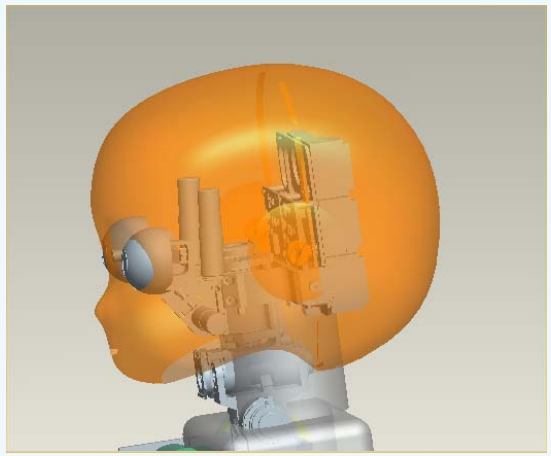
RobotCub

RobotCub



Building a humanoid robotic platform

The 1st RobotCub Open Day

Genoa, Italy, July 14ht 2005

Cogsys
Cognitive Systems

RobotCub

Outline

- Our motivations
  - Why do we do what we do?
- Building what
  - A humanoid robot
- Our goals
  - Understanding cognition, building cognition

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Two keywords

"Perception, cognition and motivation develop at the interface between neural processes and actions. They are a function of both these things and arise from the dynamic interaction between the brain, the body and the outside world"

Von Hofsten, TICS 2004

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RobotCub

- Development: to replicate something requires to know how to build it
  - Corollary: "building" is not entirely like "understanding"
- Action: interaction in the real world requires a body
  - Corollary: the shape of the body determines the affordances that can be exploited

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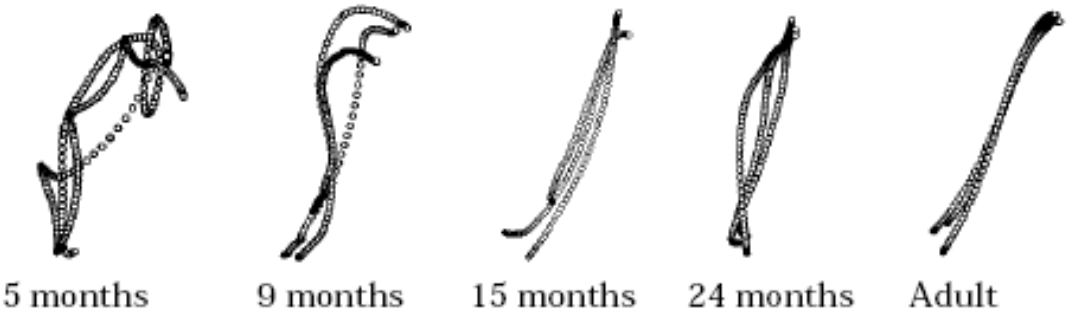
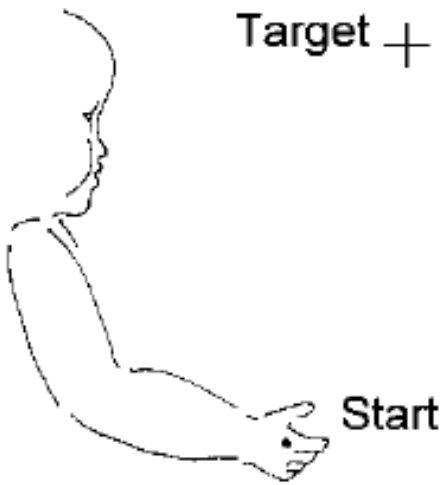
What is changing?





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- The controller is changing, coordination is changing
- Konczak et al. for instance showed that it is not a problem of peak "torque" generation but one of control

