Analysis and Planning of Graspless Manipulation
(Prof. T. Arai and Lecturer Y. Maeda (Yokohama National Univ.))

Graspless manipulation is to manipulate objects without grasping. That includes pushing, tumbling, pivoting, and so on (Fig. 1). Graspless manipulation enables robots to manipulate objects with smaller load and enhances their dexterity. However, we have difficulties in planning of robot motion for graspless manipulation. In planning of graspless manipulation, we have to consider mechanics in addition to geometry, because motion of the manipulated object depends on mechanical conditions such as friction. Moreover, a robot may be able to push an object but may not be able to pull it because of the unilateral nature of contact forces. The irreversibility of manipulation caused by mechanics makes planning more difficult.

We have developed an algorithm to plan general graspless manipulation by robot fingers and a theory of mechanics required for the manipulation planning. We conducted mechanical analysis on manipulation stability and internal force in graspless manipulation. In consideration of the stability of the manipulation, motions of the fingers including regrasping were obtained as the optimal solution (Fig. 3). By sampling C-Space adaptively, we can shorten the planning times. An example of execution of planned manipulation is shown in Fig. 4.

Keywords: Manipulation Planning, Graspless Manipulation

References
1) Kiyokazu MIYAZAWA, Yusuke MAEDA and Tamio ARAI, "Planning of Graspless Manipulation based on Rapidly-Exploring Random Trees," Proc. of 6th IEEE Int. Symp. on Assembly and Task Planning (ISATP2005), 2005 (to appear).
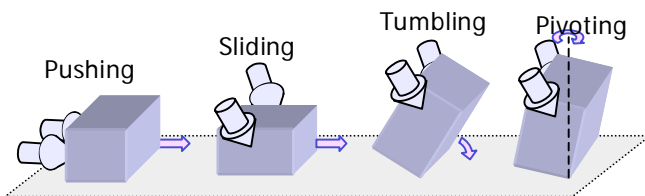
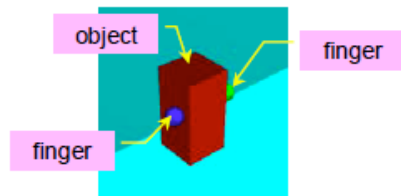Fig. 1 Graspless Manipulation
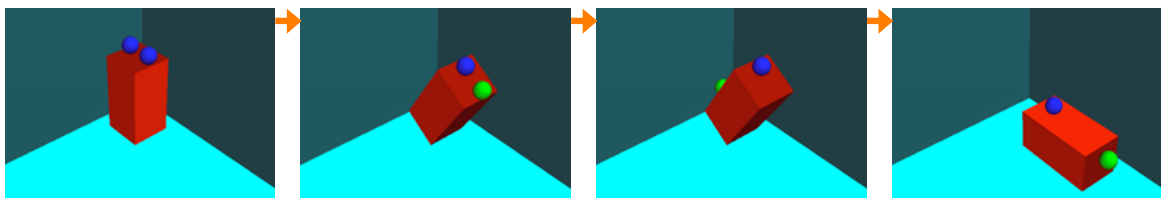

Fig. 2 Model of Graspless Manipulation

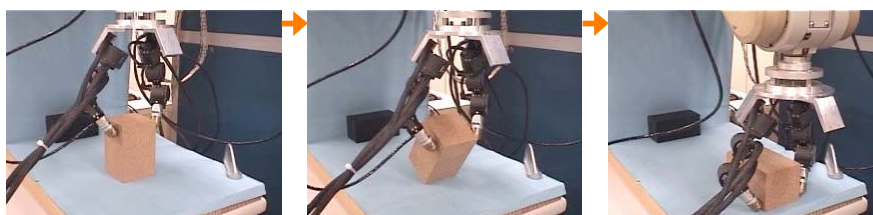Fig. 3 Planned Tumbling Operation with Regrasping

Fig. 4 Execution of Planned Tumbling Operation by Multi-Fingered Hand