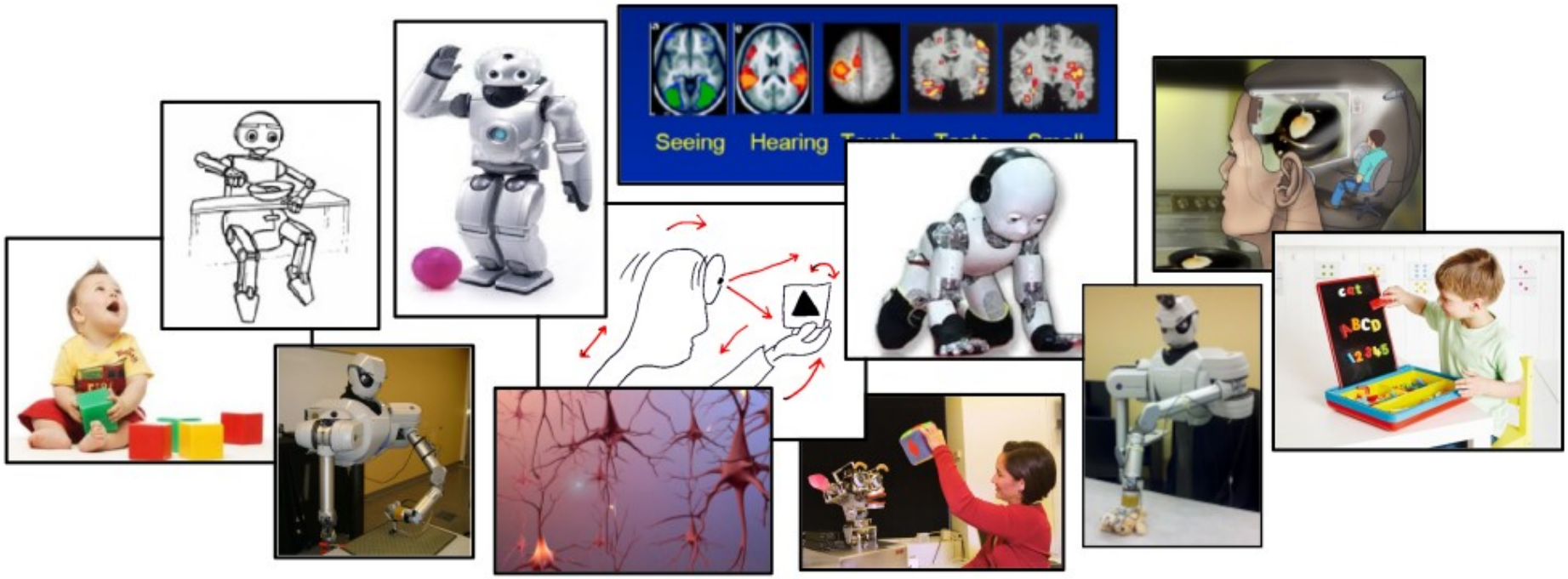


COMP 150: Developmental Robotics

Instructor: Jivko Sinapov
www.cs.tufts.edu/~jsinapov

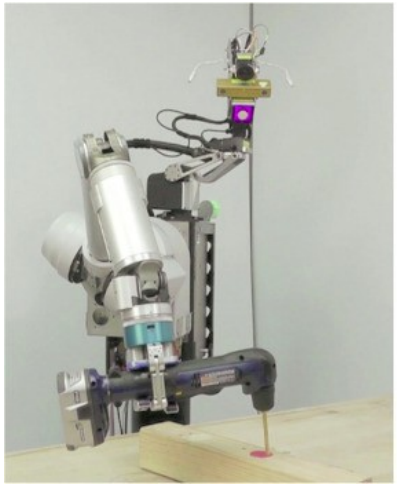
Introduction

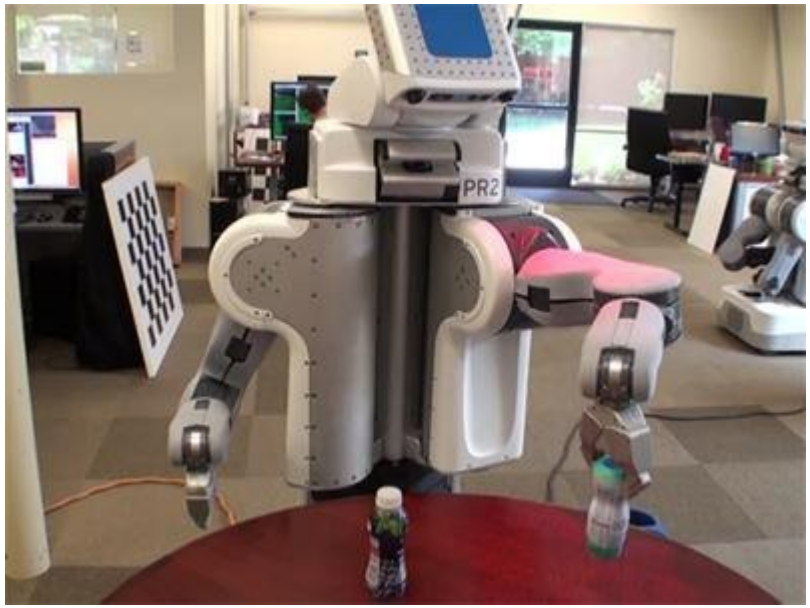
- Welcome!
- Who am I?
- Who are you?
- What to expect

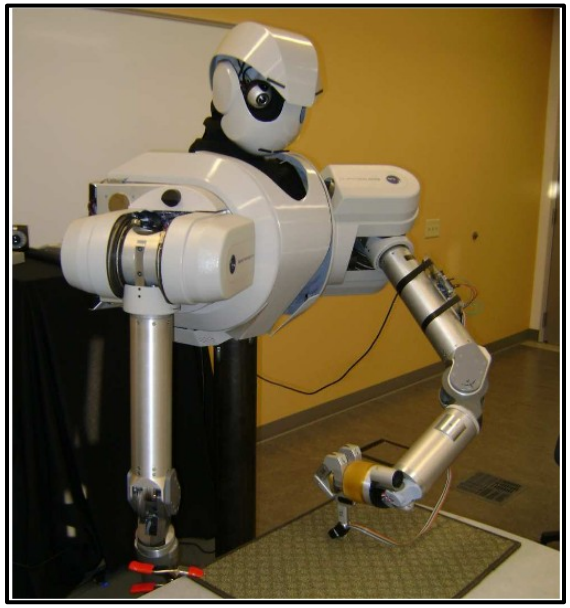

Willow Garage
STATE
UNIVERSITY of ROCHESTER
HRL LABORATORIES
THE UNIVERSITY OF TEXAS AT AUSTIN
CANADA
MEXICO
Washington
Oregon
Idaho
Montana
Wyoming
Nevada
Utah
Colorado
California
Arizona
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maine
Vermont
New Hampshire
Mass.
R.I.
Conn.
New Jersey
Delaware
Md.
Washington, D.C.
Edmonton
Vancouver
Regina
Winnipeg
Seattle
Olympia
Salem
Helena
Bismarck
Pierre
Cheyenne
Salt Lake City
Denver
Lincoln
Des Moines
Topeka
Jefferson City
St. Louis
Springfield
Indianapolis
Columbus
Lansing
Detroit
Toronto
Chicago
Albany
Boston
Providence
Hartford
New York
Trenton
Philadelphia
Harrisburg
Dover
Annapolis
Richmond
Charleston
Frankfort
Raleigh
Nashville
Columbia
Atlanta
Montgomery
Tallahassee
Baton Rouge
New Orleans
Austin
Houston
San Francisco
Phoenix
Hermosillo
Chihuahua
Monterrey
Miami
Nassau
THE BAHAMAS
Gulf of Mexico
North Atlantic Ocean
★ National capital
U.S. State
State capital
Scale 1:13,500,000
Albers Equal-Area Projection
0 500 Kilometers
0 500 Miles

My robot friends...