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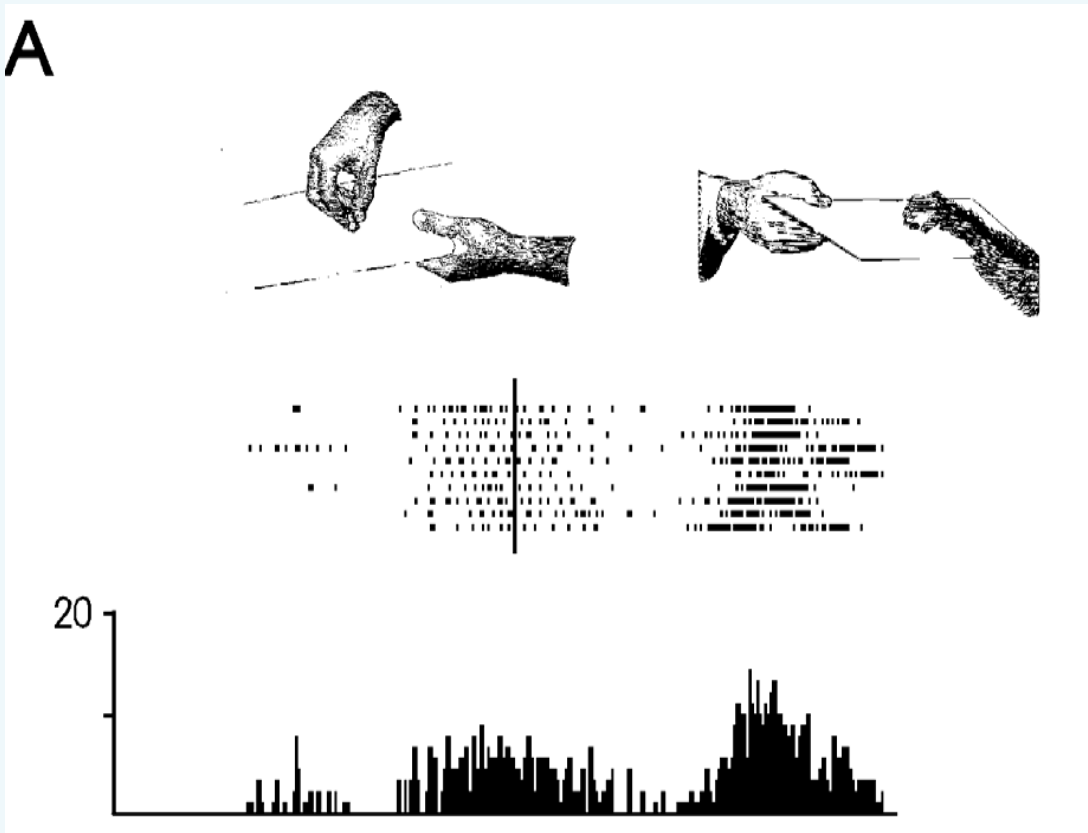
Action is important



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The perception of actions happens through the mediation of the action system

i.e. perception is not the private affair of the sensory systems

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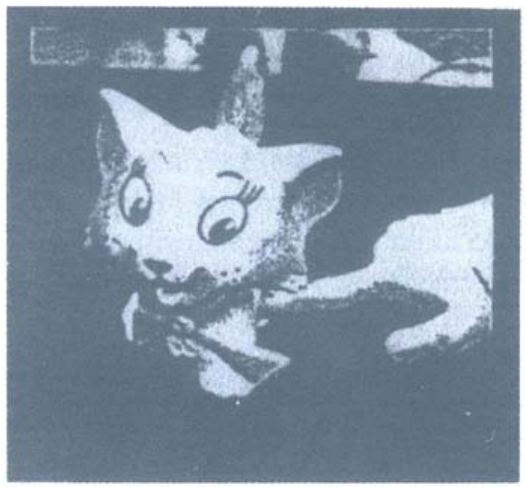
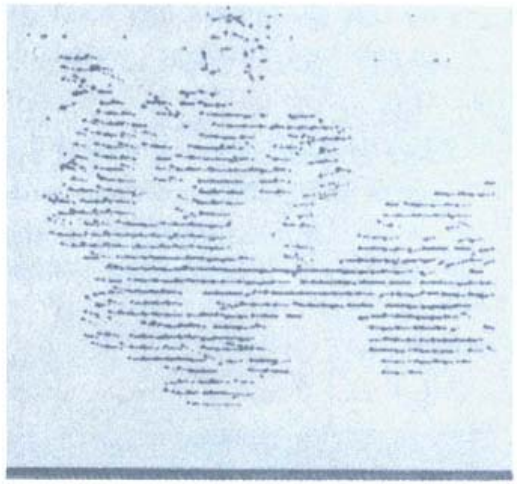
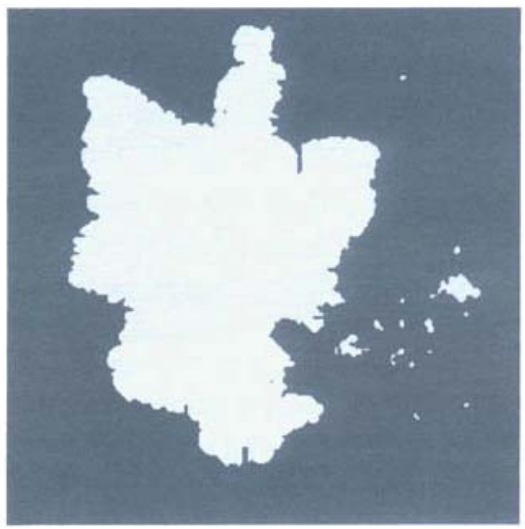
Active perception

