Dexterous robotic in-hand manipulation of micro-objects: from trajectories planning to experimental validation.

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ABSTRACT

The creativity of human is based on a fantastic brain but also on a high grasping ability enabling to respectively imagine and build highly complex systems. Testing a concept by assembling devices together in an original configuration is absolutely common in human scale but very hard in micro-nanoscale because of the lack of human grasping capabilities in small scales. Our objective is to open the door of micro-nanoscale to human creativity via a robotic nanohand enabling to grasp, move, rotate, deform, position micro-nanocomponents with the same dexterity as the human hand in macroscale.

In microscale, robotic manipulations are usually limited to simple pick and place operations [1,2], and accurate multi-axes rotational positioning of micro-objects is particularly difficult to obtain which limits the possible micro-assembly operations [3]. Another characteristic of the manipulation at the micro-scale is the presence of surface forces which overcome gravitational and inertial forces. These surface forces generate adhesion which is considered usually by the micro-robotics community as perturbation forces. Contrary to numerous microrobotic approaches that try to minimize the adhesion effects [4,5], we propose to exploit the adhesion forces that can contribute to the stability of the object during the manipulation. Indeed, as adhesion forces are larger than gravitational force, a single finger can be sufficient to have a stable grasp [6].

As the dominant forces are different at the micro-scale compared to the macro-scale, innovative solutions and methods have to be developed to perform feasible and successful dexterous micro-manipulation. The main contribution of this paper is the study of the impact of adhesion forces on grasping micro-objects and the development of a trajectory planner for in-hand dexterous micro-manipulation where original fingers trajectories are proposed. The trajectories, currently limited to planar movement, have been tested and validated experimentally on micro-objects whose typical size is below one millimeter. The results show that in-hand micro-manipulation is significantly different than macro-manipulation. Adhesion phenomena cannot be neglected and we showed that adhesion is useful in the manipulation process. Moreover, even if the adhesion is not fully predictable our planner can generate trajectories robust to adhesion variations.

The future works will involve optimization of the grasping forces on the generated trajectory. In addition, as the problem was formalized for three dimensions in-hand micro-manipulation but only solved in two dimensions, the current planner will be extended to non-planar objects and manipulations.

REFERENCES