Development and Manipulation Planning of Small Mobile Robot

Adopting robots in the manipulation of big-sized objects in domestic environments, human could be emancipated from such trivial works. However, big-scaled robots are not available in narrow domestic spaces. Owing to the small size and motion flexibility, small mobile robots are desirable for such tasks, because they can perform non-prehensile manipulation substituting manipulators by working cooperatively.

In our work, we adopted passive joints to design the mechanism of the multiple mobile robots [1,2], so as to realize the equivalent point—face contact model between the robots and the manipulated object. The costly controlling to maintain the object—robot contact could be avoided when manipulating the object. This simple contact model facilitated the manipulation planning, in which the contact state was required to be known to determine whether the robots provided adequate constraint for the manipulation.

In the manipulation planning, to deal with the distinct multi-level configuration space caused by the varying constraints in the robot-object system, a hierarchical method was adopted in our work. Defining a mode as a set of specific configurations that hold the same constraint, we specially focused on the modal planning, by which the manipulation action sequences could be determined to narrow down the configuration space for searching tasks [3]. Our proposed method determined the number of robots for manipulation stability, and investigated the mode transitions caused by the robots' motions and by the object's motions. With our method, the possible number of modes and their transitions was obviously reduced, and the determined mode sequences can be used to guide the further searching task for configuration planning.

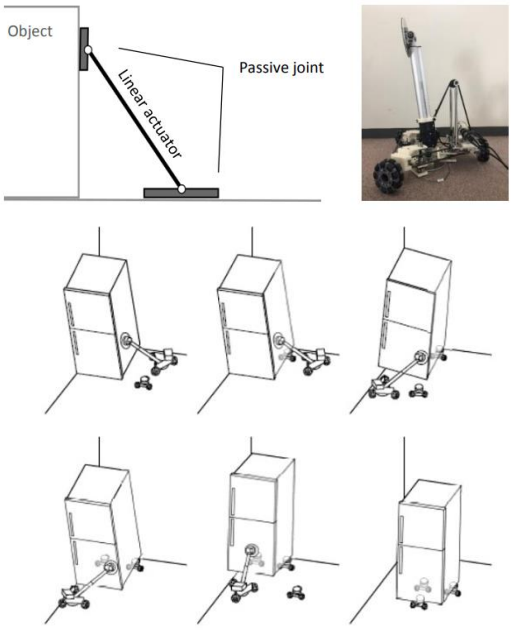

Figure 1. Constraints of the joints on the robotics leg using wires and non-circular pulleys.

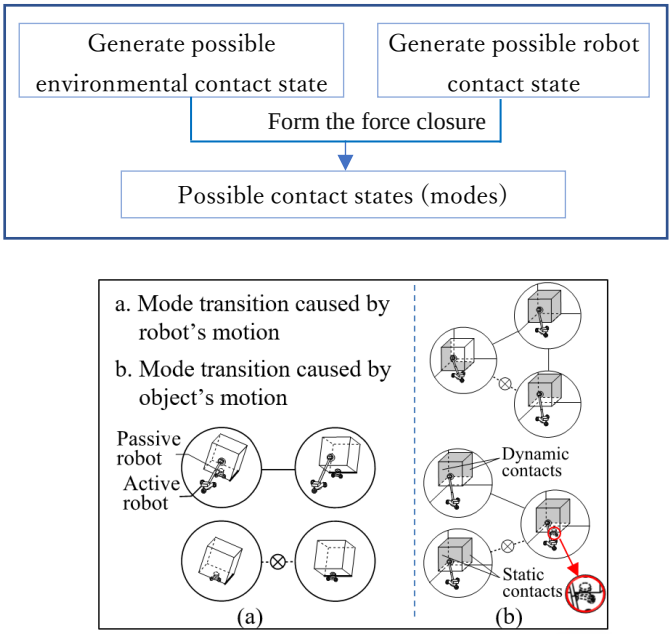

Figure 2. Mechanism to draw a letter on an egg-shaped object with less numbers of joints.

Keywords: mobile robot, simple contact model, manipulation planning, modal planning

References:

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[2] T. Ito, S. Shirafuji, J. Ota. Development of a Mobile Robot Capable of Tilting Heavy Objects and its Safe Placement with Respect to Target Objects. In Proceedings of the 2018 IEEE International Conference on Roboics and Biomimetics (ROBIO2018), Kuala Lumpur, Malaysia, 12–15 December 2018; pp. 716–722.

[3] C. Fan, S. Shirafuji, J. Ota. Modal Planning for Cooperative Non-Prehensile Manipulation by Mobile Robots. Applied Sciences, 2019, 9.3: 462.