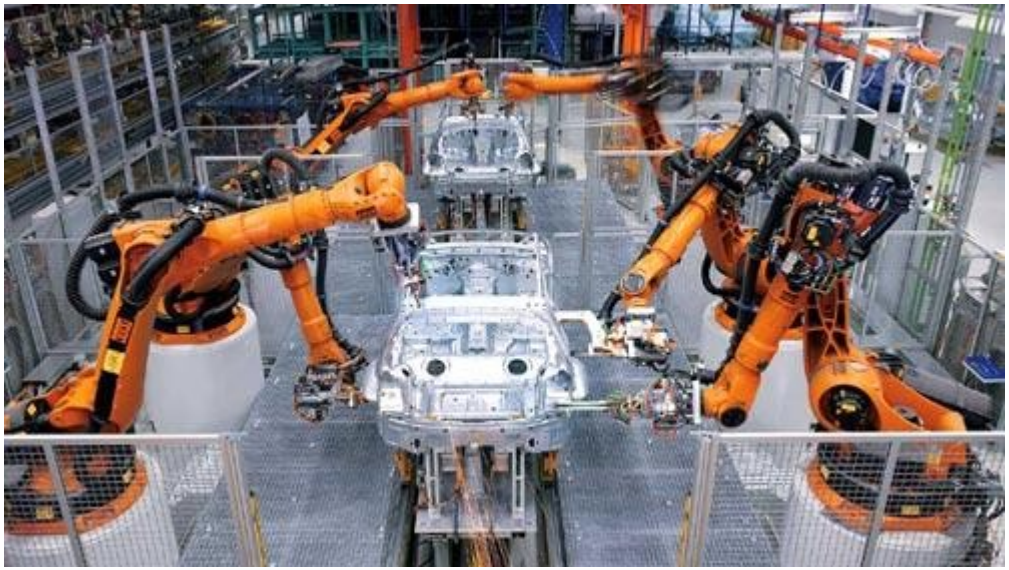



Stand or Sit

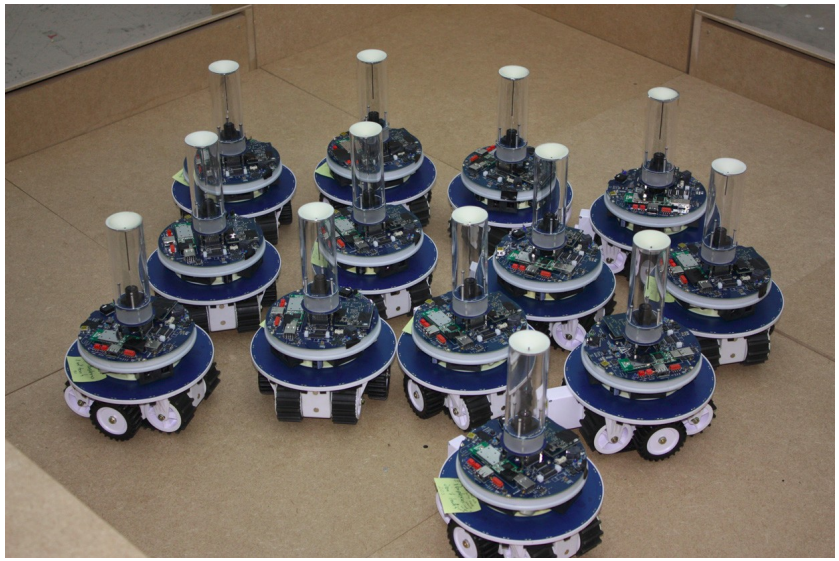
What is a robot?

(class discussion)