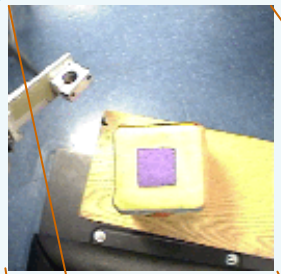




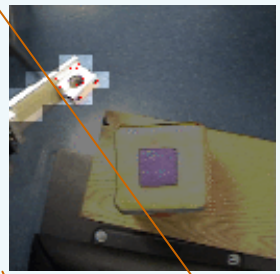


LIRA-Lab, 1991 or so

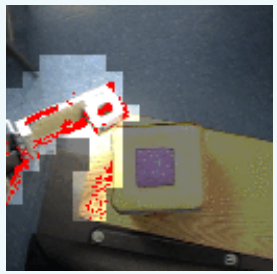
Also, objects come to existence because they are manipulated



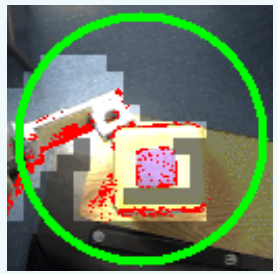
Fixate target



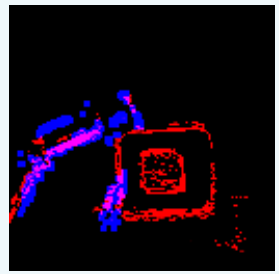
Track visual motion…



(…including cast shadows)

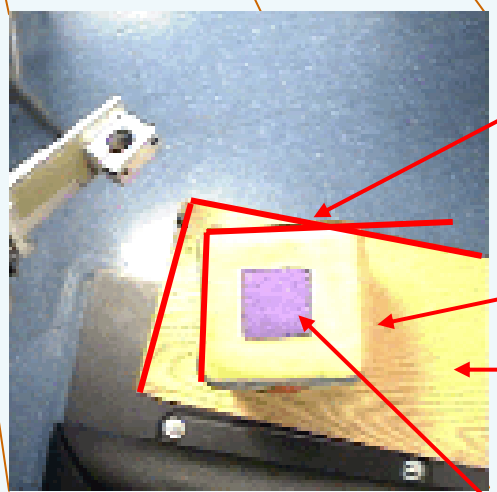


Detect moment of impact



Separate arm, object motion

Segment object



Which edge should be considered?

Maybe some cruel grad-student glued the cube to the table

Color of cube and table are poorly separated

Cube has misleading surface pattern

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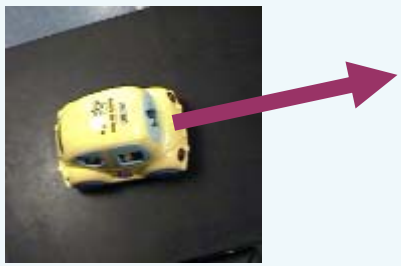
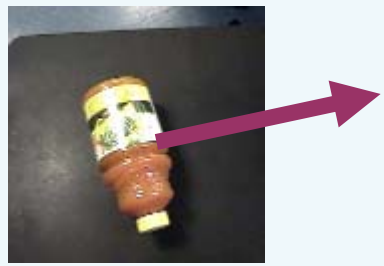
Exploring an affordance: rolling

