Sistemi Intelligenti Naturali e Artificiali

Anno Accademico 2008/2009
DIST, Università di Genova

Orario del Corso

- Lunedì 10-12, aula E5
- Giovedi 16-18, aula B6

Informazioni Utili

- Riferimenti: Lorenzo Natale e Giorgio Metta
- Laboratorio: LIRA-Lab, viale Causa 13 (Villa Bonino)
- Email: nat@liralab.it, pasa@liralab.it
- Sito web del corso: www.liralab.it/teaching/sina/
- Mailing list: sina@liralab.it

Modalità esame

- Esercitazioni a lezione e problema da risolvere in C/C++

e

- Orale

Outline of the course

- Fundamentals of Perception in Artificial and Natural Systems
- Lab practice, programming in C/C++, mostly image processing

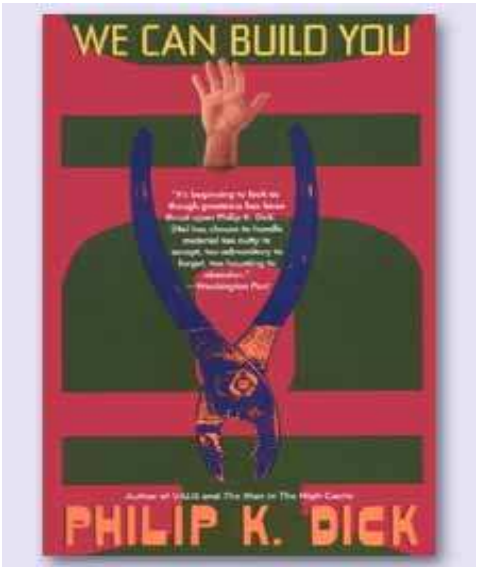
Details

- Introduction to Psychophysics
- Image formation, light and optics, camera geometric model
- Retina, anatomy of receptors
- Artificial Sensors, CCD and CMOS cameras
- Bayer Pattern, color demosaicing
- Visual Pathways, from the retina to V1
- Mathematical models of the mapping of the information from the retina to V1, Log-polar transformation
- Color perception
- Image processing, point operations, image difference, histograms, color representation, color histograms
- Image processing, neighborhood operations, edge detection
- Image processing, scene analysis, Hough Transform for lines and circles, Generalized Hough Transform, measures of similarity

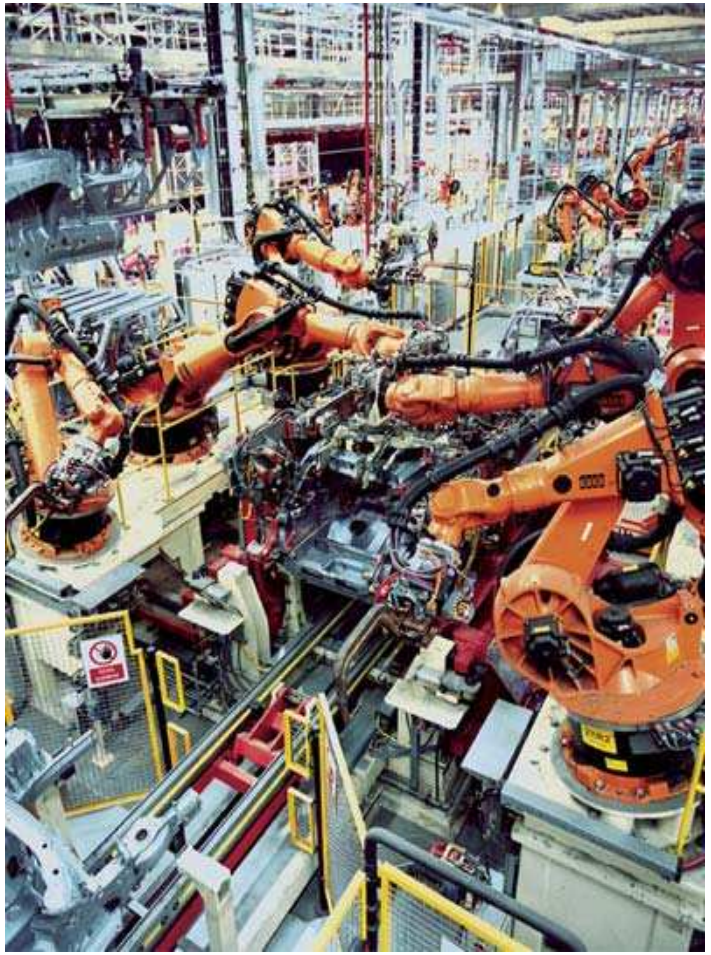
- Artificial models of attention, Itti's model
- Motion perception, optical flow in biological systems
- Motion perception, optical flow, Horn and Schunck's method
- Eye movements, biological systems and artificial systems, smooth pursuit, saccadic eye movements, VOR, OKR
- Auditory System, sound localization in biological and artificial systems, ITD and ILD
- Visuo acoustic integration in artificial systems
- Tactile sensing, artificial and biological systems

Introduction:
Robotics and Artificial Intelligence


AND DO ALL THAT WORK?!?
NO, WE'RE GOING TO INVENT A ROBOT TO MAKE THE BED FOR US!