Robots in Industry

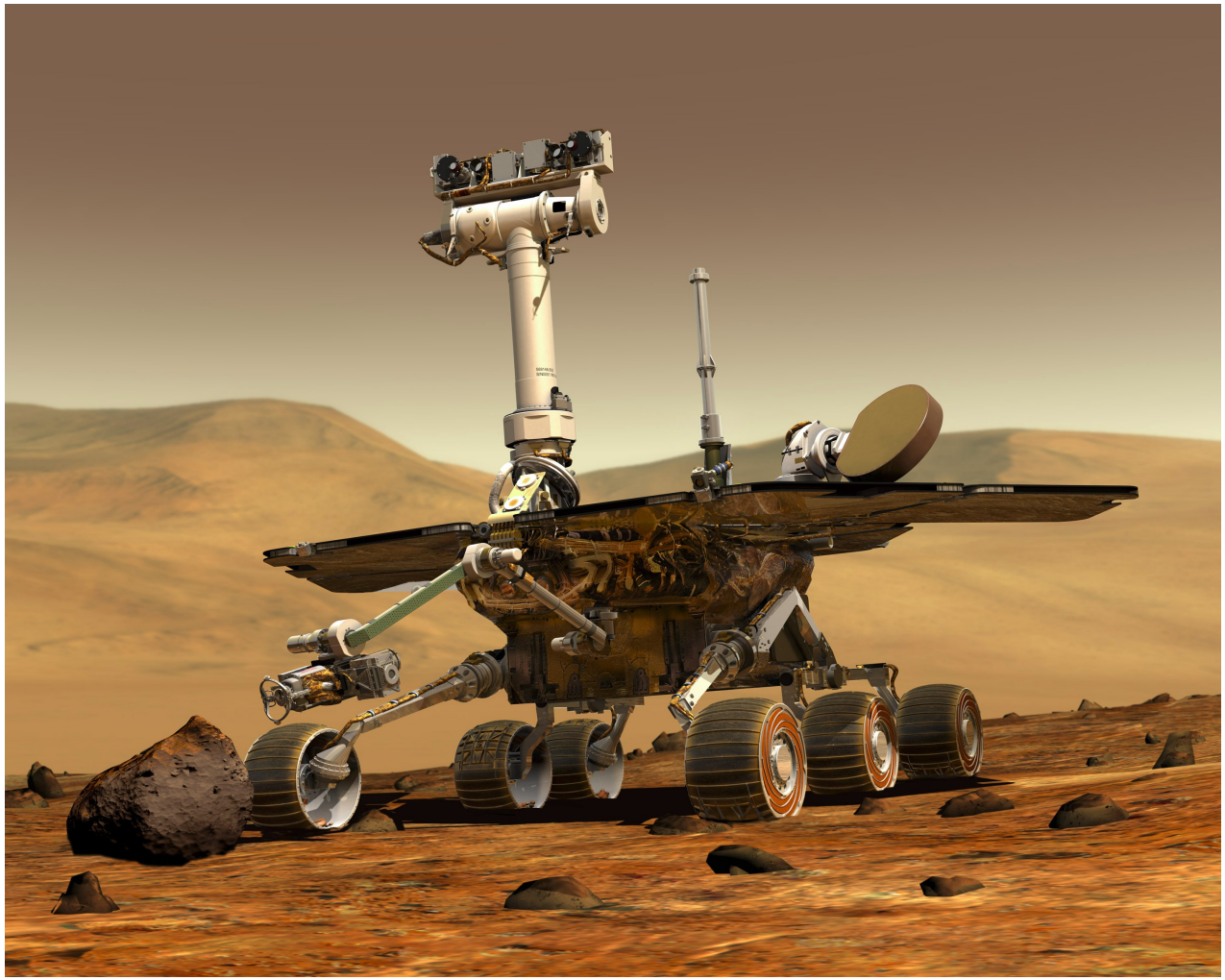


Mobile Robots



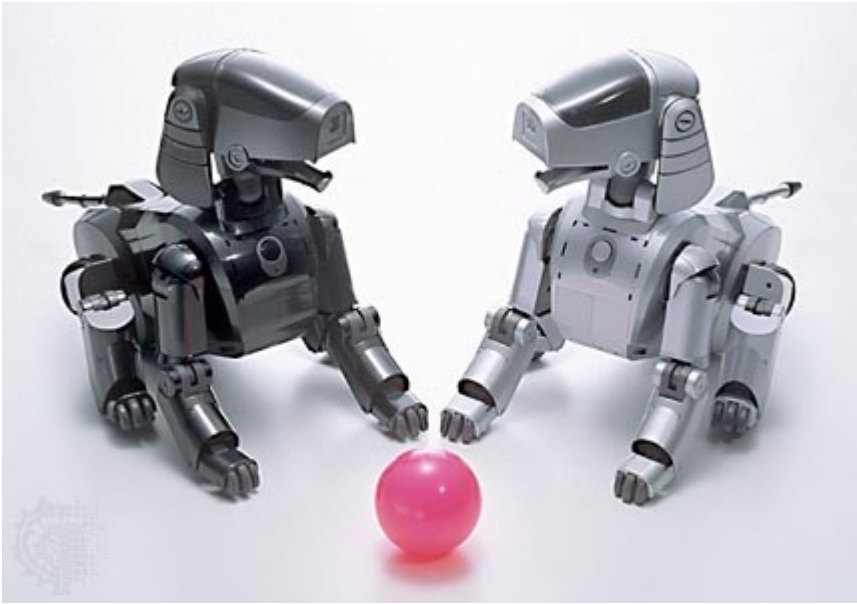
“Service” Robots

Planetary Exploration Robots

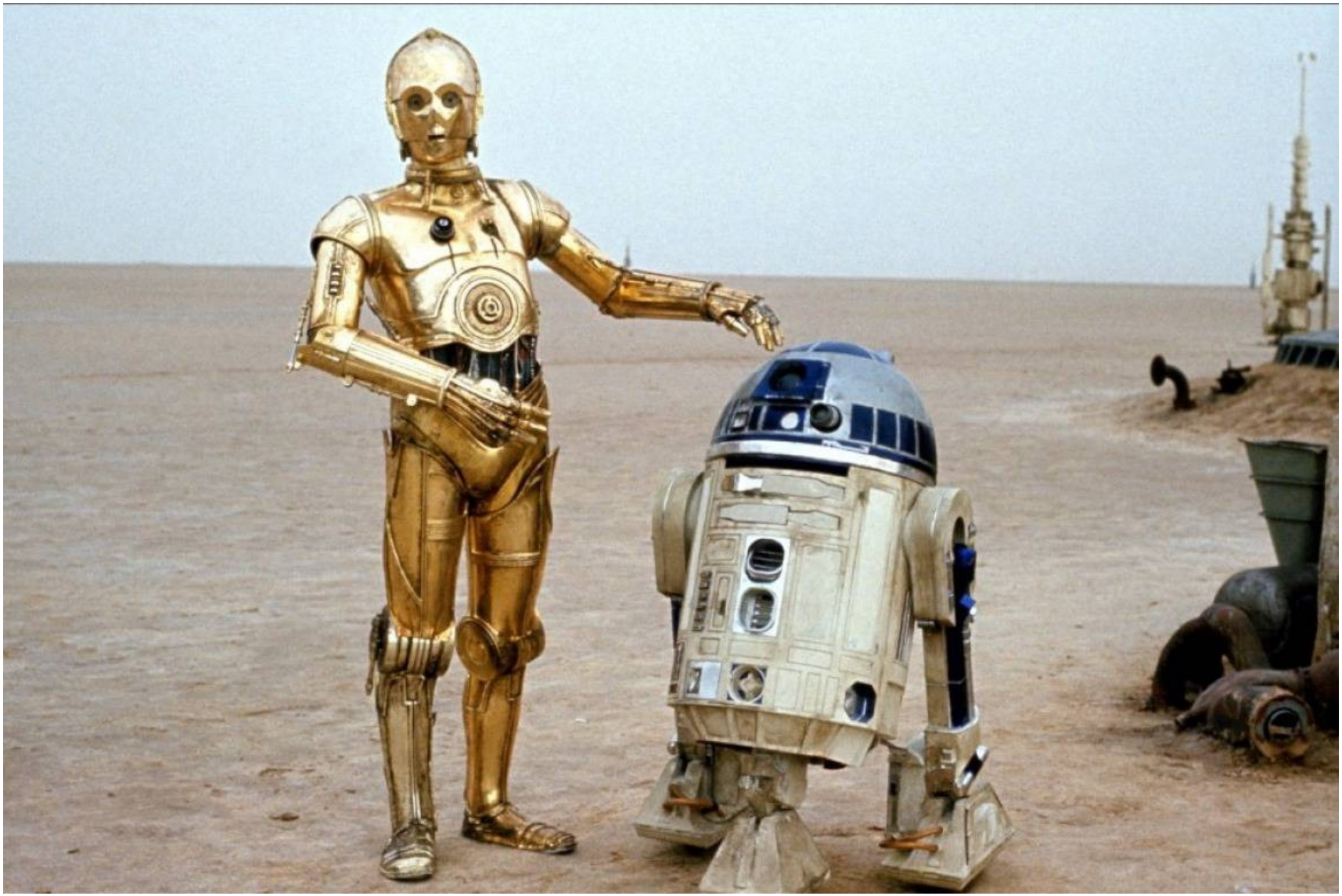


Driverless Cars

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.

HONDA

The power of dreams.™

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...

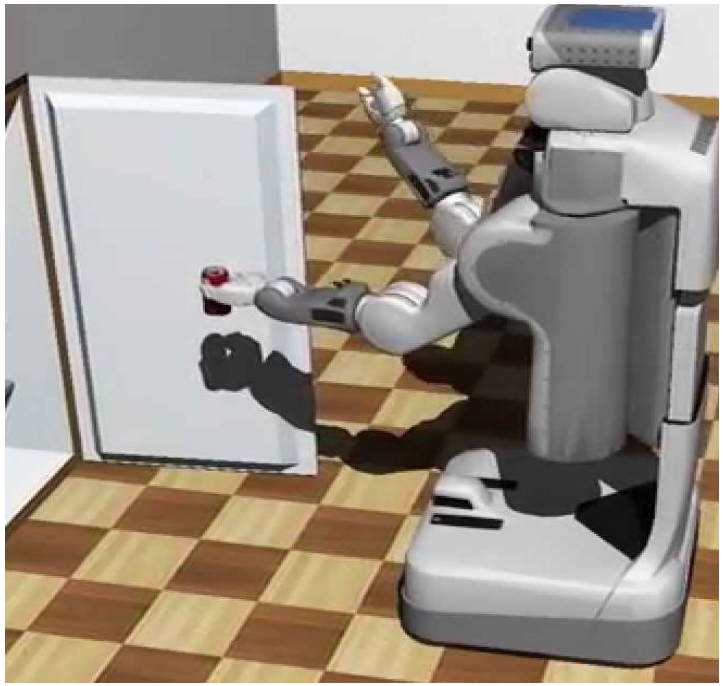
Topics

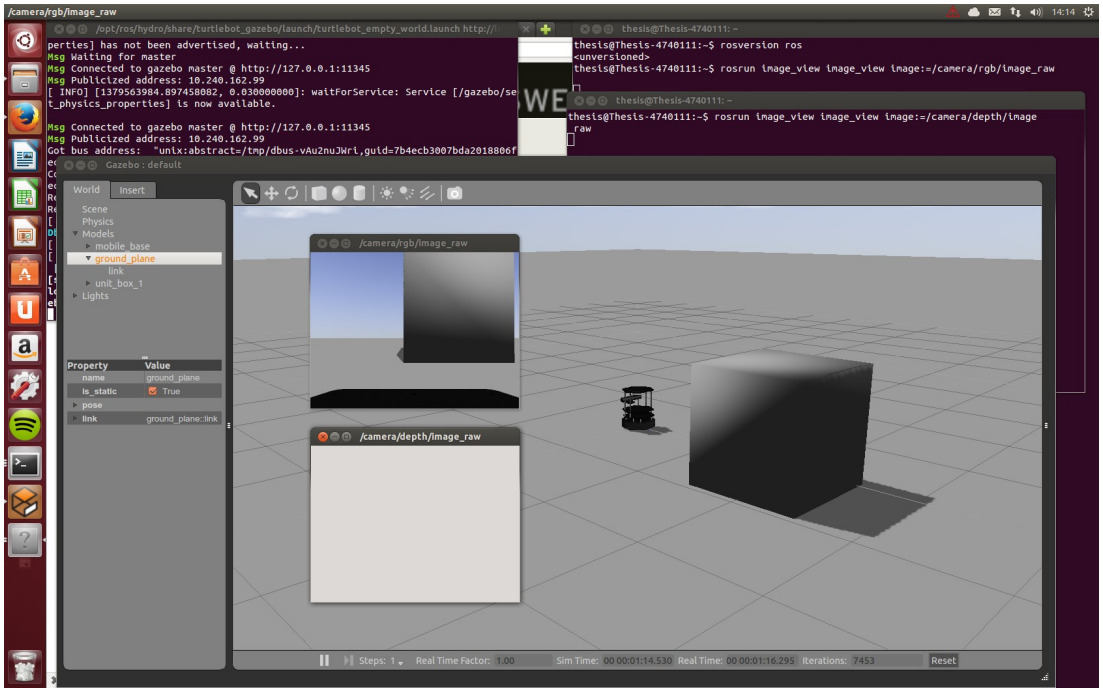
- Overview of robotics
  - Robot architectures, mobile robots and robot manipulators, learning methods for robots
- What is intelligence?
- Theories of Development
  - Nature vs Nurture? Or something else?
- Embodiment and the Sense of Self
  - Body scheme, self-recognition

Topics (2)

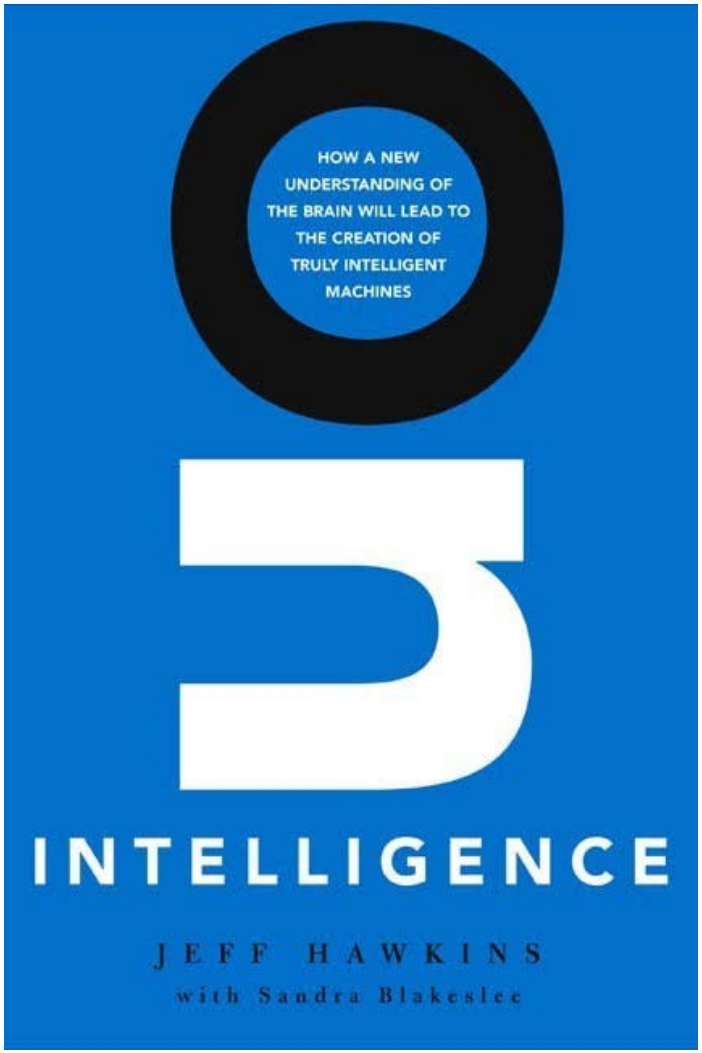
- Learning about objects and their affordances
- Tool use in humans, animals, and robots
- Multi-modal sensing and self-organization
- Theories of vision in humans and robots
- Social learning
  - Language, scaffolding, socially-guided learning
- ...

