Towards Real-Time Robotic Motion Planning for Grasping in Cluttered and Uncertain Environments

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Adaptation to unorganized, congested and uncertain environment is a desirable capability but challenging task in development of robotic motion planning algorithms for object grasping. We have to make a tradeoff between coping with the environmental complexities using computational expensive approaches, and enforcing practical manipulation and grasping in real-time. In this paper, we present a brief overview and research objectives towards real-time motion planning for grasping in cluttered and uncertain environments. We present feasible ways in approaching this goal, in which key challenges and plausible solutions are discussed.

Motion planning is an essential aspect for robotic system and control. Prevailing solutions such as sampling-based push-grasping [1, 2], optimization-based approaches [3, 4] and learning from demonstration [5] (LfD) have demonstrated their effectiveness in specific motion planning task. However, sampling-based approaches are computationally inefficient for manipulator motion planning [3, 4], optimization-based methods typically require hand-coded cost functions to achieve and formulate the desired behaviors [5]. In unorganized, congested and complex environments diffused with rigid and deformable objects, robotic motion planning for object grasping has been proven an intractable task. LfD approaches guided by human expert are plausibly the more approachable solutions towards this problem, because of their implicit behavior learning from expert demonstrations and less dependence on analytical models. Nevertheless, cluttered environment brings some challenging issues need to be solved under this method, for instance, coping with deformable obstacles. Deformable objects (e.g., flexible pipes, clothes, curtains) present different features from rigid ones because of their texture and deformability, and their infinite degrees of freedom make the configuration very intractable to recover. They may also cause uncontrolled robotic motion during grasping and/or manipulation. Towards this end, the preliminary research questions that we are approaching include how to optimally grasp and rearrange the movable deformable obstacles to reach the target object? And how to find good grasp configurations that are reachable in a cluttered environment?

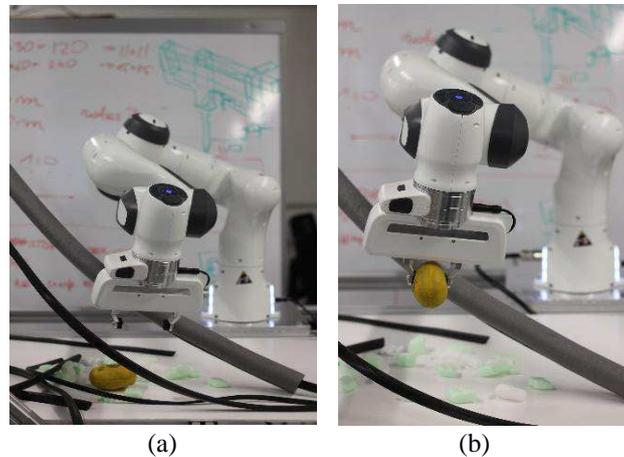Based on our previous work [5], the goal of work-in-progress (as shown in Fig. 1)

Fig. 1. (a) Motion planning and (b) grasping in cluttered environment diffused with rigid and deformable objects.

is to make steps forward through exploring the idea of expert guided trajectory optimization by LfDs as a strong influence on robotic motion planning for grasping. In real-world cluttered scenarios, it might be impossible for the robot to directly reach the target by following a collision-free trajectory and traversing between static and movable objects. Thus, this work has potential applications in push-grasping in various domains and scenarios diffused with rigid and deformable objects. For example, automated vegetable harvesting and fruit picking in agriculture, and autonomous garbage (e.g., protection suit, respirator, slightly flexible wires, and curtains) sorting in nuclear facilities. Admittedly, it is extremely hard to find cost functions that can be used to realize high quality paths in such scenarios as it is intractable to determine when and how these obstacles can be pushed/rearranged. This will be investigated in our on-going works.

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