Robot Manipulation: Sensing and Adapting to the Real World

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***Abstract*— There is a resurgence of interest in robot manipulation as researchers seek to push autonomous manipulation out of controlled laboratory settings and into real-world applications such as health care, generalized factory automation, domestic assistance, and space exploration. This workshop facilitated progress towards these goals by focusing on autonomous robot manipulation and the requisite sensing and adaptation. The workshop was a full-day event consisting of nine talks, four discussions, two poster sessions, and demos which are summarized below.**

A. Tactile Sensing

Several different approaches to tactile manipulation were presented in the morning session through talks and posters, including statistical matching of geometric models to tactile sensor readings, POMDPs for grasping of planar block-shaped objects, and behavior-based grasping of books from a shelf. Most of the work focused on grasping objects. The accompanying discussion heavily emphasized the need for off-the-shelf tactile sensing technology. It was suggested that tactile sensing for robots might be the next significant sensor to drive manipulation research, similar to the way that SICK laser range finders influenced navigation research.

B. Low-dimensional Control

Prior to lunch, two presentations on low-dimensional control for robotic grasping were given, followed by discussion. Both talks proposed a low-dimensional representation of the full manipulator configuration space. One talk used the low-dimensional representation to simplify manipulation teleoperation. The other used it to simplify search in a manipulation planning task. In the discussion that followed, it was noted that neither approach integrated realistic sensor feedback. Nevertheless, participants were interested in the potential of this approach. It was conjectured that if the majority of grasping interactions can be described in terms of a low-dimensional embedding in the manipulator configuration space, then some important autonomous manipulation problems may not be as difficult as generally believed. Participants also noted that underactuated manipulators can take advantage of this low-dimensional representation mechanically, instead of computationally.

C. Keynote Talk

Andrew Ng from Stanford University gave the keynote talk after lunch. He discussed a diverse set of research projects in progress at Standford including the STAIR Project (Stanford AI Robot) that he leads. This research addressed the themes of the workshop with a strong emphasis on visual sensing. It culminated in several examples of integrated real-world robotic systems performing manipulation tasks using visual, laser-based, and tactile perception. For example, the STAIR robot fetched a stapler in another room for a person sitting at a table in a conference room. One interesting challenge that Andrew Ng mentioned in his talk is the lack of robust and effective visual object recognition in real-world settings. He asserted that because visual recognition techniques are currently not as robust as necessary, it may be worthwhile for manipulation research to circumvent this problem by using RFIDs or other technologies.

D. Poster and Demo Session II

As part of a second poster and demo session after the keynote talk, posters focused on a variety of different topics ranging from learning to human safety. The demonstrations showed off-the-shelf robot arms and hands from Barrett Technologies, Neuronics, and Shadow.

E. Visual Sensing

The session on visual sensing looked at methods for visually locating door handles, detecting rotary joints in planar objects through manipulation, and using human-in-the-loop control to train visual-motor controllers. The discussion touched on a number of issues, including the desire for perceptual systems that attend to what is important in a given task. Attendees also expressed interest in the potential for sensors that provide reliable, dense depth information over an entire plane. The general consensus was that current sensors do not do this sufficiently well, but that high-quality off-the-shelf sensors of this nature could potentially have a dramatic impact on robot manipulation.

F. The Future

The workshop concluded with three very short impromptu talks and a moderated discussion of potential future applications for autonomous robot manipulation. In the discussion, participants identified some promising applications, technical challenges impeding these applications, and milestones for research. The notes from this discussion, a schedule, accepted submissions, and more can be found at the workshop website:
http://manipulation.csail.mit.edu/rss07/
and in the workshop proceedings:
http://www.archive.org/details/sensing_and_adapting_to_the_real_world_2007.