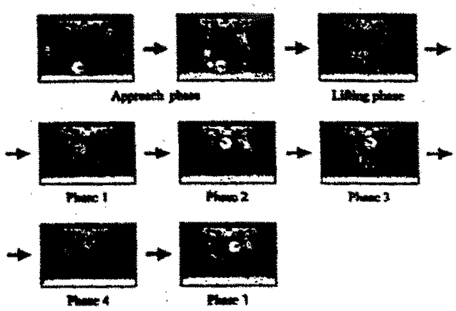

Figure 4. An experimental result.

the total force set always appears in the upward direction for the left object and in the downward direction for the right object. This condition guarantees only a small relative motion between two objects. Figure 4 shows an experimental result, where each finger first approaches and grasps two objects placed on a table and starts to manipulate them by changing the torque commands step by step. In this particular experiment, we prepared four sets of torque commands depending upon the relative position of the objects. Each torque command is chosen so that it is sufficient for producing a slipping motion at the point of contact between the objects. We believe that this is the first experiment on the manipulation of multiple objects within the hand.