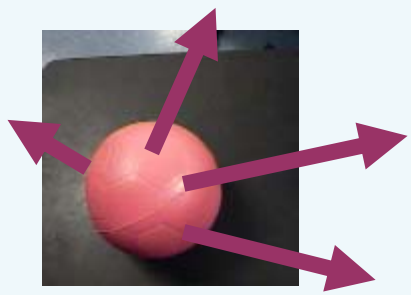


A toy car: it rolls in the direction of its principal axis



A bottle: it rolls orthogonal to the direction of its principal axis

A toy cube: it doesn't roll, it doesn't have a principal axis



A ball: it rolls, it doesn't have a principal axis

RobotCub

An old video…

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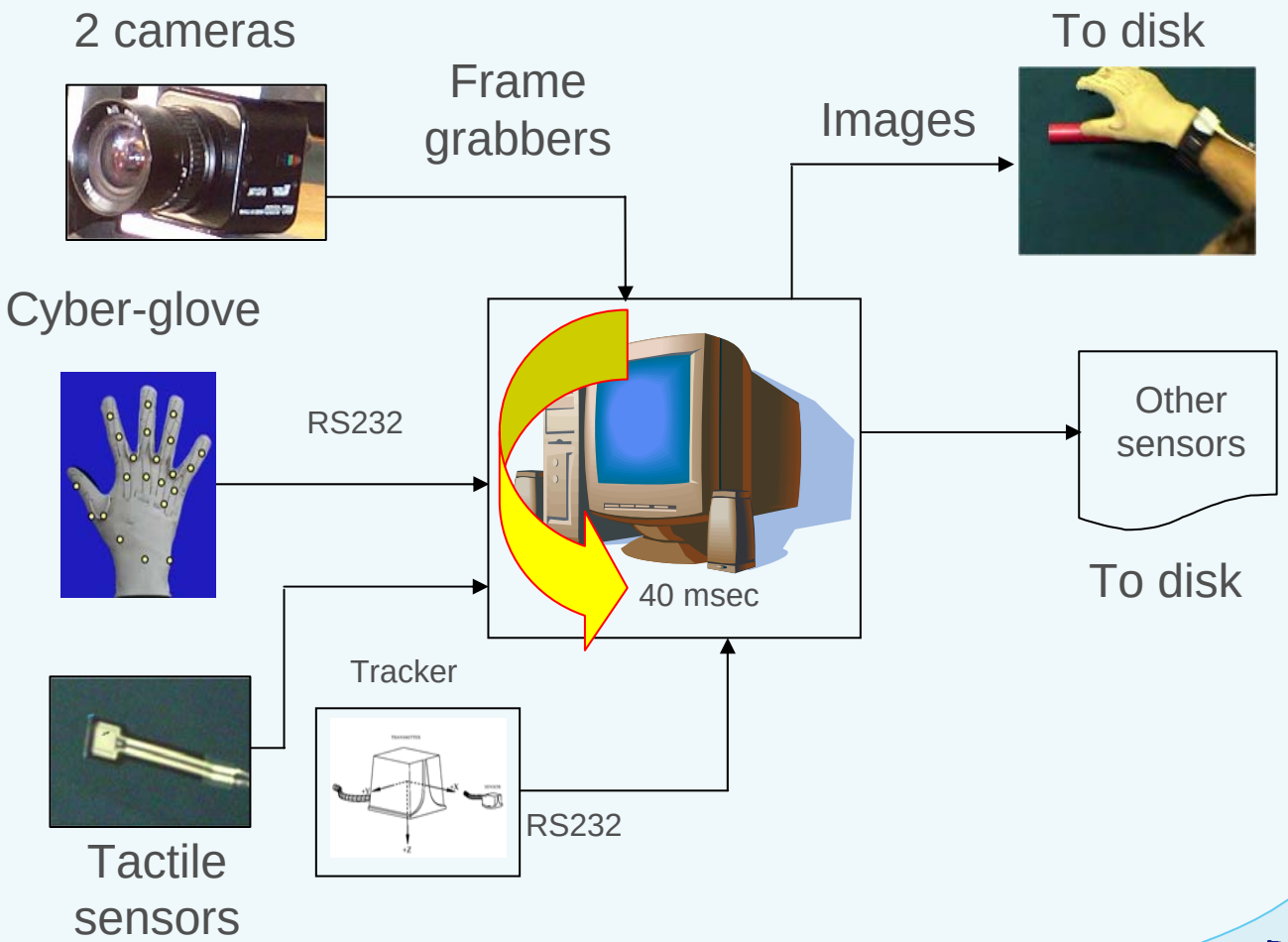
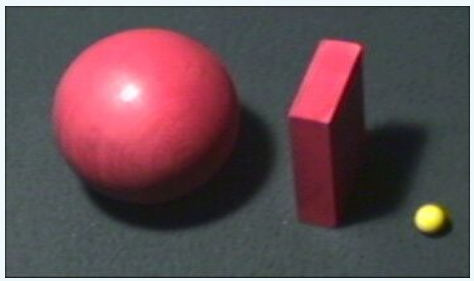
The MIRROR project

