Improving robotic manipulation is critical for robots to be actively useful in real-world factories and homes. While some success has been shown in simulation and controlled environments, robots are slow, clumsy, and not general or robust enough when interacting with their environment. By contrast, humans effortlessly manipulate objects. One possible reason for this discrepancy is that, starting from birth, humans have years of experience to collect data and develop good internal models of what happens when they manipulate objects. If robots could also learn models from a large amount of real data, perhaps they, too, could become more capable manipulators. In this thesis, we propose to improve robotic manipulation by solving two problems. First, we look at how robots can collect a large amount of manipulation data without human intervention. Second, we study how to build statistical models of robotic manipulation from the collected data. These data-driven models can then be used for planning more robust manipulation actions.

To solve the first problem of enabling large data collection, we perform several different robotic manipulation experiments and use these as case studies. We study bin-picking, post-grasp manipulation, pushing, tray tilting, planar grasping, and regrasping. These case studies allow us to gain insights on how robots can collect a large amount of accurate data with minimal human intervention.

To solve the second problem of statistically modeling manipulation actions, we propose models for different parts of various manipulation actions. First, we look at how to model post-grasp manipulation actions by modeling the probability distribution of where an object ends up in a robot’s hand, and how this affects its success rate at various tasks such as placing or insertion. Second, we model how robots can change the pose of an object in their hand with regrasp actions. Third, we improve on the place and pick regrasp action by modeling each separately with more data. These learned data-driven models can then be used for planning more robust and accurate manipulation actions.

Abstract

Improving robotic manipulation is critical for robots to be actively useful in real-world factories and homes. While some success has been shown in simulation and controlled environments, robots are slow, clumsy, and not general or robust enough when interacting with their environment. By contrast, humans effortlessly manipulate objects. One possible reason for this discrepancy is that, starting from birth, humans have years of experience to collect data and develop good internal models of what happens when they manipulate objects. If robots could also learn models from a large amount of real data, perhaps they, too, could become more capable manipulators. In this thesis, we propose to improve robotic manipulation by solving two problems. First, we look at how robots can collect a large amount of manipulation data without human intervention. Second, we study how to build statistical models of robotic manipulation from the collected data. These data-driven models can then be used for planning more robust manipulation actions.