# Cognitive (robotic) Systems

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## Presentation Outline

Some requirements of Cognitive (robotic) Systems

I: Understanding Human Activities

II: Learning about the world (context, affordances, )

III: Interaction/Communication w/ others

IV: Conclusions

# Understanding human activity

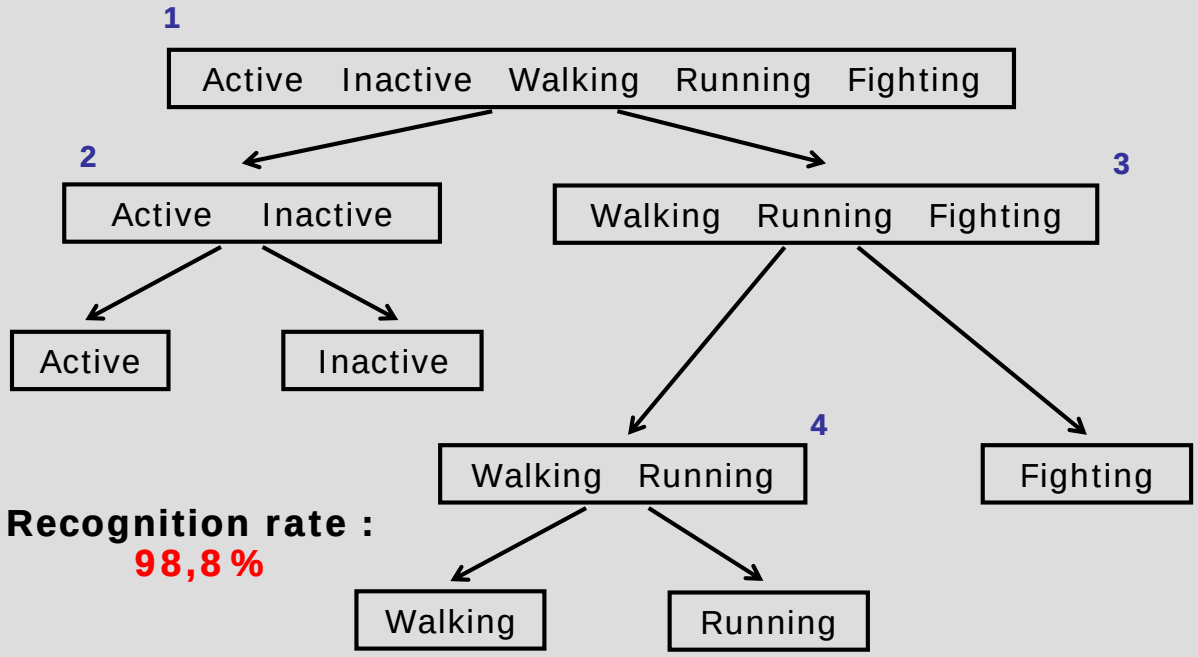
**Example**


**EU-Project CAVIAR (U. Edinburgh, IST-Lisbon, INRIA)**



# Understanding human activity

Hierarchical classifier:



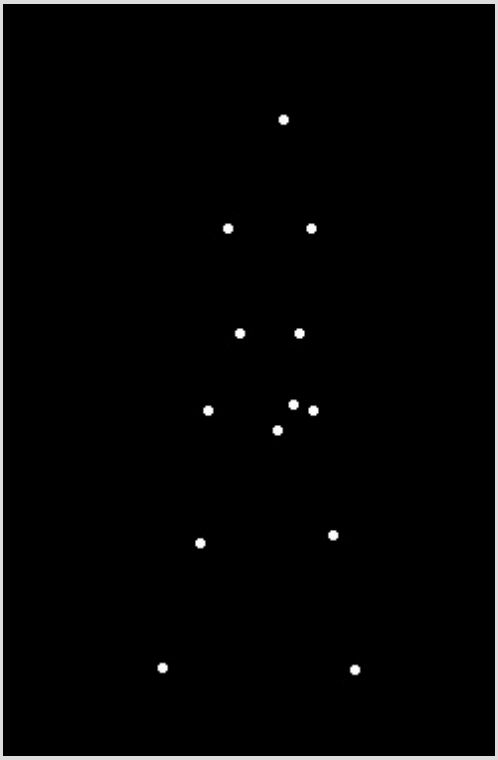

**Recognition rate :**
**98,8 %**

# Understanding human activity

Johansson G (1973)

"Visual perception of biological motion and a model for its analysis."