WE CAN BUILD YOU
PHILIP K. DICK

Robotics now



Industrial Robots,
very efficient but very specific

Another example

Roomba, the robot cleaner, more generic but still simple

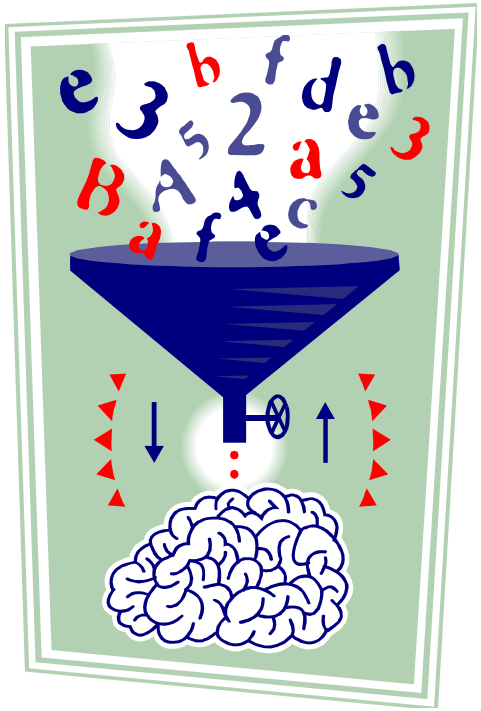
what is missing?

…the challenge is to build robots that are *intelligent*

Artificial Intelligence (1)

Classical Approach:

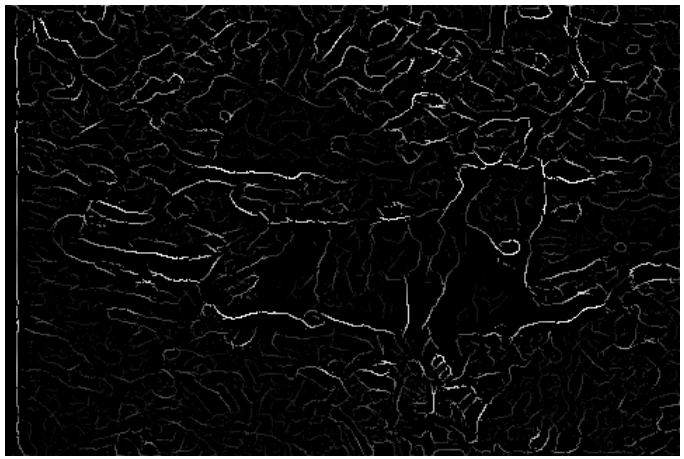
- Symbolic reasoning, builds a symbolic representation of the world
- Often search for an *exact* solution (often: *optimal*)



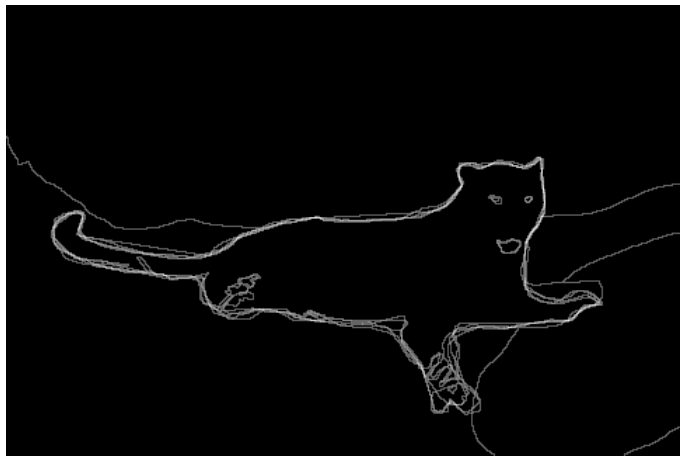
A machine can be better than a human in a specific task

… but can we say that a machine is more intelligent than a human?