Robot Simulators



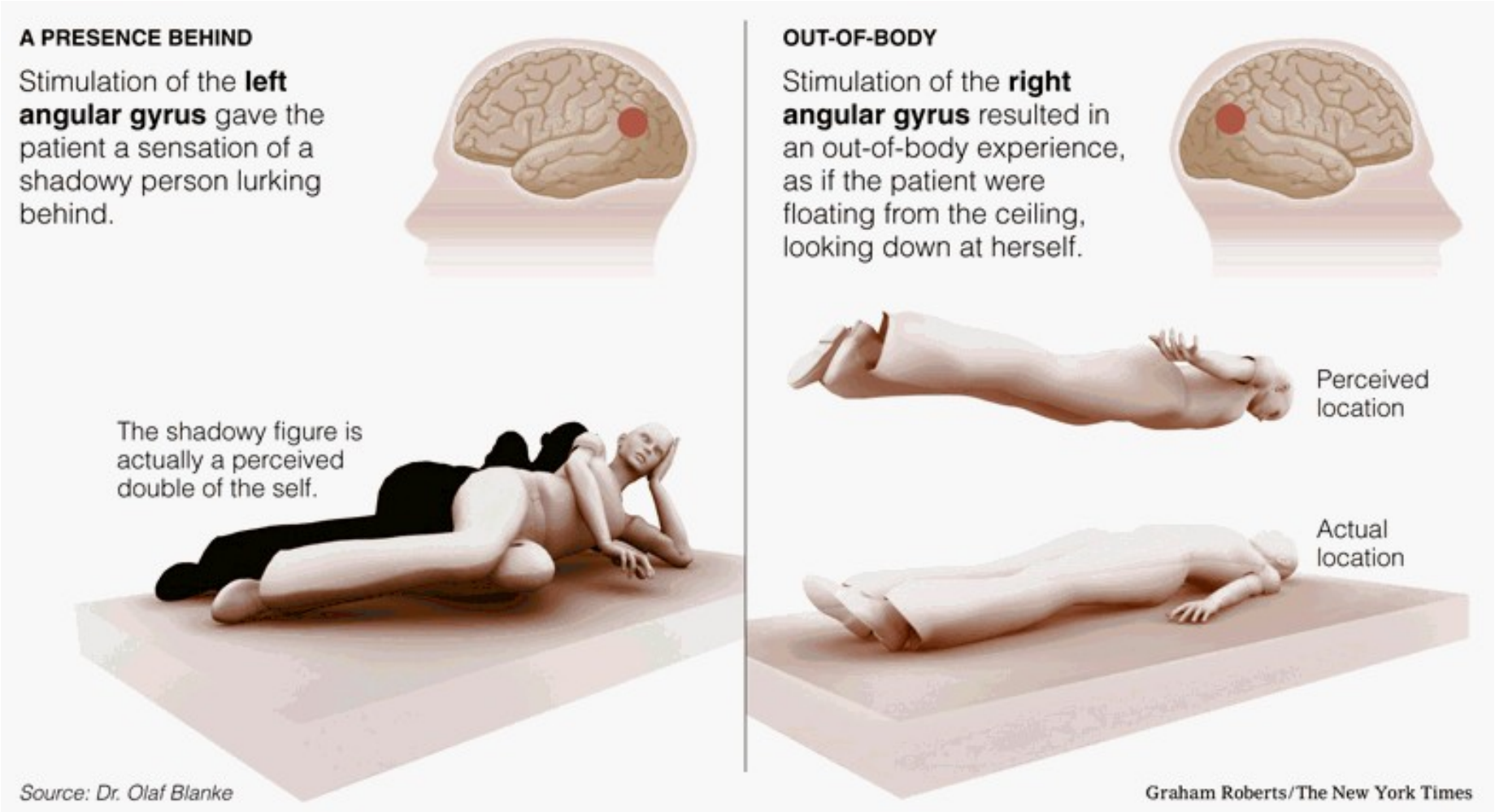


What is Intelligence?

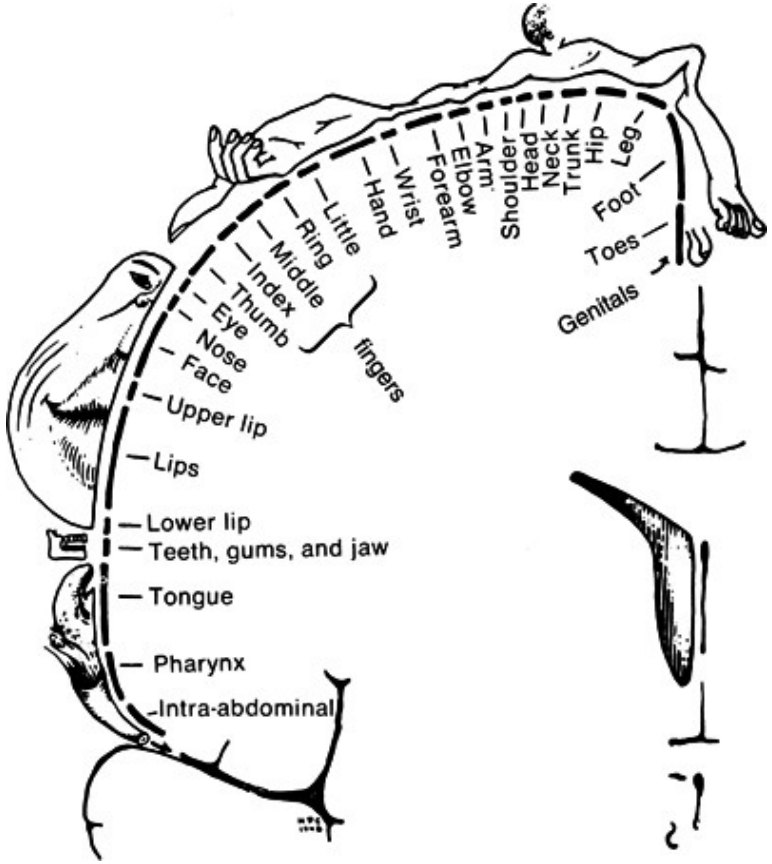


Embodiment

The Sense of Self



Body Schema


Lips
Lower lip
Teeth, gums, and jaw
Tongue
Pharynx
Intra-abdominal
Upper lip
Face
Nose
Eye
Thumb
Index
Middle
Ring
Little
fingers
Hand
Wrist
Forearm
Elbow
Arm
Shoulder
Head
Neck
Trunk
Hip
Leg
Foot
Toes
Genitals