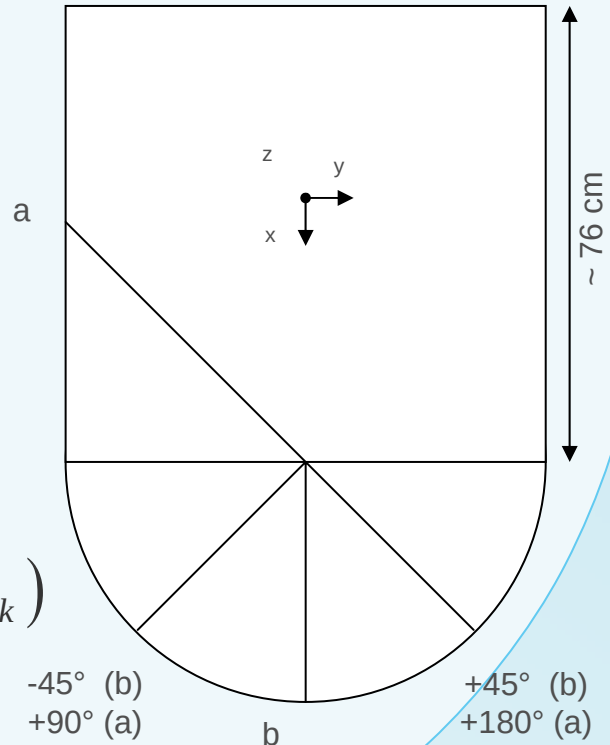


Bayesian classifier

168 sequences per subject
10 subjects
6 complete sets

$\{G_i\}$: set of gestures
F: observed features
$\{O_k\}$: set of objects



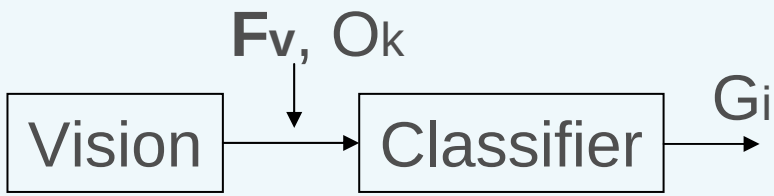


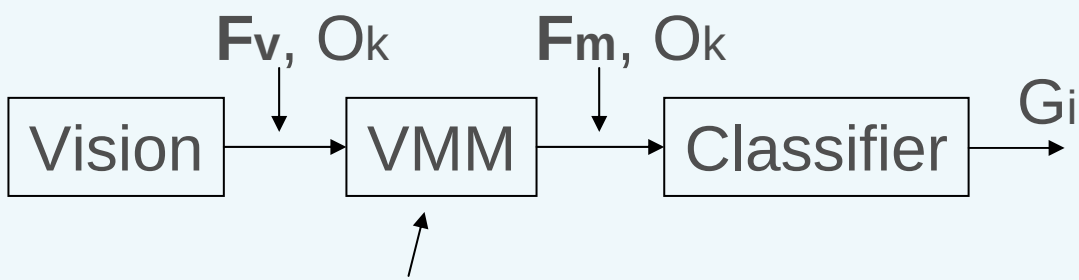
$p(G_i|O_k)$: priors (affordances)
$p(\mathbf{F}|G_i,O_k)$: likelihood to observe **F**

$$p(G_i \mid \mathbf{F}, O_k) = p(\mathbf{F} \mid G_i, O_k)\, p(G_i \mid O_k) / p(\mathbf{F} \mid O_k)$$