What happens with “simpler” problems

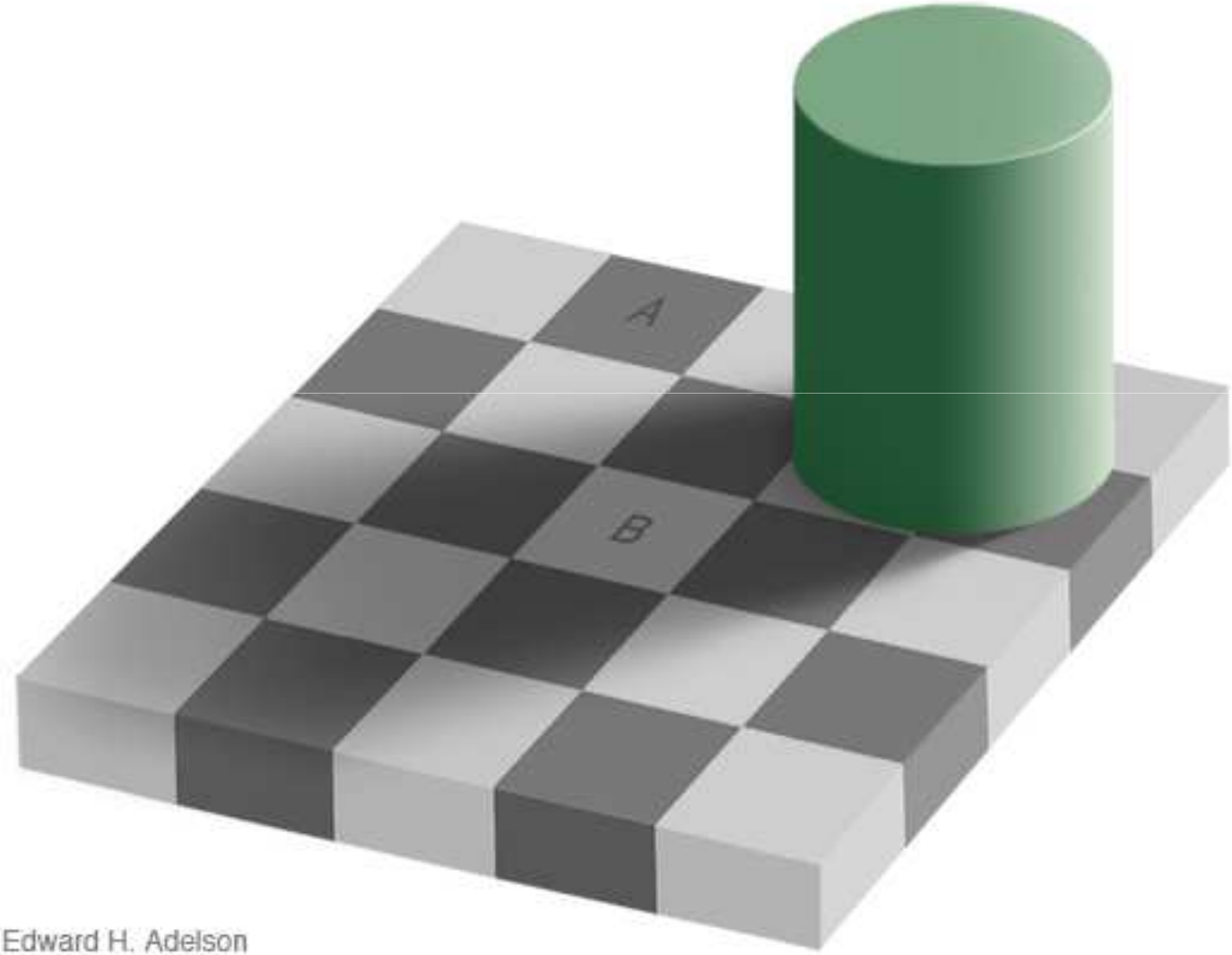


what a machine sees



what we see

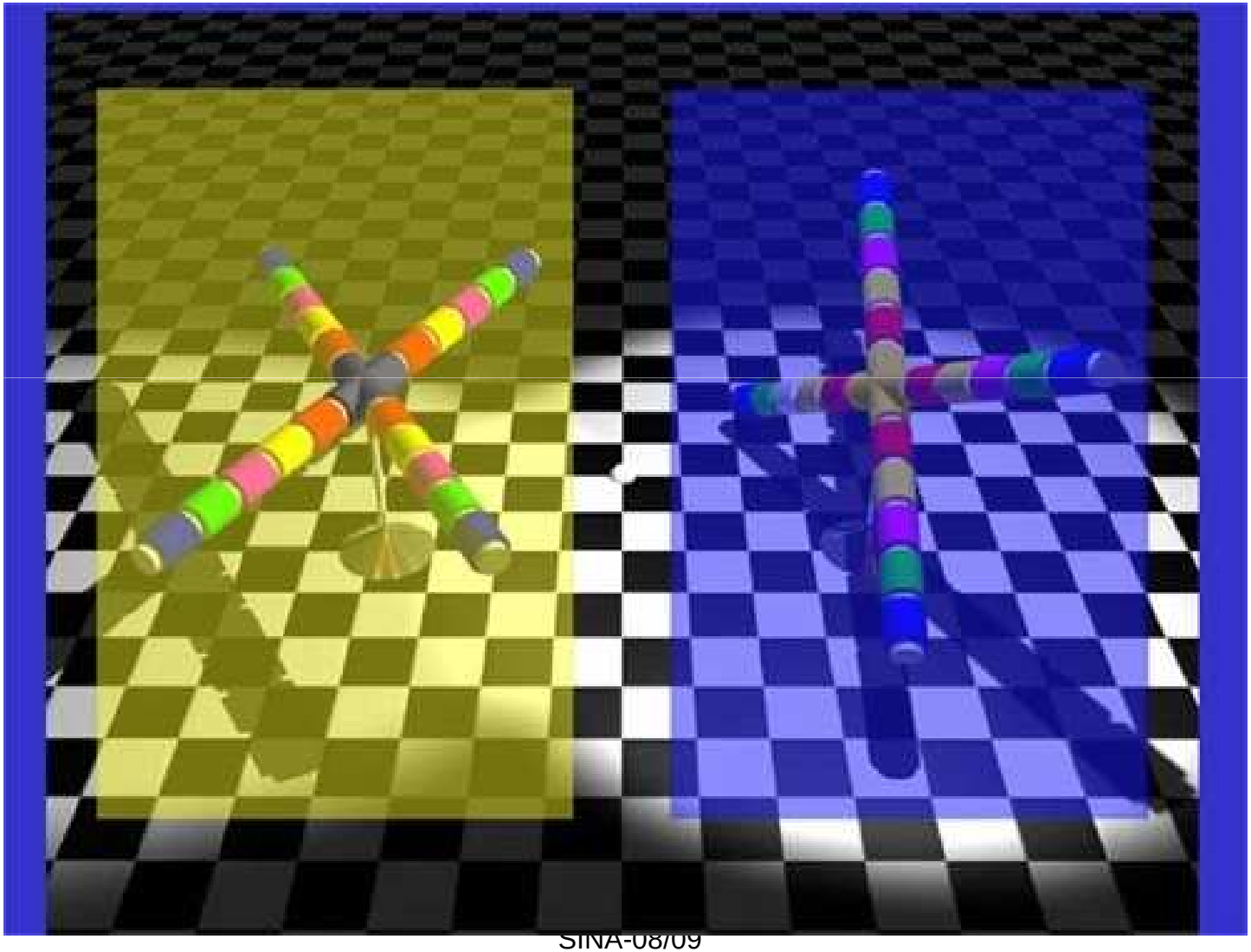
Our perception of the world is not always “correct”