Extensible Body Schema

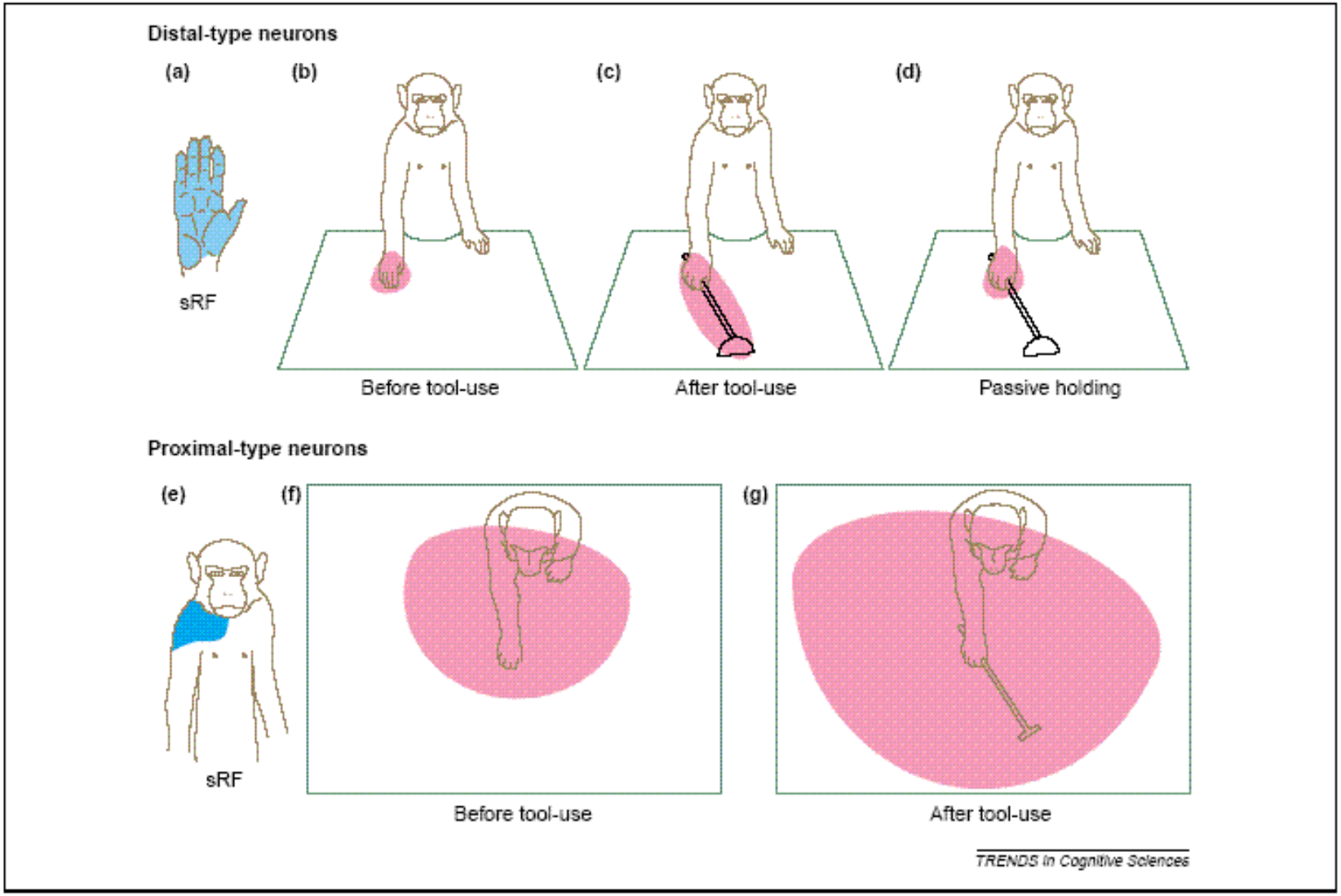
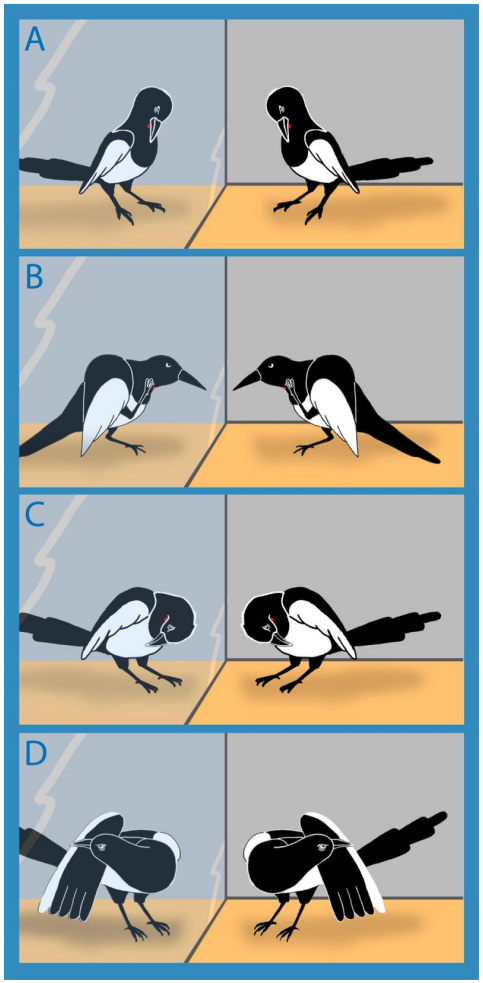
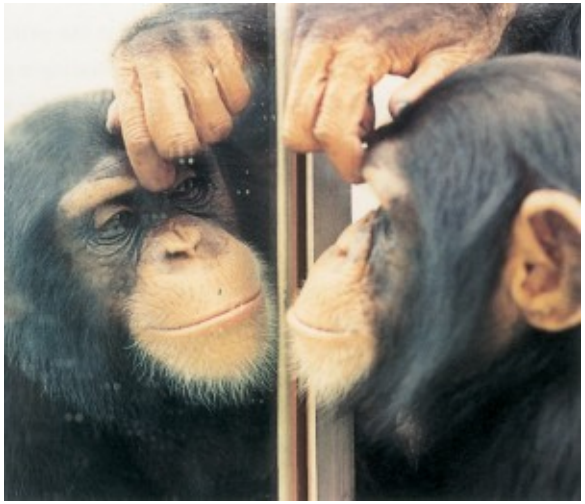


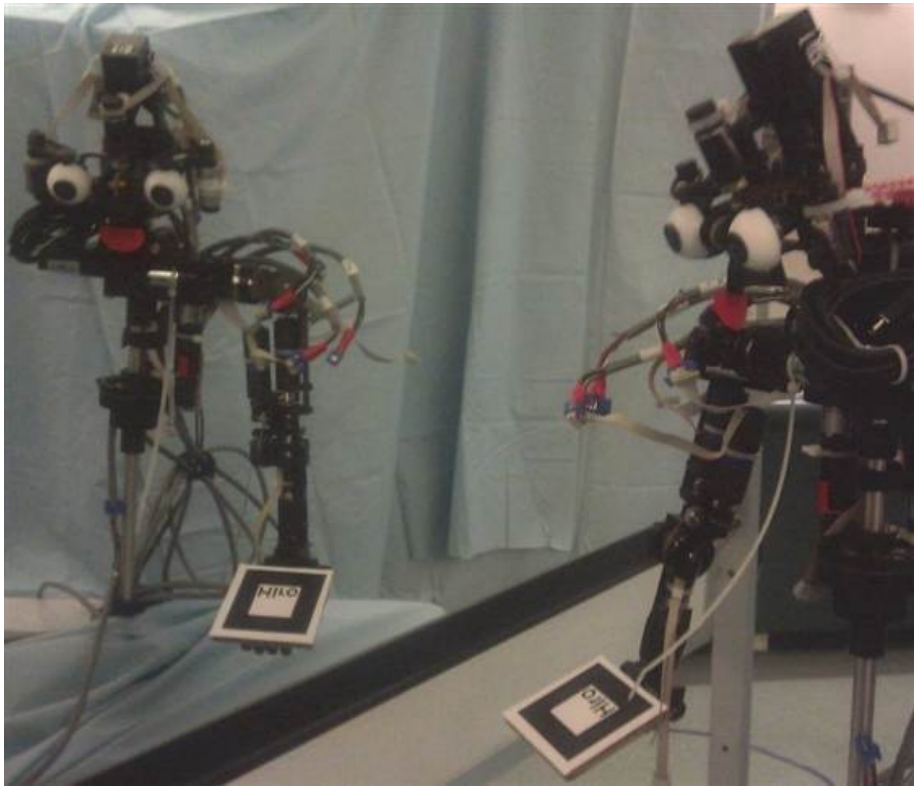
Figure 1. Changes in bimodal receptive field properties following tool-use. The somatosensory receptive fields (sRF) of cells in this region were identified by light touches, passive manipulation of joints or active hand-use. The visual RF (vRF) was defined as the area in which cellular responses were 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.

