Personal Robotics Clinic
Algorithms and Applications

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http://www.cs.washington.edu/education/courses/cse599j/12sp/
### Comparing Personal Computers and Personal Robots

<table>
<thead>
<tr>
<th>MITS Altair 8800</th>
<th>Apple ][</th>
<th>Xerox Alto</th>
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</thead>
<tbody>
<tr>
<td><img src="image" alt="MITS Altair 8800" /></td>
<td>![Apple ]<a href="image"></a></td>
<td><img src="image" alt="Xerox Alto" /></td>
</tr>
<tr>
<td>iRobot Roomba</td>
<td>Still waiting</td>
<td>Willow Garage PR2</td>
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Visualizing Personal Robots with the PR1
Tele-operated PR1 (Personal Robot 1) from Stanford & Willow Garage

Tidy room
Care for elderly
These illustrate application scenarios and show mechanical feasibility

How it was done:
A puppet-master behind the scenes
Visualizing Personal Robots
Tele-operated PR1 (Personal Robot 1) from Stanford & Willow Garage

Sweep & vacuum

Fetch beer
Personal Robotics Applications

Service / assistance
- Fetch; Laundry; Dishwasher loading; Elder / disabled care

Transportation / mobility / logistics
- Driving / delivery; Warehouse automation (e.g. Kiva)

Manufacturing / un-manufacturing
- Assembly assistance; Trash / recycling sorting & disassembly
- “Flexible fabrication” (beyond 3D printing, e.g. programmatic domino set up)

Entertainment & Sports
- Games: Chess, Rubik’s Cube
- Sports: Ping pong, Pool, Hide & Seek, etc
Robotic laundry folding

Cloth Grasp Point Detection based on Multiple-View Geometric Cues with Application to Robotic Towel Folding

Jeremy Maitin-Shepard
Marco Cusumano-Towner
Jinna Lei
Pieter Abbeel

Department of Electrical Engineering and Computer Science
University of California, Berkeley

International Conference on Robotics and Automation, 2010
Beer fetching
**Bio Fetch**

Biological Fetch: Helper Monkeys cost $35K and take 5 years to train.
Rubik’s Cube

PR2 SOLVING A RUBIK'S CUBE

Chris Burbridge
Lorenzo Riano

University of Ulster
Intelligent Systems Research Centre
A robot that “smells its food” by sensing Electric Fields

Robot, Feed Thyself: Plugging In to Unmodified Electrical Outlets by Sensing Emitted AC Electric Fields, ICRA-2010.
B. Mayton, L. LeGrand, J.R. Smith
Gambit: A Chess playing automaton
Robotic Capabilities

Robotic capabilities

Navigation
Manipulation
Walking
Jumping
Social interaction
Navigation

Stanford Cart 1979
(video speed: 200 x realtime)

CMU Boss 2007
(video speed: 1 x realtime)
Manipulation
Pile manipulation: Singulation of unknown objects
Walking (Big Dog)
Jumping
Social Interaction
Social Interaction
Robotic Research Disciplines

Research disciplines
Sensing
Perception
Control
Planning
2007: Velodyne laser rangefinder

Breakthrough: direct measurement of 3D information
Enabler for navigation
Electric Field Sensing

E-Field sensing is used by fish but not by humans
Fish generates & detects a weak electric field (green lines)
Objects (red) change detected electric field (lighter green line)

Black ghost knife fish
(*Apteronotus albifrons*)
1KHz continuous wave

Fish tail curling behavior increases image contrast
W. Heiligenberg. Studies of Brain Function, Vol. 1:
Principles of Electrolocation and Jamming Avoidance
New Sensors

Electric Field Pretouch

An Electric Field Pretouch System for Grasping and Co-Manipulation, ICRA-2010.
B. Mayton, L. LeGrand, J.R. Smith
Taking object from person, from table
Seashell effect pretouch

APPLICATION I:

Reactive Grasping of Compliant Objects
Sensor Design on PR2

Sensor size on fingertips: 5mm(diameter) x 8mm(length)

Utilize ambient noise → Passive!
Sensor Characterization: Performance

The box and whisker plot of 1000 estimated resonance frequencies at 1-10 mm.

**Application Parameters**
- Frequency: 9500 Hz
- Distance: 3 mm
Seashell effect pretouch & grasp planning

APPLICATION II:

Pretouch-Assisted Grasp Planning

Given the pointcloud from camera, the pretouch sensor will add additional points.

The concatenated pointcloud will be used for grasp planning.
Algorithm focus in this course: planning

Path planning
- Dijkstra
- A*
- RRT
- Laplace

Arm planning
- Forward Kinematics
- Inverse kinematics
  - Direct; Iterative
Other possible topics

path smoothing
collision detection algorithms
grasping
Potential novel research --- final project?

Apply Laplace planners to arm planning
Hybridize RRT & Laplace planning
PR2 Mobile Manipulation planning

move PR2 base, torso, and arms together