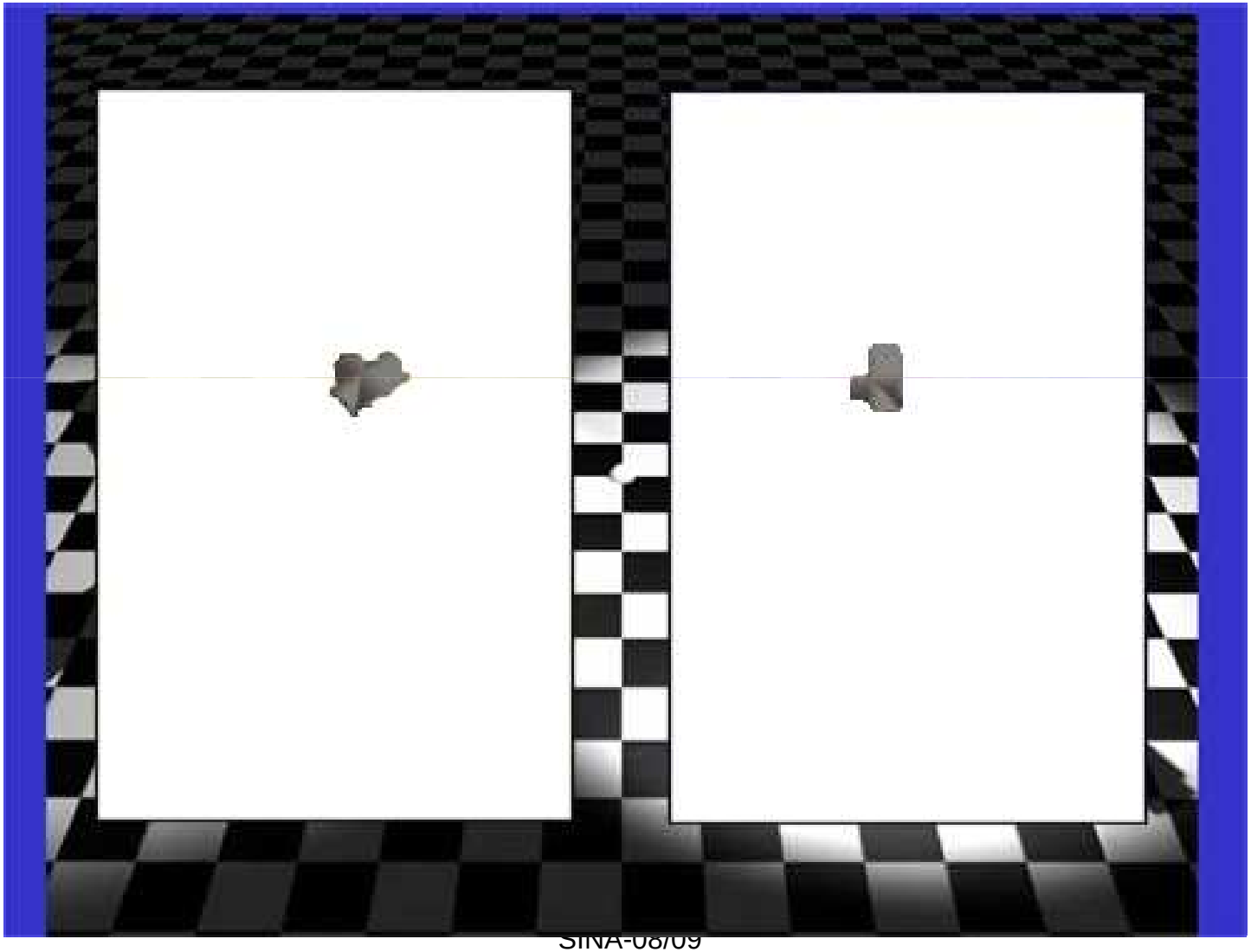
Edward H. Adelson

Our perception of the world is not always “correct”

Another example



Another example



…elephants do not play chess!
(R. Brooks, 1990)

…intelligence is much more than just problem solving, intelligence is also in the ability to successfully interact with the environment


Carnegie Mellon
DARPA
Boston Dynamics

Sensation and perception

- **sensation**: the process of *detecting* a stimulus in the environment (eyes, ears, nose, skin, vestibular system...)
- **perception**: the way in which we interpret the information that is gathered (and processed) by the senses

  →***cognitive psychology***

  how the brain builds an *"internal model"* of the external world, based on the sensation provided by the sensory system

