CHALLENGES FOR ROBOT MANIPULATION IN HUMAN ENVIRONMENTS

DEVELOPING ROBOTS THAT PERFORM USEFUL WORK IN EVERYDAY SETTINGS

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Presentation Overview

- Motivation
- Challenges Inherent to Human Environment
- Today's Robots (& Their Limitations)
- Approaches to Combating These Challenges
- Smooth (Incremental) Paths to Progress
- (Ambitious) "Grand Challenges"
- Discussion

Motivation

- Observation: The everyday manipulation tasks we take for granted would stump even the greatest robot bodies and brains in existence today.
- Question: Why are robots so glorious in the factory, yet so incompetent in the home?
- Goal: We would like robots, in both domestic settings and the workplace, to physically alter the world they inhabit, and to improve the life of humans.

The Challenges inherent to Human Environments

- People are present
- Environments built-for-humans
- Other autonomous actors are present
- Dynamic variation
- Real-time constraints

More Challenges…

- Variation in object placement and pose
- Long distances between relevant locations
- Need for specialized tools
- Variation in object type and appearance
- Non-rigid objects and substances
- Sensory variation, noise, and clutter

Today's Robots (& Their Limitations)

- 1. Simulation: we program the robot to behave in accordance with the world around it
- 2. Controlled Environment: the world can be adapted to match the capabilities of the robot
- 3. Operated by a Human : (teleoperation)

Approaches to Combating These Challenges

- Perception
  - Active Perception and Task Relevant Features
  - Vision
  - Tactile Sensing

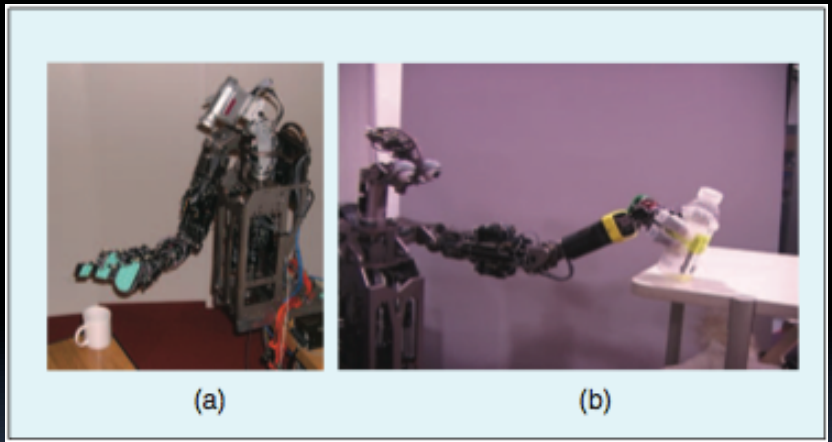

Figure 3. *(a) MIT robots Obrero and (b) Domo use compliance and force control to safely reach out into the world. Obrero reaches in the general direction of an object and then finds and grasps it haptically [8]. Domo initially reaches out toward a shelf in order to confirm its location and find a posture for placing objects. Once Domo has an object in hand, it reaches for the shelf with this posture and uses force control and compliance to let the object settle into place. [5].*

Approaches to Combating These Challenges (Continued)

- Learning
  - Opportunities for Learning (teleoperation)
  - Common Sense for Manipulation (Databases)

Figure 6. *Researchers from Brown and Vanderbilt have been developing methods that enable Robonaut to learn to behave autonomously from teleoperated examples. At the workshop, they presented a method that discovers instances of success and failure from teleoperated examples of Robonaut using a power drill [11].*

Approaches to Combating These Challenges (Continued)

- Working With People
  - Semi-Autonomous Teleoperation
  - Human Interaction and Cooperation
  - MIT's Domo helps clean house
- Platform Design
  - Safety
  - Designing for Uncertainty
  - On Human Form

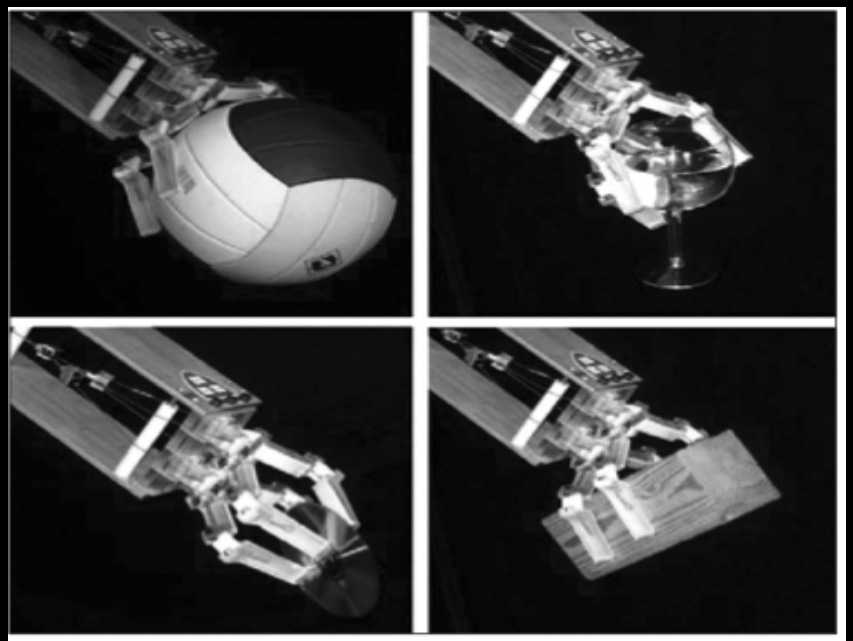

Figure 12. *A compliant grasper developed by A. Dollar and R. Howe at Harvard University leverages its adaptive physical design to robustly grasp unknown objects [16].*

- Meka H1 Hand demo - Grasp reflex

Smooth (Incremental) Paths to Progress

- By Approach
- By Module, Platform, and Algorithm
- From Semi-Autonomy to Full Autonomy
- From simple to complex tasks

- Integrated systems vs. basic research?
  - What are the tradeoffs?
  - Can we get the best of both?

(*Ambitious*) Grand Challenges

- Disordered House to an Ordered House
- Preparing and Delivering an Order at a Burger Joint
- Outdoor Party Preparation

- Assembling a shelter from truss materials?

Discussion Question

- In light of what we just covered, do you still think robots are at the very brink of becoming a "pervasive tool?"