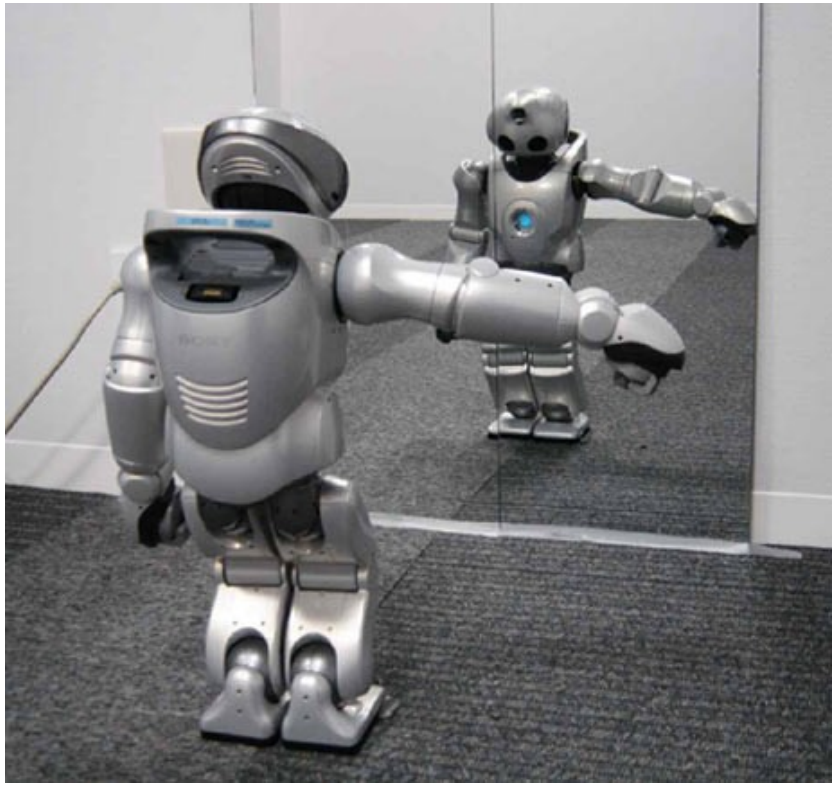
Self-Recognition





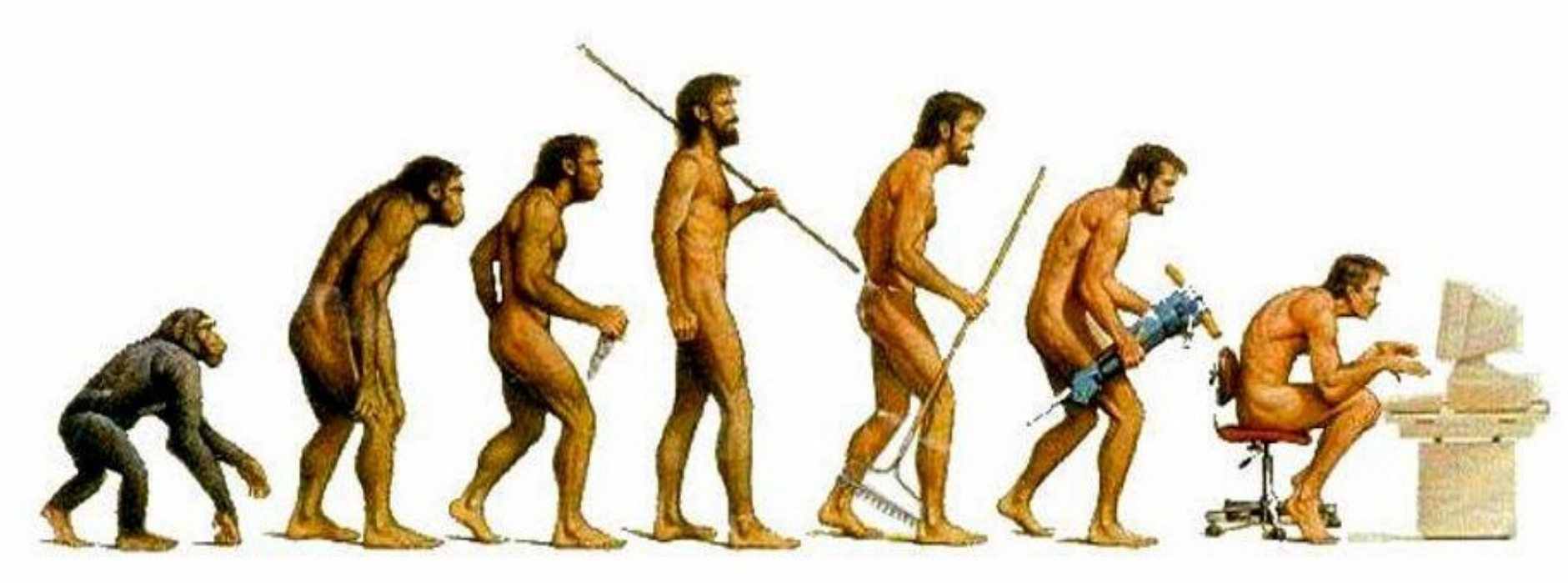
Self-Recognition in Robots



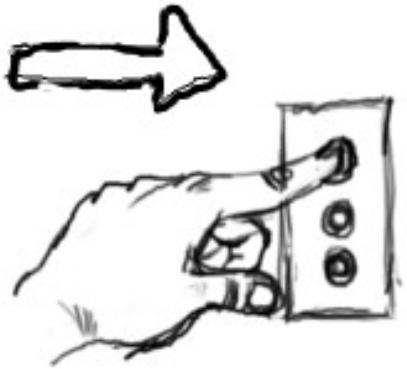


Theories of Development

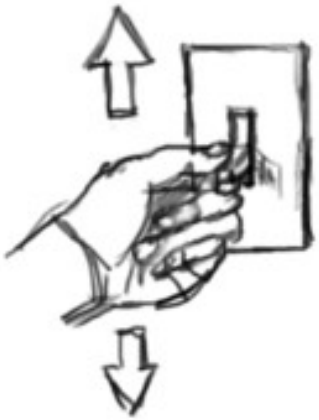
Theories of Development



Affordances

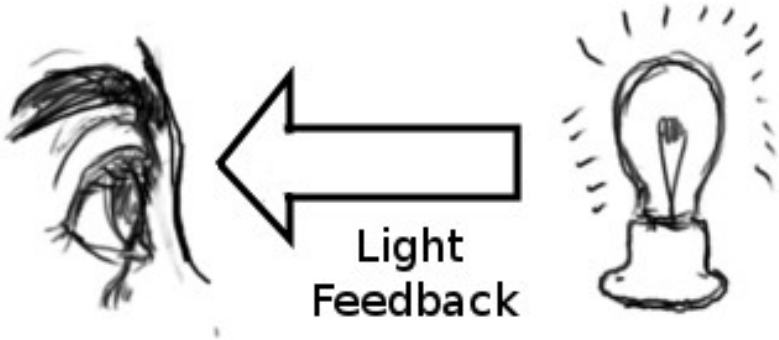


Button - Push

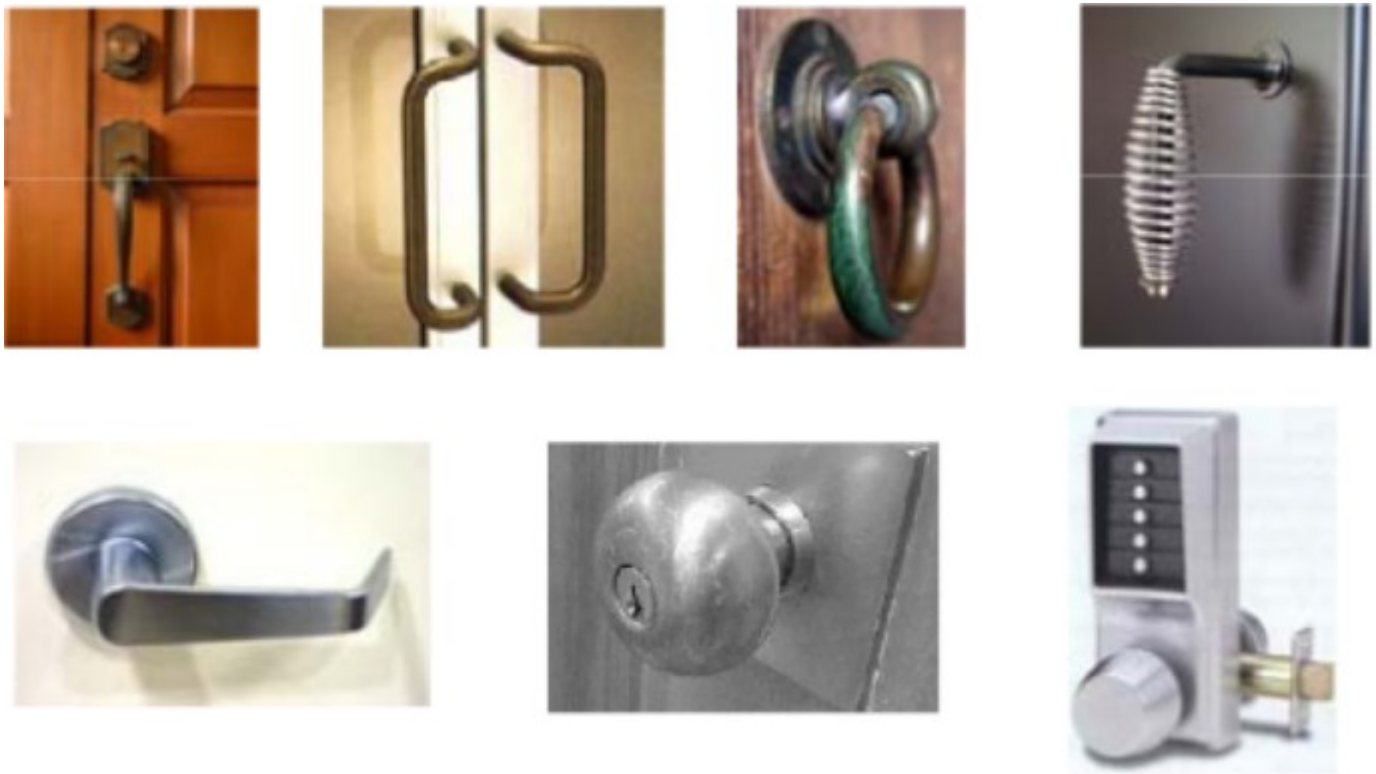


Switch - Flip

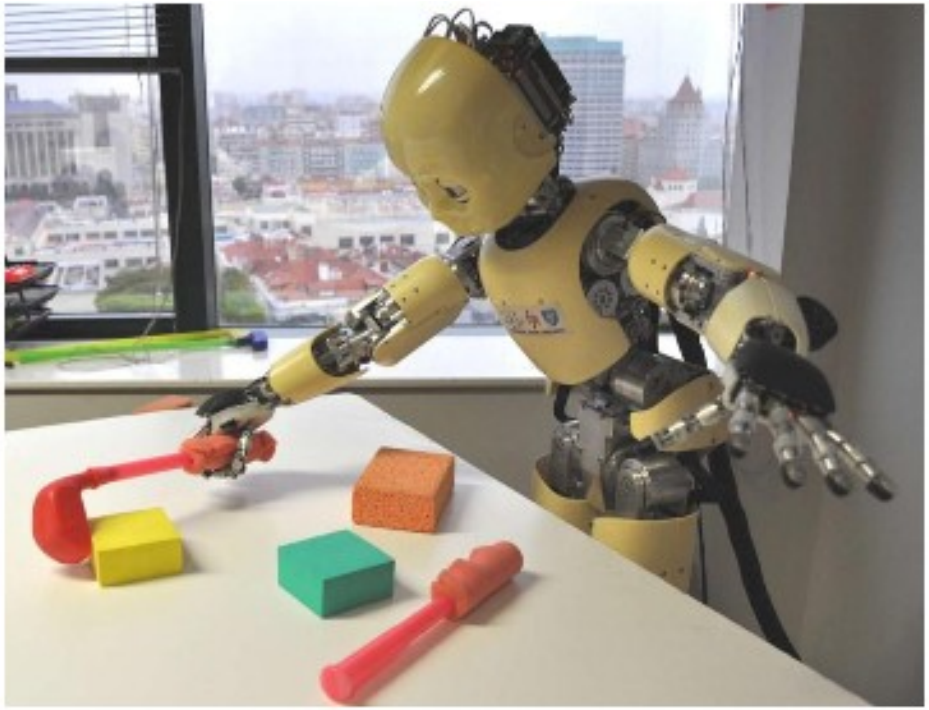
Knob - Rotate



Example: Doors



Learning Affordances

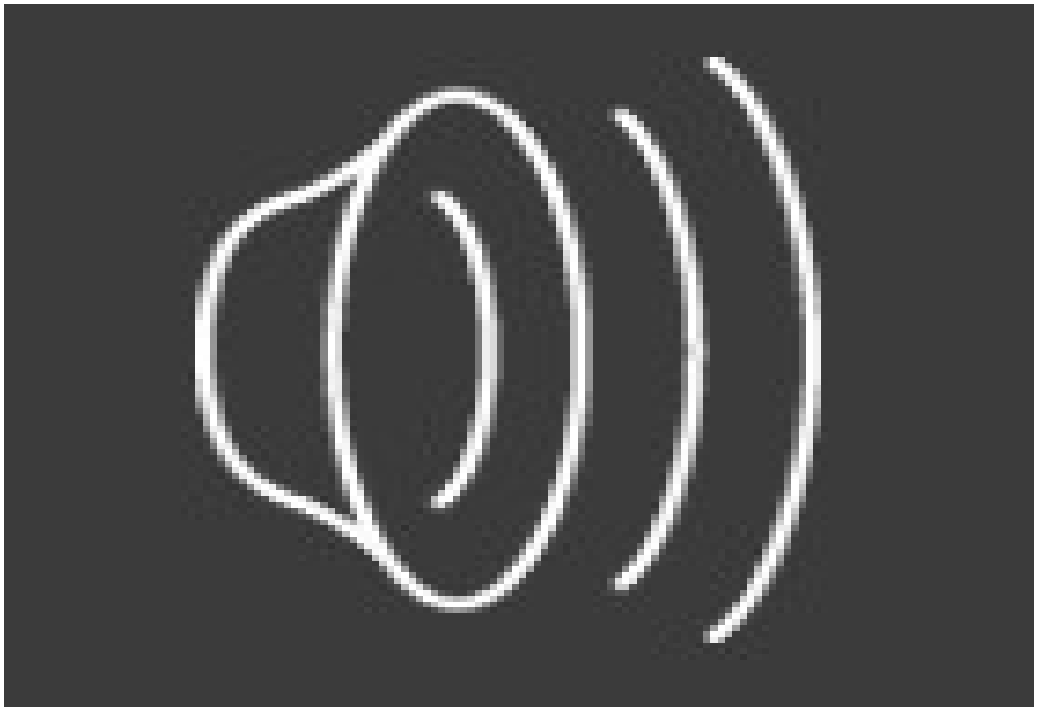


Tool Use






Tool Use by Robots



