The Grasp Acquisition Strategy of the Velvet II

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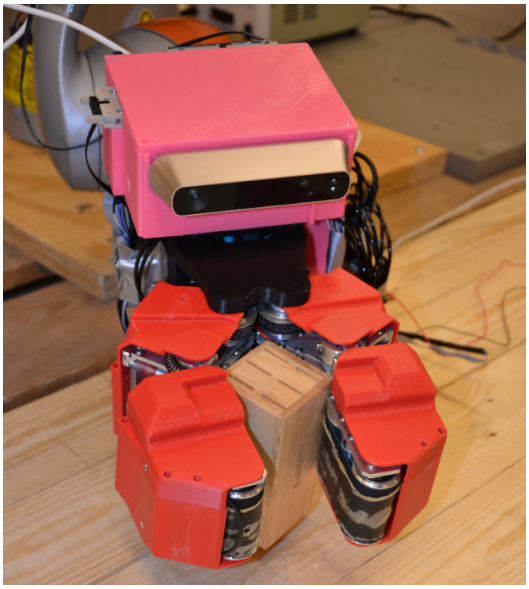

Fig. 1. A power grasp of a wooden object with the Velvet-II dexterous gripper.

In this work we exploit the combined effects of the under-actuation and the active surfaces of the Velvet II dexterous gripper. The aim is to achieve a firm enveloping grasp, starting from an initial pinch grasp. The pull-in grasping strategy described here turns out to be very useful in untidy environments where the scene is populated by many objects in a cluttered disposition. In this context, a nimble fingertip grasp is more likely to be feasible than a robust enveloping grasp [1], [2].

The Velvet-II is composed of two fingers, each of which can be regarded as a RR planar manipulator with a distal and a proximal phalanx each. One motor in the palm drives the opening and closing of the fingers through an under-actuated mechanism. During the closure, the fingers are extended and form a V-like shape while moving without obstruction. When the proximal phalanges are blocked by an object however, the closure behavior changes and the distal phalanges continue to rotate achieving a stable enveloping grasp. Additionally, the gripper comprises four independent active surfaces, one for each phalanx. These are implemented by controlled conveyor belts located on the fingers inside.

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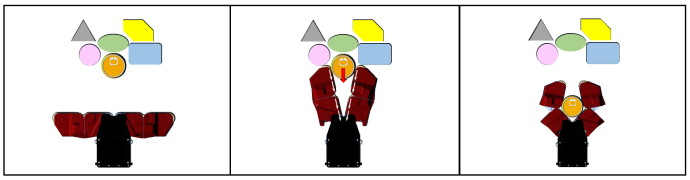

Fig. 2. Grasp Execution Control: (Left) as the gripper starts closing, the current through the opening motor is monitored; (Middle) after the fingertip contact with the object, the actuated belts are switched on to pull it in; (Right) the controller strives to maintain a given current set-point in order to enable compliant in-hand manipulation behavior.

The developed grasping strategy can be split in three stages as illustrated in Fig.2. First, a relatively low current threshold is given to the open/close motor controller and the fingers start closing. The V-like closure leads to a pinch grasp and the powering of the motor continues until the current absorption indicates a proper tip grasping force to ensure high friction between the object and the belts. Then stage two is triggered and the belts are actuated to pull in the object. While the object is dragged in, the current control gives the gripper a compliant behavior. Then, when the object reaches the proximal phalanges, the intrinsic adaptability of the gripper which is due to the under-actuated structure of the fingers leads to an enveloping grasp. In this grasping acquisition step, the encoders of the belts and the encoders of the joints between the phalanges are monitored. When the belts block and the phalanges have wrapped around the object, the final stage starts. Here, a higher current set-point is given to the open/close motor controller to ensure a firm grasp.

The set-point values are empirically tuned for a set of household objects. In general, they depend on the friction between target object and the belts, as well as on the friction between the object and its supporting surface. Also the object mass plays a significant role.

References

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[2] Krug, R., Stoyanov, T., Bonilla, M., Tincani, V., Vaskevicius, N., Fantoni, G., A. Birk, A. J. Lilienthal and Bicchi, A. (2014). Improving Grasp Robustness via In-Hand Manipulation with Active Surfaces. In IEEE International Conference on Robotics and Automation (ICRA).