- The brain interprets the environment from the energy intercepted by the senses

  Examples:

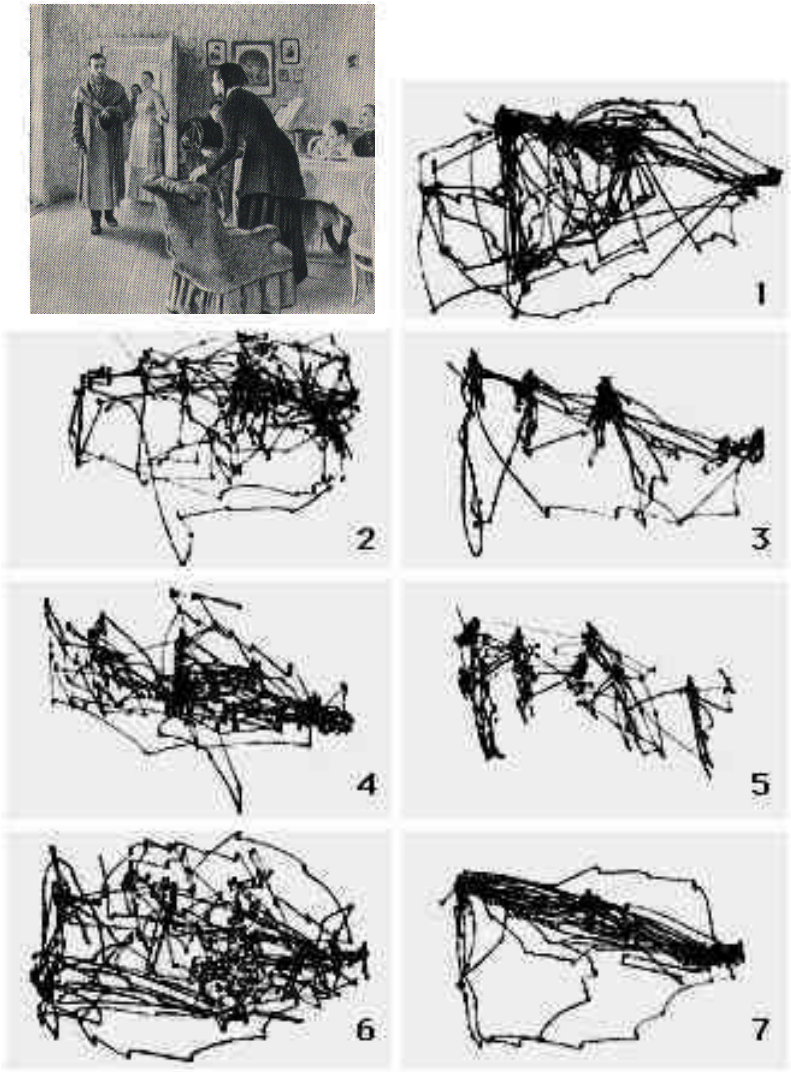
  – light and sound carry information about objects or events at considerable distance from us

  – pressure on the skin → information about objects we touch

Perception is an active process

- This energy is of no use unless it is channeled to our receptors (light must be focused to the retina, sound channeled to the inner ear)
- We always have an active role in this process → move the eyes or the neck to look at something, explore objects with the hand to determined their shape, consistency or texture

Perception as an active process (1)



(from Yarbus 1967)

Yarbus recorded the eye movements of subjects during different visual tasks:

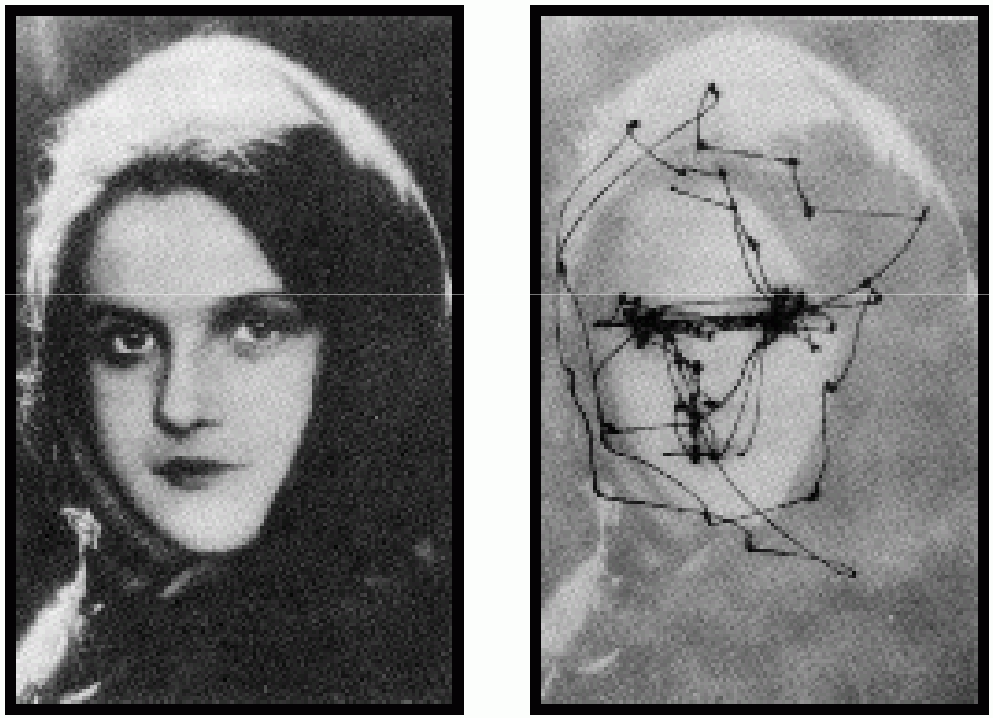
1) free examination of the picture
2) determine the condition of the family
3) determine the age of the people
4) determine what the family had been doing before the arrival of the visitor
5) remember the clothes of the people
6) remember the location of objects and people
7) estimate how long the visitor had been away

Note:

-Eye trajectories are not “raster-like”, the eyes jumps back and forth to fixate specific points on the image

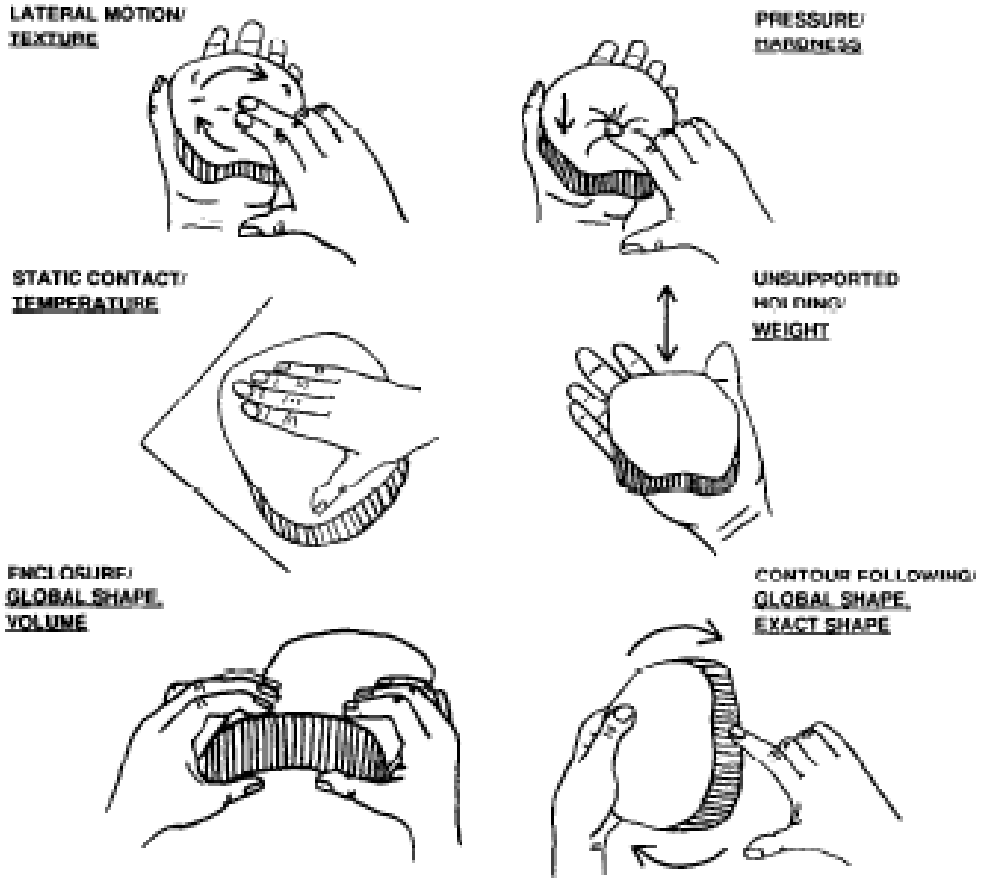
- The scan-paths depend on the cognitive task to be performed

Another example...