$$\hat{G}_{MAP} = \arg\max_{G_i} (G_i \mid \mathbf{F}, O_k)$$

Two types of experiments

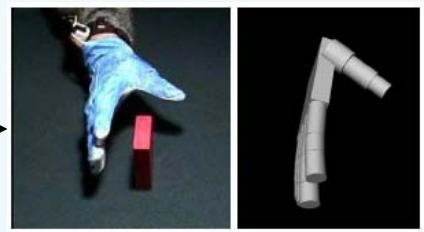




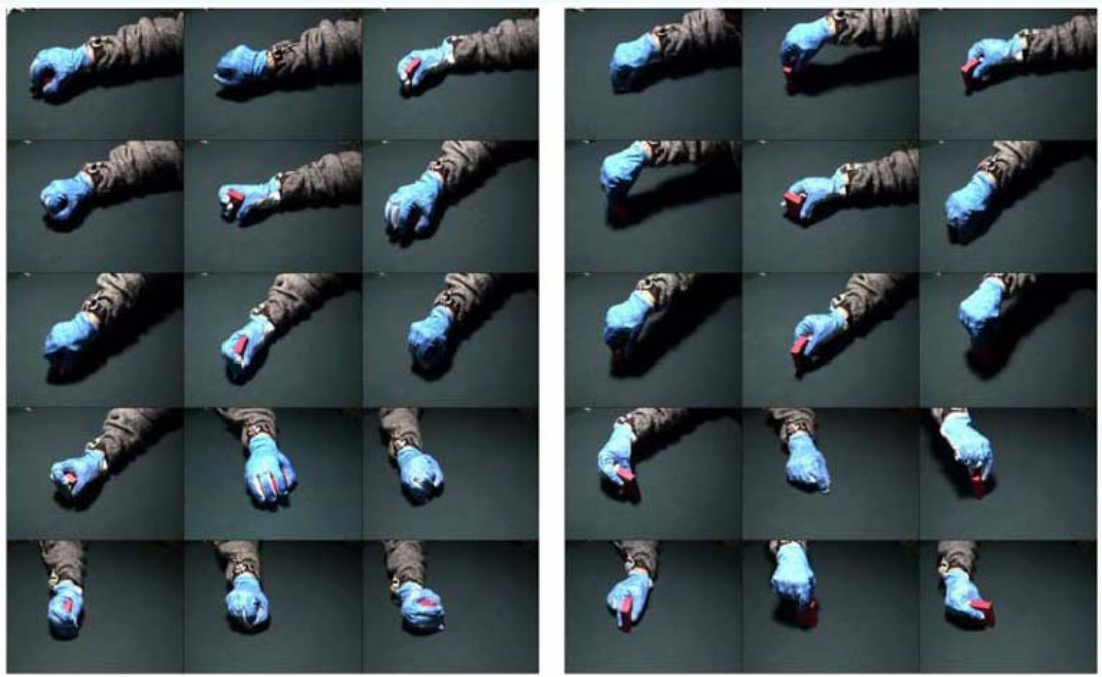
Has motor information anything to do with recognition?

Object affordances (priors)

Visual space Motor space



Classification
(recognition)



Grasping actions

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Some results…

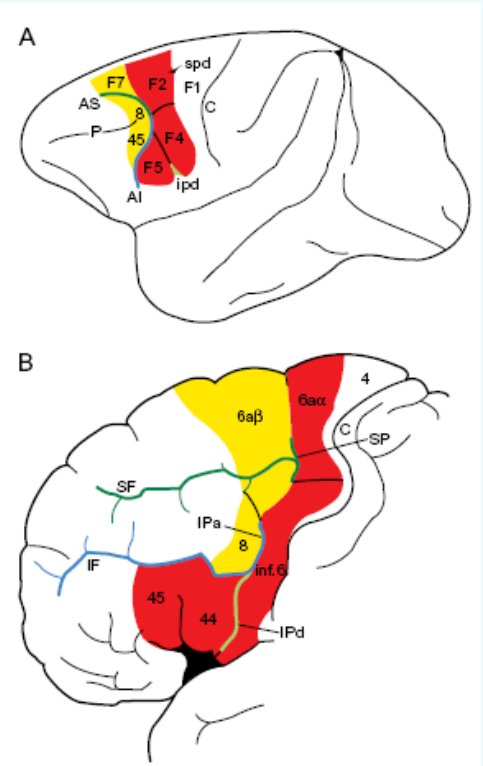
	Exp. I (visual)	Exp. II (visual)	Exp. III (visual)	Exp. IV (motor)
	Training			
# Sequences	16	24	64	24
# of view points	1	1	4	1
Classification rate	100%	100%	97%	98%
# Features	5	5	5	15
# Modes	5-7	5-7	5-7	1-2
	Test			
# Sequences	8	96	32	96
# of view points	1	4	4	4
Classification rate	100%	30%	80%	97%

RobotCub

Language within our grasp

Giacomo Rizzolatti and Michael A. Arbib

In monkeys, the rostral part of ventral premotor cortex (area F5) contains neur
both when the monkey grasps or manipulates objects and when it observes
making similar actions. These neurons (mirror neurons) appear to represent a sy



"In all communication, sender and receiver must be bound by a common understanding about what counts; what counts for the sender must count for the receiver, else communication does not occur. Moreover the processes of production and perception must somehow be linked; their representation must, at some point, be the same."

[Alvin Liberman, 1993]

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European Journal of Neuroscience, Vol. 15, pp. 399–402, 2002

SHORT COMMUNICATION
Speech listening specifically modulates the excitability of tongue muscles: a TMS study

Luciano Fadiga,[1] Laila Craighero,[1,2] Giovanni Buccino[2] and Giacomo Rizzolatti[2]
[1]Dipartimento di Scienze Biomediche e Terapie Avanzate, Sezione di Fisiologia Umana, Università di Ferrara, via Fossato di Mortara 17/19, 44100 Ferrara, Italy
[2]Istituto di Fisiologia Umana, Università di Parma, via Volturno 39, 43100 Parma, Italy

Keywords: mirror neurons, motor-evoked potentials, motor system, motor theory of speech perception

The ultimate constituents of speech are articulatory gestures (one and the same thing, one concept to rule them all)

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Mirror neurons?