Perception and Psychophysics 14:201–211"





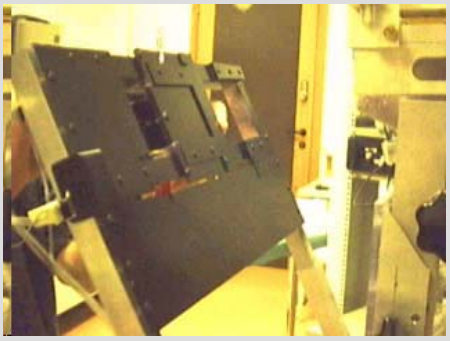
# Understanding human activity


Frank Pollick
Dpt Psychology, University of Glasgow

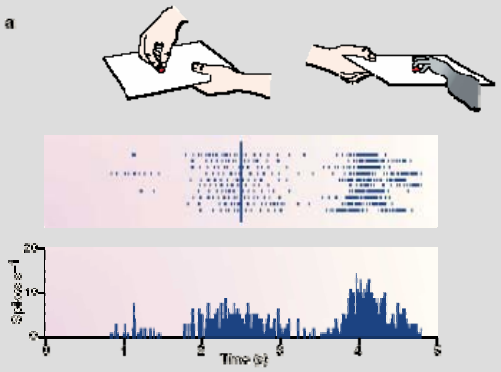
# Mirror Neurons

[Gallese, Fadiga, Fogassi and Rizzolati, Brain, 1996]

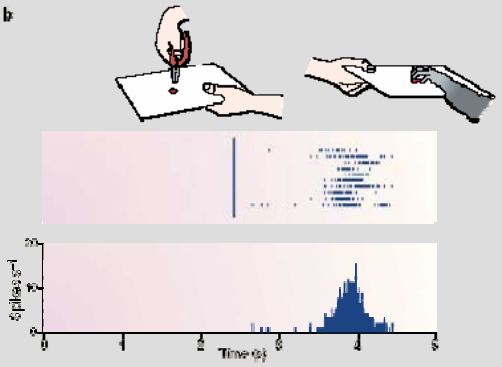
Active during observation of another monkey's or experimenter's hands interacting with objects.



Observed & executed actions are the same:

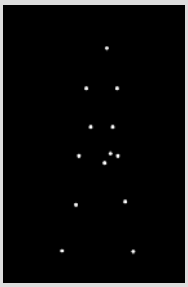



Observed & executed action are NOT the same (tool):



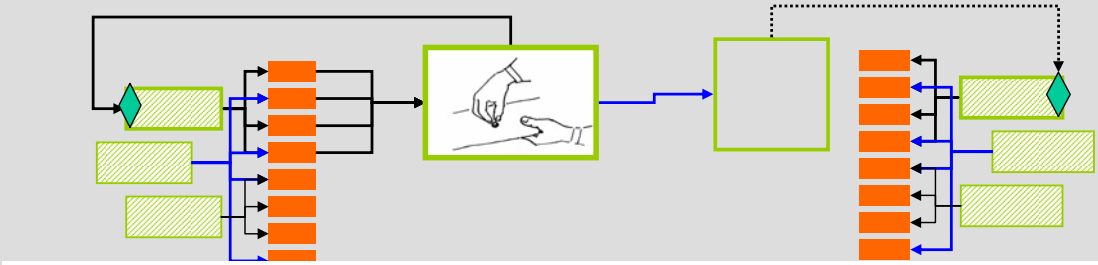


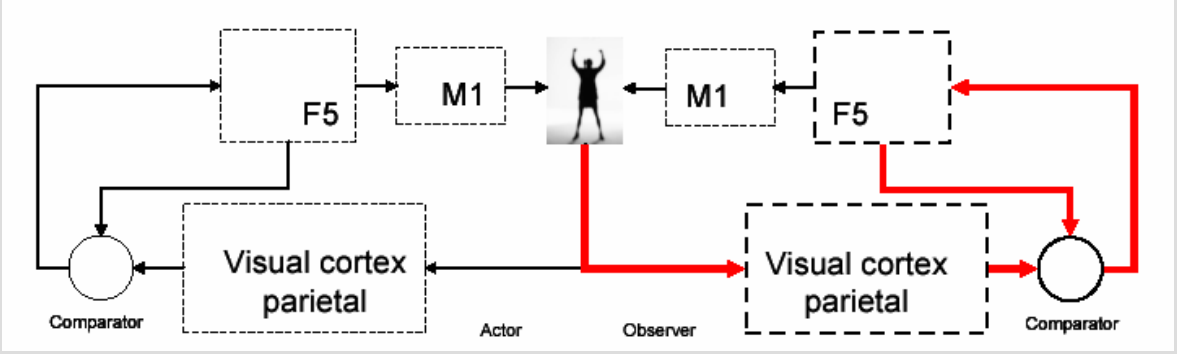

# Action observation / execution ressonance



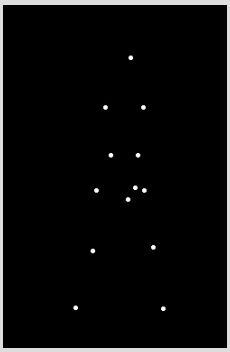
Individual A

Individual B





# “Motor” Gesture recognition



Training Set:

24 sequences

15 visual features;

15 joint angles

Test Set:

96 seqs.

| | Exp. I (visual) | Exp. II (visual) | Exp. III (visual) | Exp. IV (motor) |
|---|---|---|---|---|
| | Training | | | |
| # Sequences | 16 | 24 | 64 | 24 |
| View Points | 1 | 1 | 4 | 1 |
| Classif. Rate | 100% | 100% | 97% | 98% |
| # Features | 5 | 5 | 5 | 15 |
| # Modes | 5-7 | 5-7 | 5-7 | 1-2 |
| | Test | | | |
| # Sequences | 8 | 96 | 32 | 96 |
| View Points | 1 | 4 | 4 | 4 |
| Classif. Rate | 100% | 30% | 80% | 97% |



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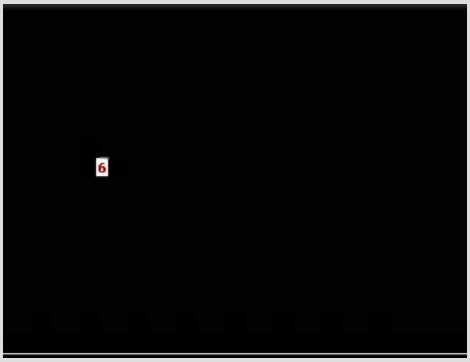
# Context





# Affordances

**Affordances as models for prediction, action selection and execution …**

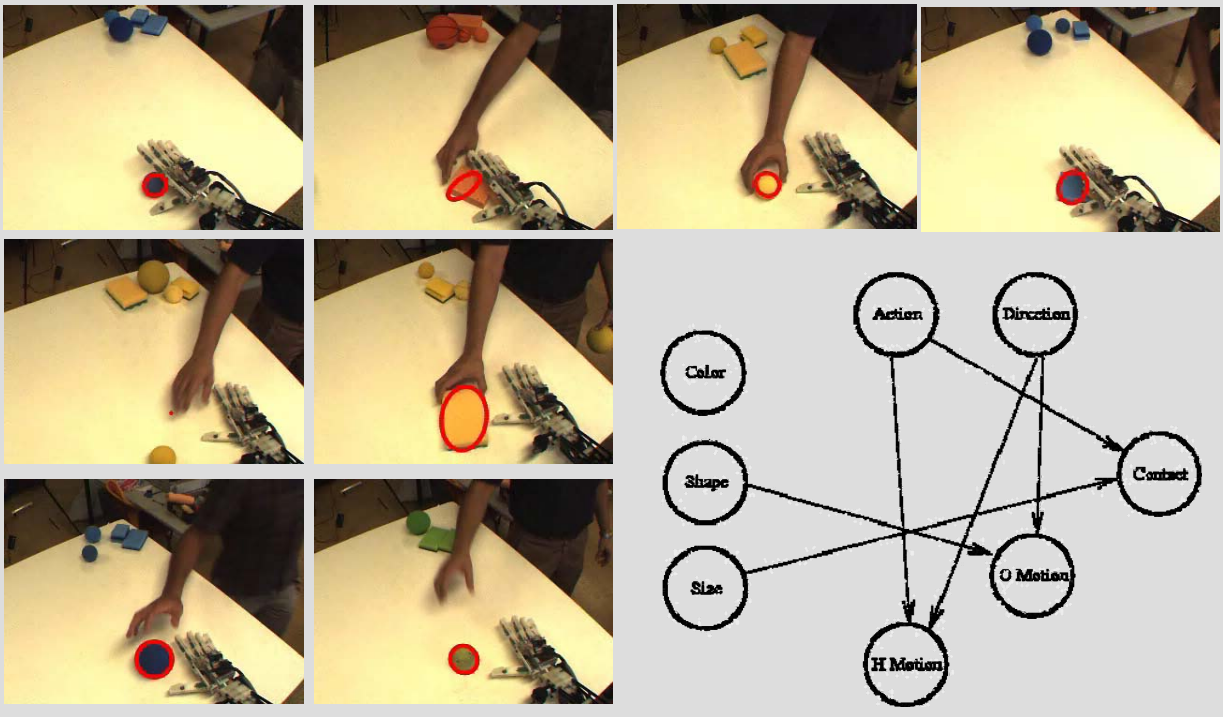
- "action possibilities" on a certain object, with reference to the actor's capabilities [James J. Gibson, 1979]
- links **Actions**, **Objects** and the consequences of acting on objects (**Effects**).
- Grounded of the particular experience and capabilities of the agent.