Perception as an active process (2)

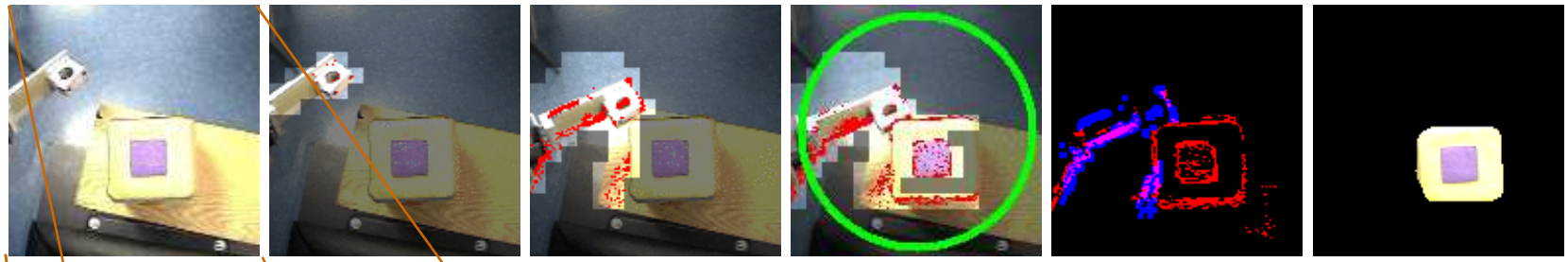
Subjects use specific hand patterns to evaluate different properties



Adapted from Lederman & Klatzky, 1993

Robotic Examples

Objects come to existence because they are manipulated



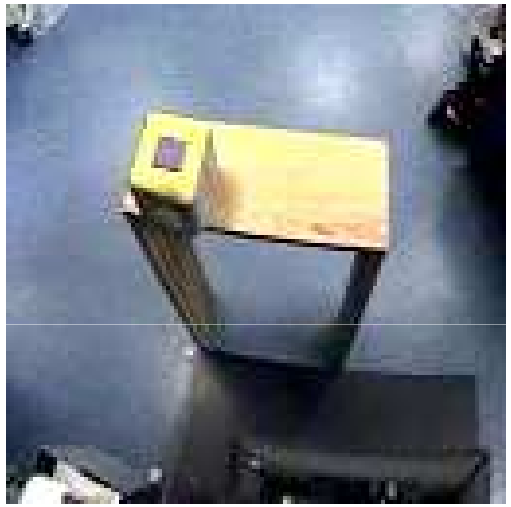
Fixate target | *Track visual motion…* | *(…including cast shadows)* | *Detect moment of impact* | *Separate arm, object motion* | *Segment object*

Which edge should be considered?

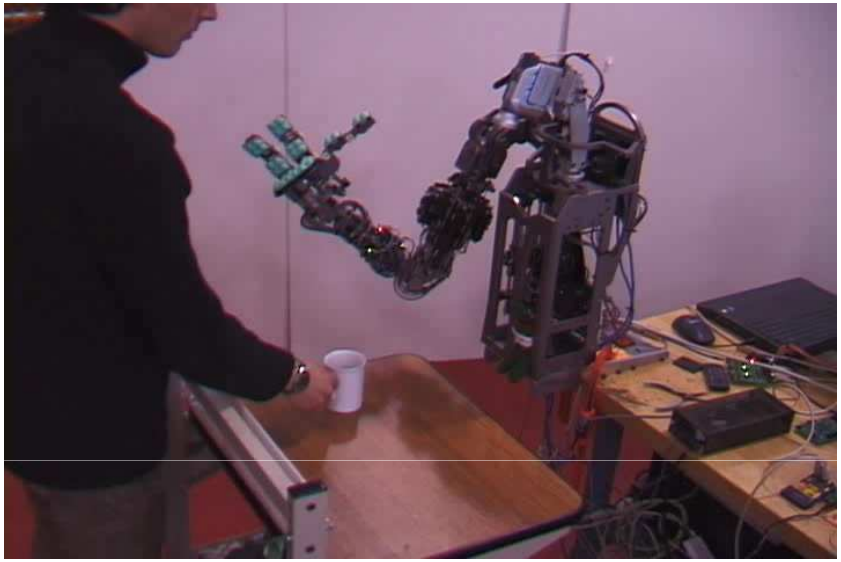
Color of cube and table are poorly separated

Cube has misleading surface pattern

Fitzpatrick and Metta (2003)

