COMP 150: Developmental Robotics

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Introduction

- Welcome!
- Who am I?
- Who are you?
- What to expect
My robot friends...
Stand or Sit
What is a robot?

(class discussion)
Robots in Industry
Mobile Robots
“Service” Robots
Planetary Exploration Robots
Driverless Cars
Entertainment Robots
Robots in Science Fiction
We’re building a dream, one robot at a time.

The dream was simple. Design a robot that, one day, could duplicate the complexities of human motion and actually help people. An easy task? Hardly. But after more than 15 years of research and development, the result is ASIMO, an advanced robot with unprecedented human-like abilities. ASIMO walks forward and backward, turns corners, and goes up and down stairs with ease. All with a remarkable sense of strength and balance.

The future of this exciting technology is even more promising. ASIMO has the potential to respond to simple voice commands, recognize faces, carry loads and even push wheeled objects. This means that, one day, ASIMO could be quite useful in some very important tasks. Like assisting the elderly, and even helping with household chores. In essence, ASIMO might serve as another set of eyes, ears and legs for all kinds of people in need.

All of this represents the steps we’re taking to develop products that make our world a better place. And in ASIMO’s case, it’s a giant step in the right direction.
腕と多指ハンドを使った作業
Performing tasks using arms and multi-fingered hands
ASIMO opens a lid/pours drink into a cup
Toyota's Attempt 20 years later…
Partner Robot

Toyota's Human Support Robot
Why are we not there yet? What are the greatest difficulties towards getting robots to be autonomous and intelligent?
Developmental Robotics

“Truly intelligent robot behavior cannot be achieved in the absence of a prolonged interaction with a physical or social environment. In other words robots must undergo a developmental period similar to those of humans and animals.”

- Alexander Stoytchev
Developmental Robotics

- Relatively small sub-field...but with great potential

- Started early 2000s – many ideas have now filtered out and become mainstream

- Relatively unexplored
Repeating Themes

- Pre-programming is not enough!
- Interaction
- Embodiment
- Self-organization
- Grounding
- Verification and correction of internal representations
- Stages of development...
Topics

• Overview of robotics
  – Robot architectures, mobile robots and robot manipulators, learning methods for robots

• What is intelligence?

• Theories of Development
  – Nature vs Nurture? Or something else?

• Embodiment and the Sense of Self
  – Body scheme, self-recognition
Topics (2)

- Learning about objects and their affordances
- Tool use in humans, animals, and robots
- Multi-modal sensing and self-organization
- Theories of vision in humans and robots
- Social learning
  - Language, scaffolding, socially-guided learning
- ...

Robot Simulators
What is Intelligence?
Embodiment
The Sense of Self

A PRESENCE BEHIND
Stimulation of the **left angular gyrus** gave the patient a sensation of a shadowy person lurking behind.

The shadowy figure is actually a perceived double of the self.

OUT-OF-BODY
Stimulation of the **right angular gyrus** resulted in an out-of-body experience, as if the patient were floating from the ceiling, looking down at herself.

Perceived location
Actual location

Source: Dr. Olaf Blanke

Graham Roberts/The New York Times
Body Schema
Extensible Body Schema

Figure 1. Changes in bimodal receptive field properties following tool-use. The somato-sensory receptive fields (sRF) of cells in this region were identified by light touches, passive manipulation of joints or active hand-use. The visual RF (vRF) was defined as the area in which cellular responses were evoked by visual probes (the most effective ones being those moving towards the sRF. (a) sRF (blue area) of the ‘distal type’ bimodal neurons and their vRF (pink areas) (b) before tool-use, (c) immediately after tool-use, and (d) when just passively grabbing the rake. (e) sRF (blue area) of ‘proximal type’ bimodal neurons, and their vRF (pink areas) (f) before and (g) immediately after tool-use.
Self-Recognition
Self-Recognition in Robots
Theories of Development

Fetal Growth From 8 to 40 Weeks
Theories of Development
Affordances

- Button - Push
- Switch - Flip
- Knob - Rotate

Light Feedback
Example: Doors
Learning Affordances
Tool Use
Tool Use by Robots
Sensory Substitution
Image-to-Sound Mapping

Hearing is seeing is believing
By converting images into a series of sounds, the vOICe system can restore "vision" to the blind

The vOICe device uses a webcam, mounted on a pair of sunglasses, which captures the scene in front of the user.

This image is sent to a computer that converts the picture into a series of sounds (a "soundscape") that are played into the user's ears.

The user's brain initially tries to decode this information in the auditory cortex.

After 10-15 hours of training, however, regions of the visual cortex begin to "light up". This shows a very rapid redirecting of pathways in the brain.

Around the time that the visual cortex becomes active, the users become more adept at understanding the soundscapes and recognising objects.

The vOICe software scans across the image from left to right, converting each pixel into a beep, with the frequency representing its vertical position. The volume of each beep represents the brightness of the pixel.
Sensory Substitution
Theories of Vision
Seeing is making an internal representation

detailed internal representation

Seeing is knowing about things to do
standard view

Brain creates experience

detailed internal representation

new view

Brain creates actions and has knowledge
Language Acquisition
Learning Multi-modal Grounded Linguistic Semantics by Playing "I Spy"
...and much more!
Reading Assignment 1

• Posted on course website
Homework 0

- Read the syllabus and the course web page and think of a question you have that is not answered – email it to me (subject: [comp150])!

- Course web-page:
  
  http://www.cs.tufts.edu/comp/150DR/
Questions / Comments?