# Example: Grasp, Tap & Touch

- Objects have:
  - Two different shapes
  - Two sizes
  - Three colors
- Effects:
  - Contact
  - Object Motion



# Exploring the space of actions



# Using the affordances

- Probabilistic inference & planning for recognition, prediction and decision making
- Imitation, action clustering
- Hierarchical organization for sequences

| inputs | outputs | function |
|---|---|---|
| $(O, A)$ | $E$ | Predict / Recognize Effect $P(E\|O, A)$ |
| $(O, E)$ | $A$ | Plan / Recognize action $P(A\|O, E)$ |
| $(A, E)$ | $O$ | Search / Recognize object |
| $O$ | $E, A$ | Object Affordance |
| $E$ | $O, A$ | Plan /Search |
| $A$ | $O, E$ | Interpret Intentions |



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# Task Learning
## through observation

### Task description

Grasp green object
Release at position 1
Grasp yellow object
Release at position 2
Grasp green object
Release at position 3

### Assuming

Colour based segmentation

Motion restricted fronto-parallel plane



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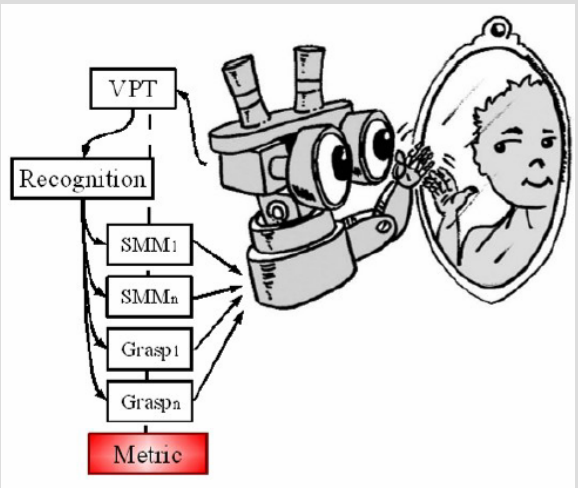
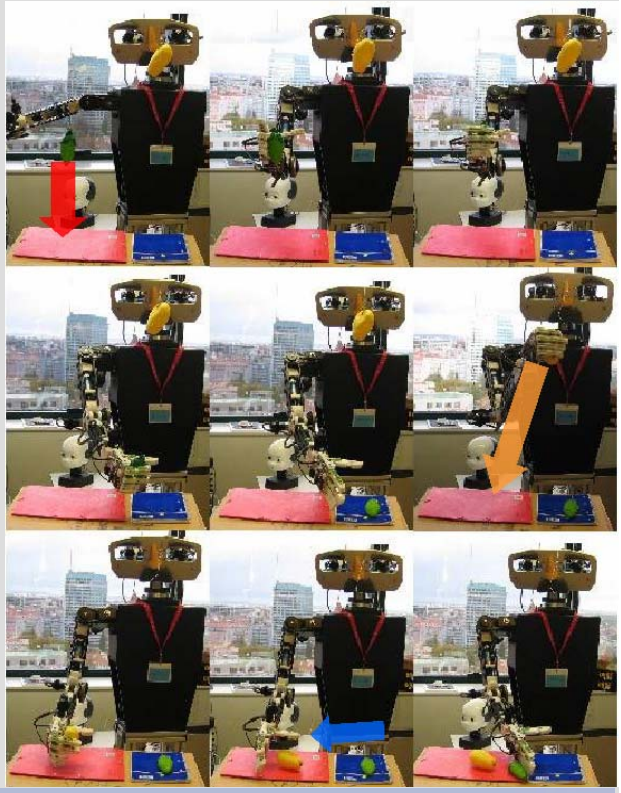
# Learning by imitation