Vision	Acoustic
Manipulation	Speech
Motor	Motor
Watching others	Listening to others

RobotCub

Manipulation, i.e. taking actions → speech

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RobotCub

The iCub

- Requirements
  - Hands to manipulate
  - Arms with a large workspace
  - Head with fast camera movements
  - Waist and legs for crawling
- Able to crawl & reach to fetch objects and sit to manipulate them
- Child-like size

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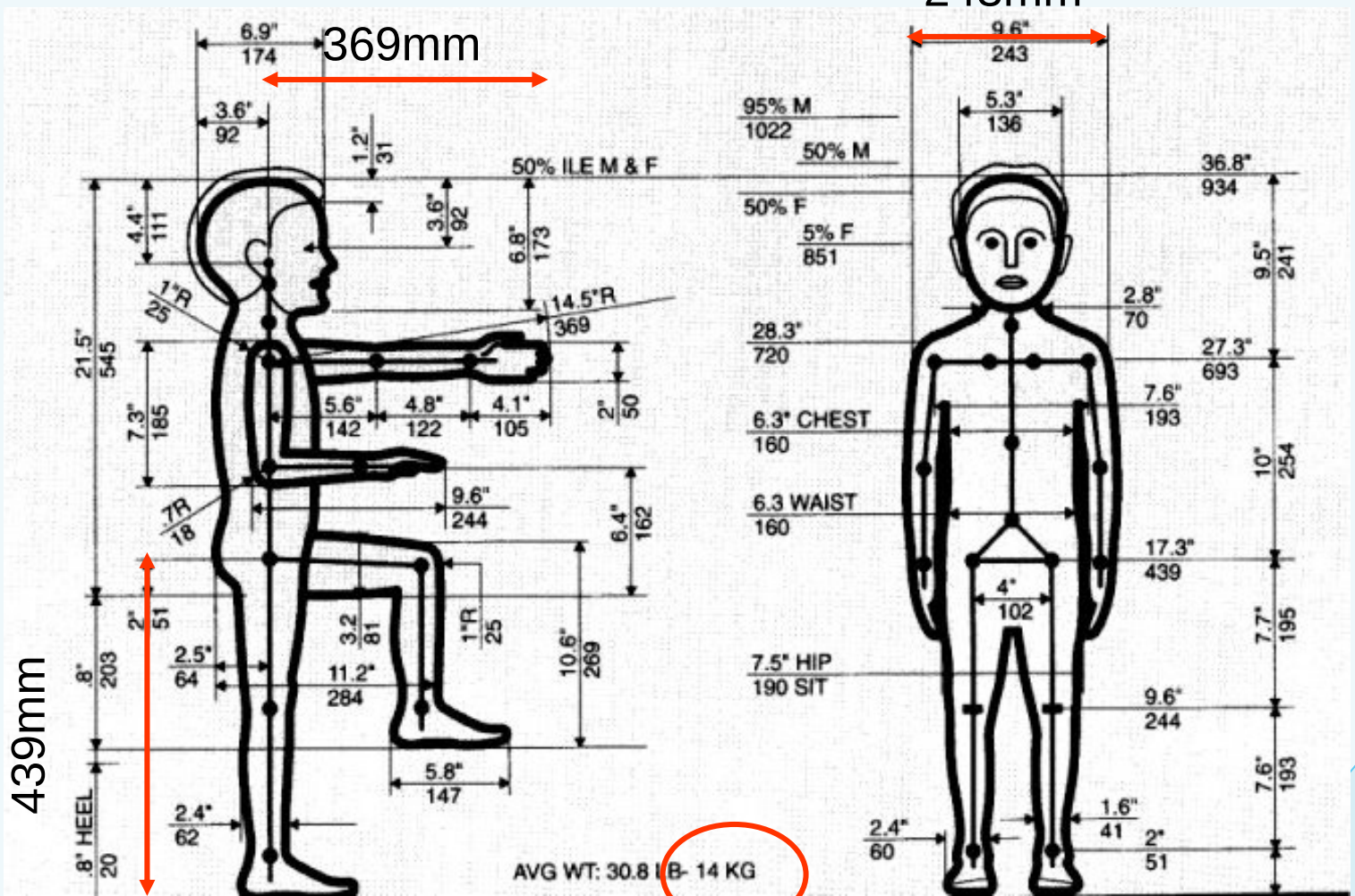
Child-like, how much?