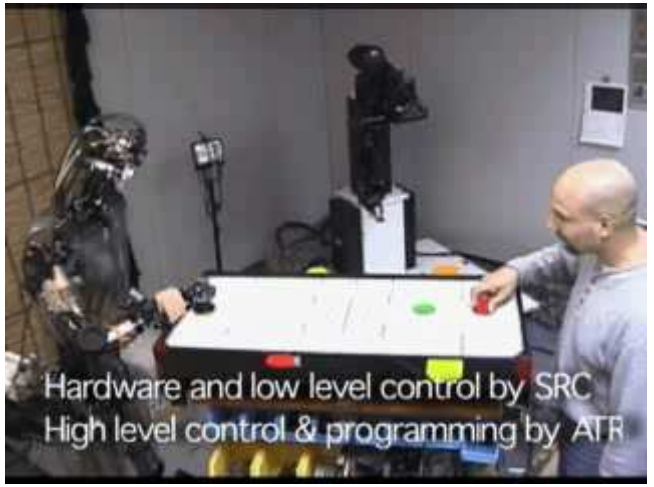


Haptic perception



Interesting A.I. Projects
with
SARCOS
and other groups

Contact SARCOS



RobotCub

Multimodal Saliency-Based Bottom-Up Attention

A Framework for the Humanoid Robot iCub

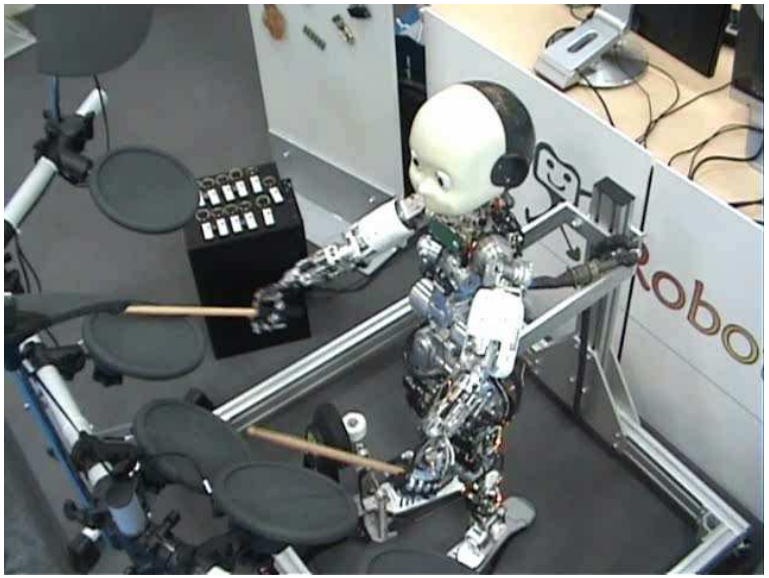
Jonas Ruesch[1,2], Manuel Lopes[1], Alexandre Bernardino[1], Jonas Hörnstein[1], José Santos-Victor[1], Rolf Pfeifer[2]

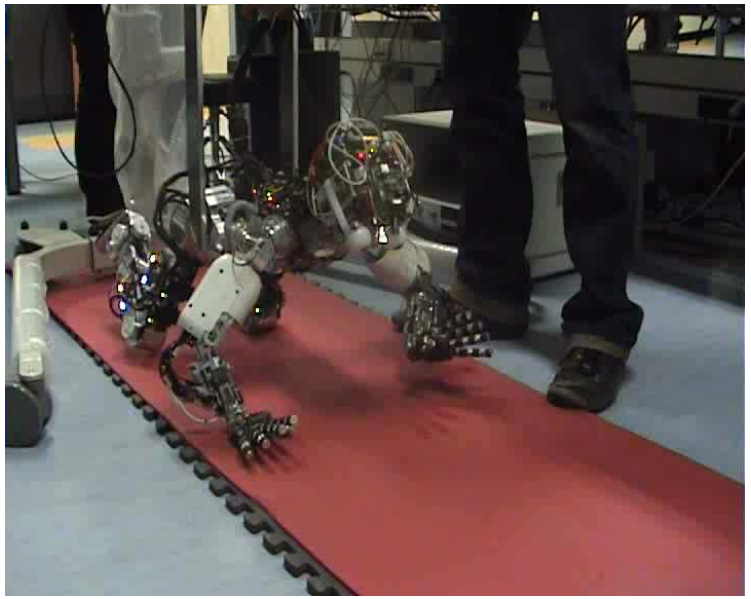
Presented at ICRA'08, May 21, Pasadena, US

1) Instituto Superior Técnico Lisboa, VisLab, Portugal
2) University of Zurich, AILab, Switzerland

Cogsys Cognitive Systems

RobotCub.org





Back to perception

- Given the information of the sensors the brain makes the most reasonable interpretations of the world
- From an engineering perspective, we would like to understand the mechanisms used by the brain to make these interpretations, and reproduce them in an artificial system
- We will try to study what are the mechanisms used by the brain to make these interpretations
- ...and how similar mechanisms can be artificially implemented