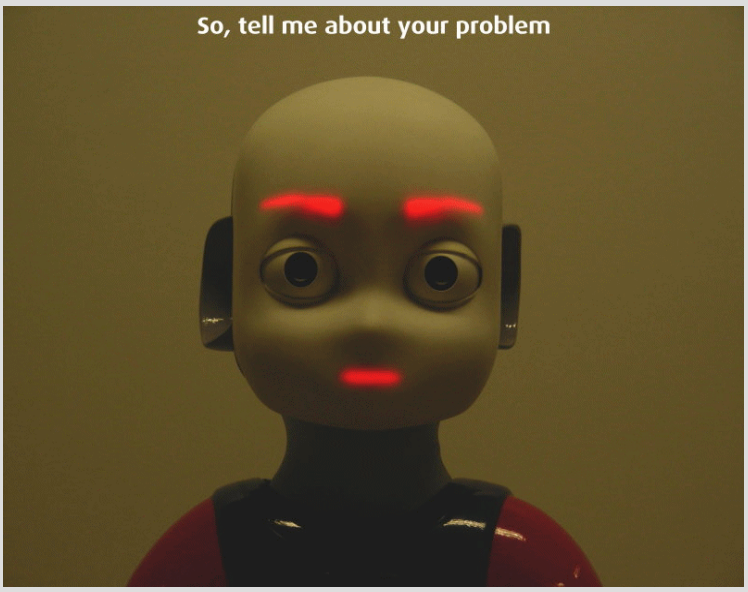


Similar morphology between the robot and humans might simplify the task transfer

Basic capabilities should be present to allow learning of more complex ones

# Interaction / Communication




Explicit and implicit communication:

- Body expressions
- Sound
- Image
- Language acquisition



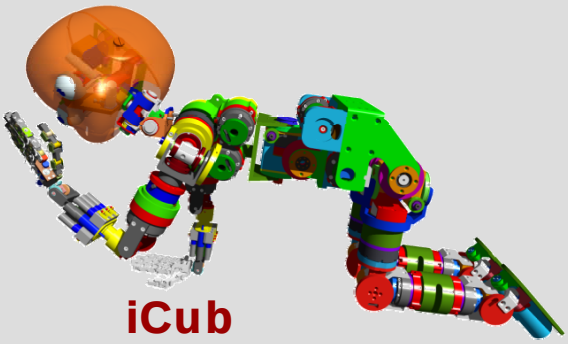
# The ROBOT-CUB Project

- Design and construction of a humanoid robotic platform for research in cognition and cognitive development.

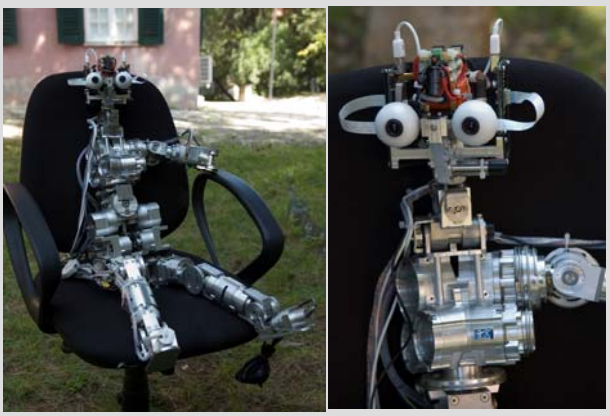
-Consortium: roboticists + neuroscientists + psychologists + ..

2.5 yr child, ~23kg

~50 DOFs



iCub



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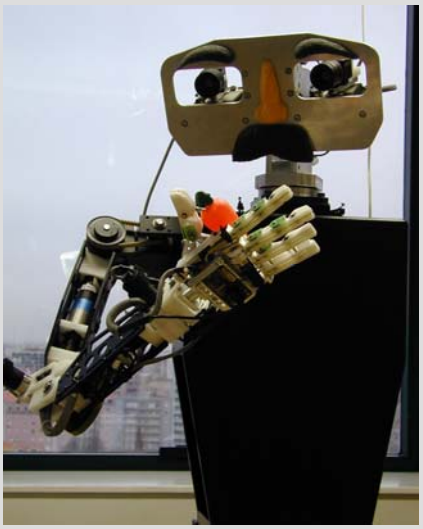
# Roads(map)

- Action understanding/ recognition
- Learning/decision making
  - Affordances, context
- Imitation/communication
  Dissimilar bodies
  (shared) attention
  empathy, emotions
  Language acquisition
- Architectures/ scalability
- General theory of cognition
- Developmental psychology / neuroscience, .. : multidisciplinarity
- Learning algorithms in large dimensional spaces
- High-dimensional motor control
- Communication/interfaces



***Rich sensor data***
***"Drinking from the fire hose"***



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## Credits

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## URL

http://vislab.isr.ist.utl.pt
www.robotcub.org

http://www.isr.ist.utl.pt/labs/vislab

Computer and Robot Vision Laboratory