Sensory Substitution

Image-to-Sound Mapping

Hearing is seeing is believing

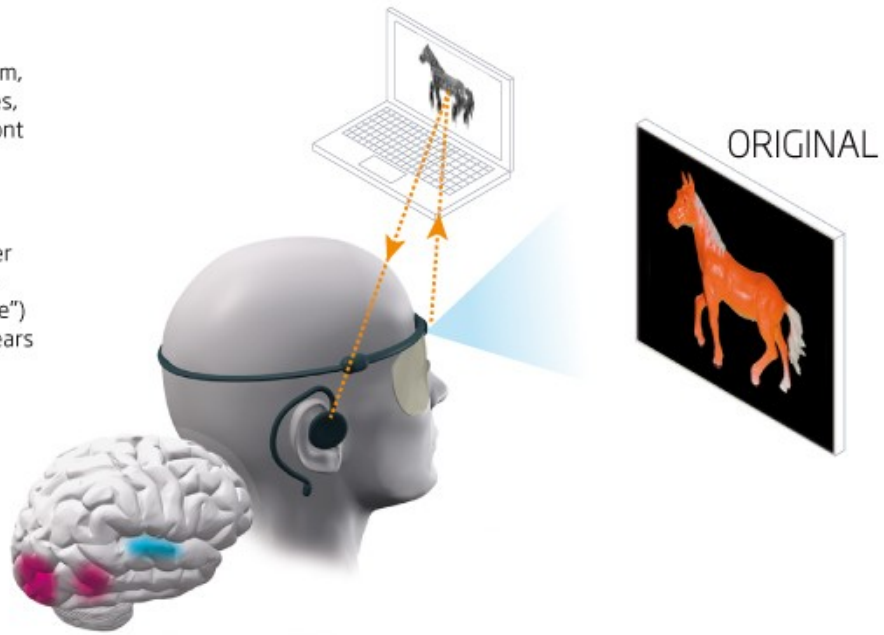
©NewScientist

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

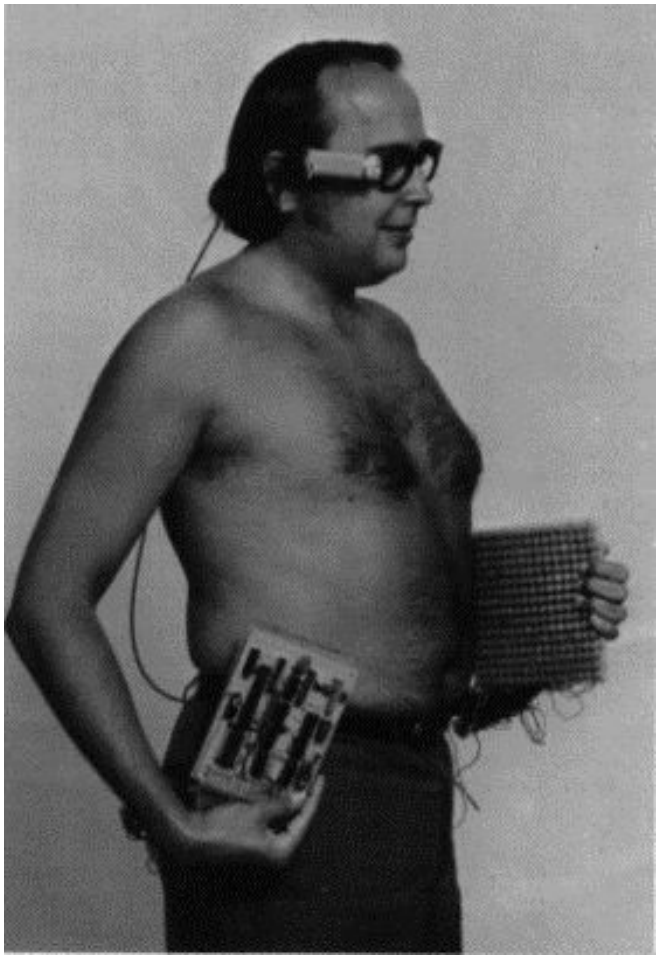


After 10-15 hours of training, however, regions of the visual cortex begin to "light up". This shows a very rapid redirecting of pathways in the brain

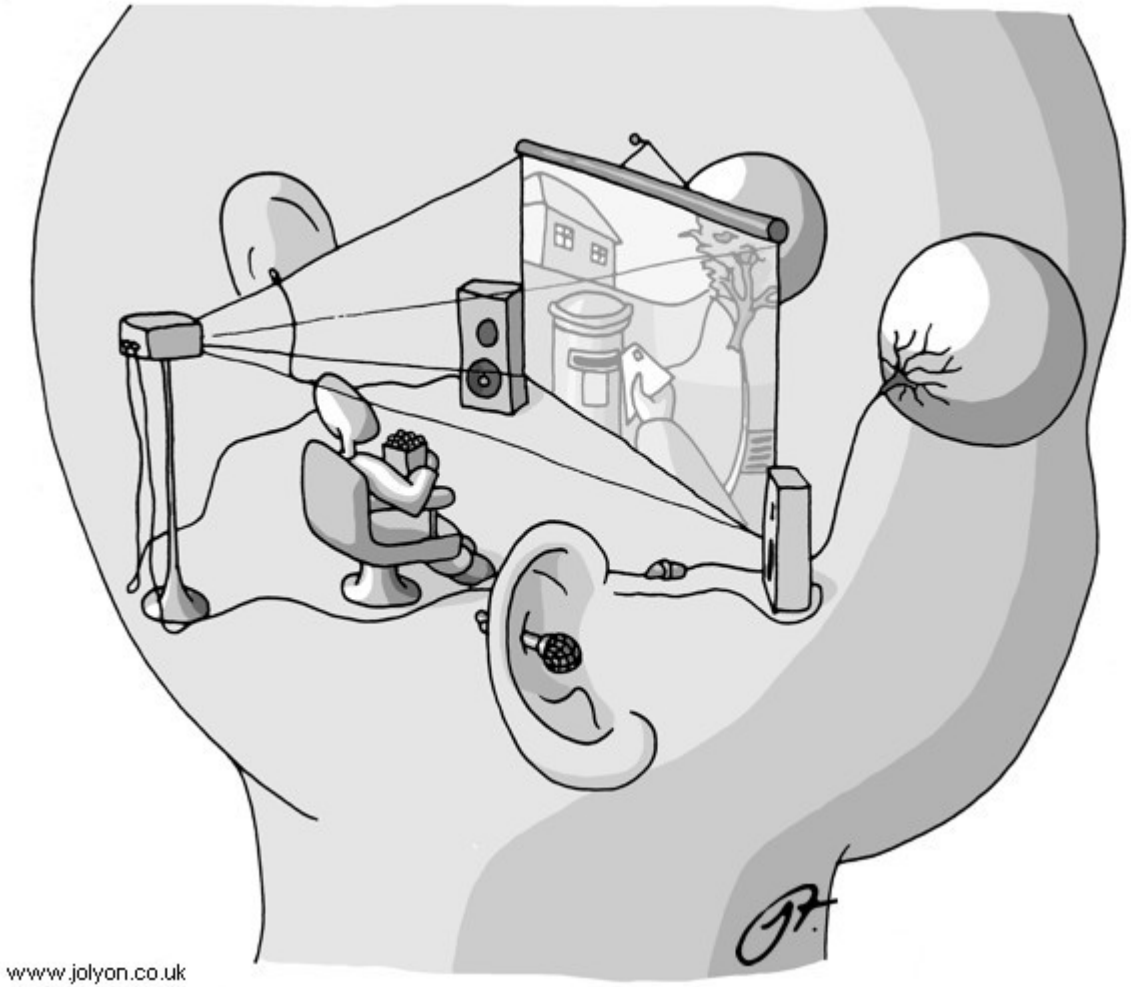
Around the time that the visual cortex becomes active, the users become more adept at understanding the soundscapes and recognising objects