Avg. 14Kg - 30.8 lb

RobotCub

Well…

- It is going to be heavier: ~23Kg
- 53 degrees of freedom
  - 9 x2 hands
  - 7 x2 arms
  - 6 head
  - 6 x2 legs
  - 3 torso
- Embedded electronics

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RobotCub

Sensors

- Cameras
- Microphones
- Gyroscopes, linear accelerometers
- Tactile sensors
- Proprioception
- Torque sensors
- Temperature sensors

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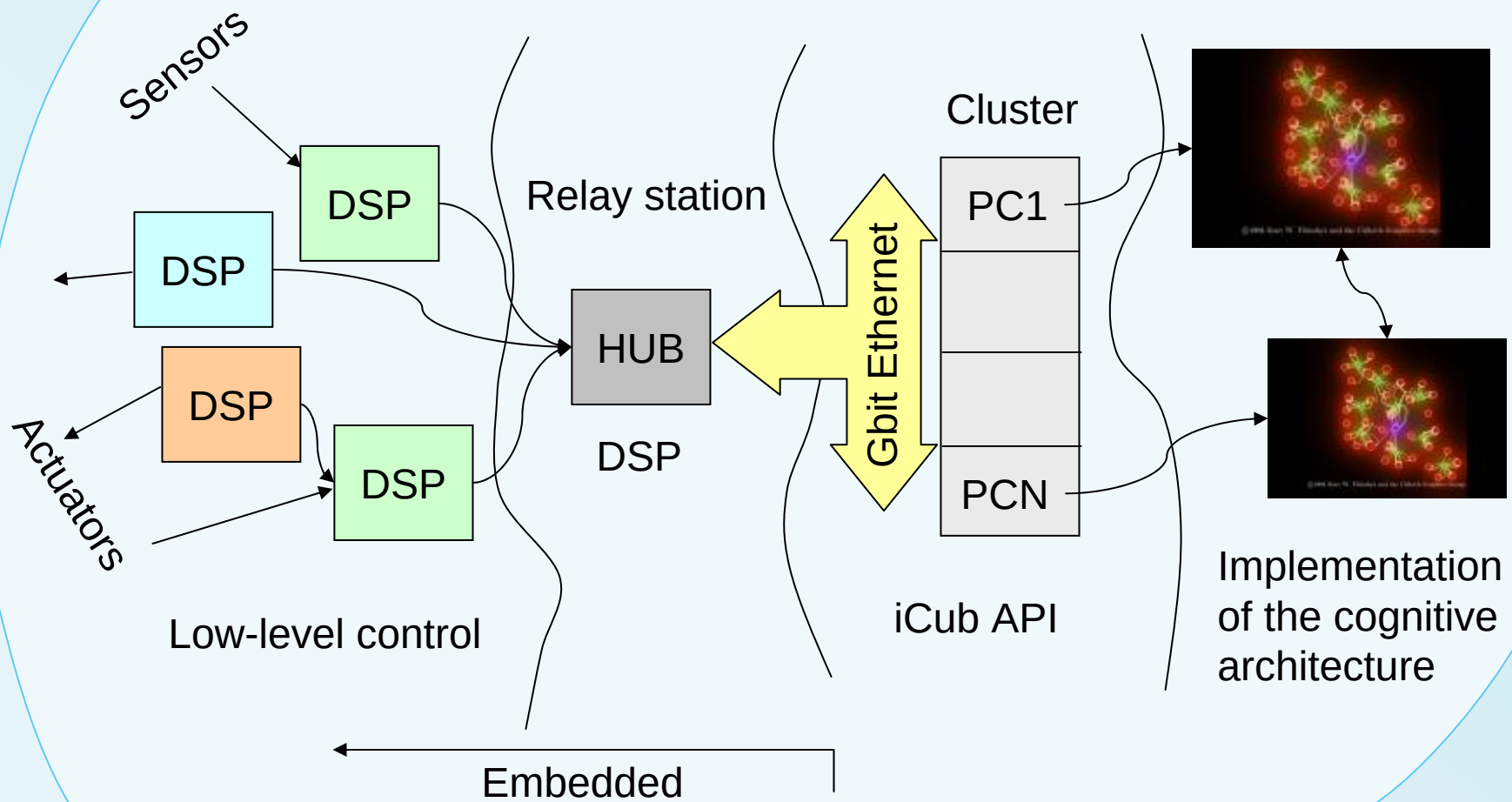
Levels


Sensors
DSP
DSP
DSP
DSP
Actuators
Low-level control
Relay station
HUB
DSP
Embedded
Gbit Ethernet
Cluster
PC1
PCN
iCub API
Implementation of the cognitive architecture

RobotCub

...and, yes, it is open!

- GPL for all the software, controller, tools, everything that runs on the robot
- FDL for the drawings, electronics, documentations, etc.

- Open to new partners and collaborations worldwide

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RobotCub

Meet the iCub

See you in March 2007!

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