The vOICe software scans across the image from left to right, convertingeach pixel into a beep, with the frequency representing its vertical position. The volume of each beep represents the brightness of the pixel

Sensory Substitution

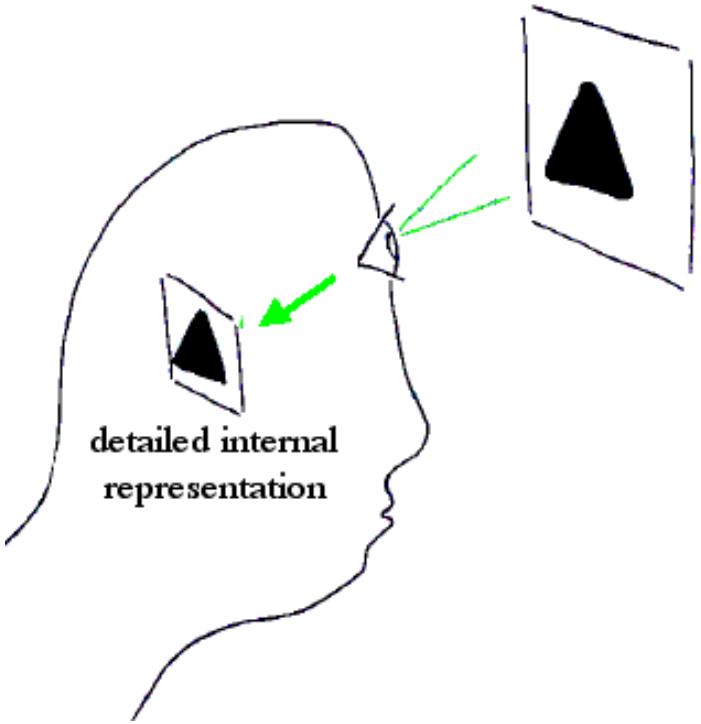


Theories of Vision



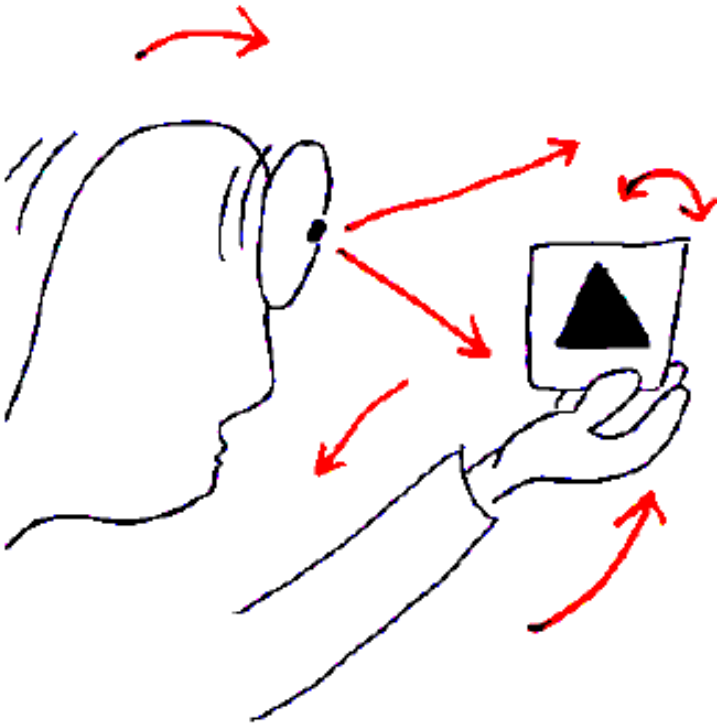
standard view

Seeing is making an internal representation



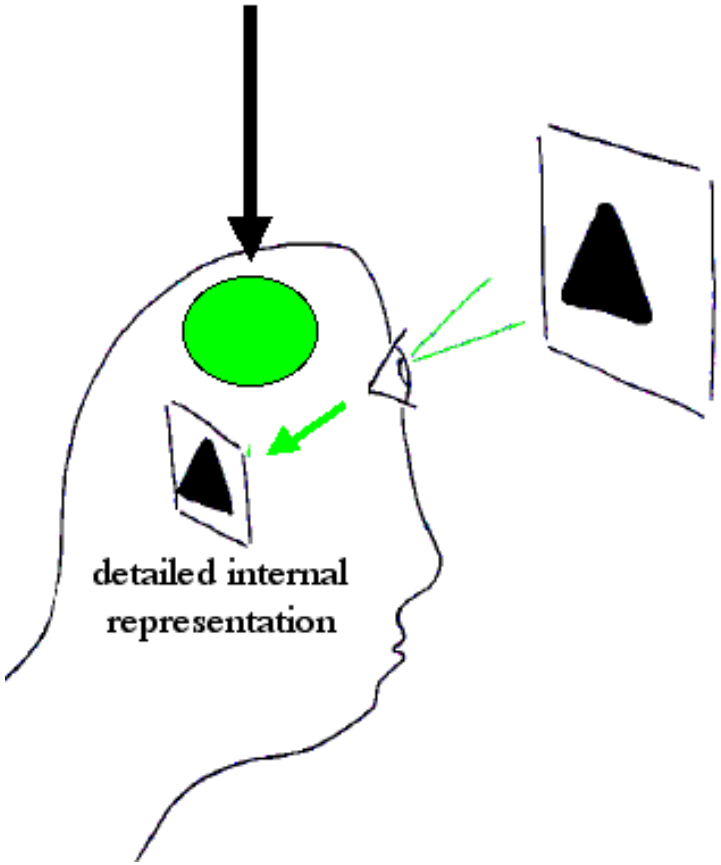
new view

Seeing is knowing about things to do



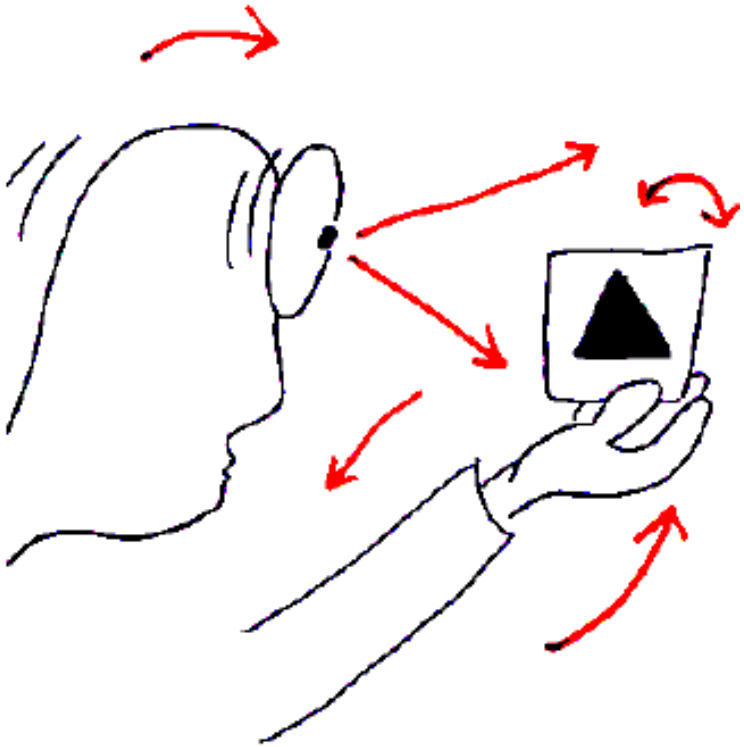
standard view

Brain creates experience



new view

Brain creates actions and has knowledge



Language Acquisition

Learning Multi-Modal Grounded Linguistic Semantics

by Bryan Tisbt

...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?