Why Humanoids

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Humanoids: what's next?
IEEE Humanoids 2010
Nashville, USA

Let's start with a statement...

The goal of our research in robotics is to build systems that can interact with humans and communicate in "natural ways"



..robots that can be our everyday companions...



Can everyday companions be different from humanoids?

If robots have to work with us we can motivate the choice of humanoids at a superficial, yet very important, level...

...morphological: we need humanoids because our world and our tools are made to be used by humans







..unless we want to grow wheels...

In a stylish way...

In a cheap way...

...but that there is another, more fundamental reason for which we need humanoids and this is not really rooted in the way robots are shaped but in the way robots behave

In this sense we can define "humanoids" as systems that behave like humans but not necessarily with a human-like shape

In this sense being a humanoid is more about "interaction" than "action"

Humanoids without humans are not so interesting (the key is interaction)

...so, why humanoids?

Because:

1. We still do not know how to build systems that behave like humans.
2. We still do not know what it means to interact like a human
3. ...and humanoids are essential tools to study these issues

We need humanoid robots to design and realize systems that can work with humans and communicate in "natural ways"....

We need to move from the "remote control" approach

...to human-like interaction based on *mutual understanding*

based on sharing of knowledge and experience ...

...and achieved through information exchanged in "natural ways" (including contacts and forces)

In the last years we have been forming a community with neuroscientists sharing a scientific interest on action execution and understanding

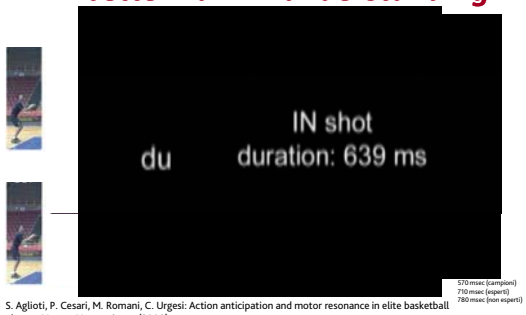
Object's perceptual properties are coded in motor terms

- Position of objects in space can be coded in terms of the action required to reach it (with any body part)
- Object trajectories can be coded in terms of the action required to intercept it (or avoid it)
- Size can be coded in terms of "grasp type" (small is every object that can be grasped with a pinch grasp)

Mirror Neurons

Interpreting actions performed by others means to activate the areas of the brain that are activated when we execute the same actions

...The better I am in doing, the better I am in understanding...



S. Aglioti, P. Cesari, M. Romani, C. Urgesi: Action anticipation and motor resonance in elite basketball players, Nature Neuroscience (2008)

From the engineering point of view mirror neurons show that if the goal is to build systems that "understand", we need to design also the skills required to act

If you want to understand humans you need to be able to behave like a human

...when interacting with others we implicitly assume that the others are feeling our own sensations and emotions, that they will react in the same way we would do...

...mutual understanding...

Mutual understanding means being able to put yourself in someone else shoes

Humanoid robotics allows the study of how to build a system able to put itself in the shoes of a human being

So in the last years we have developed a strong synergy between robotics and neuroscience around the science and engineering of "action execution and understanding"

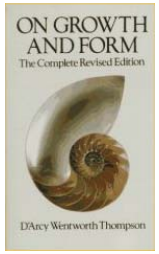
What else is missing to address human-like interaction?

1. From the scientific point of view we miss a few important ingredients
2. From the engineering point of view we need to develop new integration tools

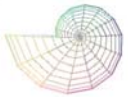
...but remember that we have still to solve some fundamental, "vintage" problems such as: vision, touch, ecc...

...for example...

Form and function are correlated in biological systems



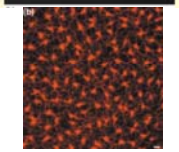
Physical growth and morphological change is an essential ingredient of nature's smart solutions



"Natural" minds are shaped by interactions

In nature also the bodies are shaped by interactions

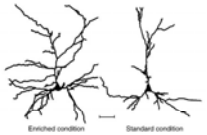
Micromechanical hypothesis of mosaic assembly

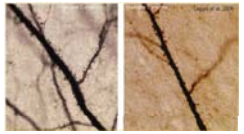


Lucia Galli, TRENDS in Neuroscience Vol. 25 No. 12 – December 2002

In biological systems body and mind co-develop

Development and learning are associated to morphological changes at the musculoskeletal and at the neuronal level



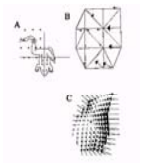


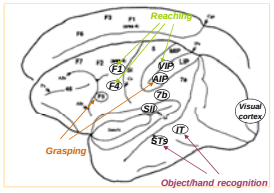
Is this unique of biological systems?

Can we think about "artificial growth"?

Solutions in biological systems are always multi-technological

Intelligent manipulation depends as much on how the controller works (mind) as on the physical properties of the muscles





Bizzi e Mussa-Ivaldi theory of force fields Exploit visco-elastic properties of muscles

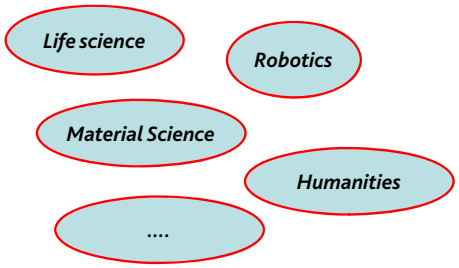
Rizzolatti discovery of Mirror Neurons: exploit motor representation for visual recognition

Exploit co-development of function and physical growth

Living materials: living in the sense that their physical characteristics are changed by functions (e.g. they become harder or softer, they change shape, they "grow" according to function).

...the missing dimensions...?

...so far we have attempted to study the adaptation of the mind but the body is fixed...



A new community

Research in this field requires the foundation of a new *human centered discipline* where results from neuroscience, material science, engineering, physics, humanities philosophy are jointly investigated to embed human-like interaction abilities in artificial systems.

This new community needs tools specifically designed to help the development, integration and consolidation of knowledge coming from different sciences and technologies

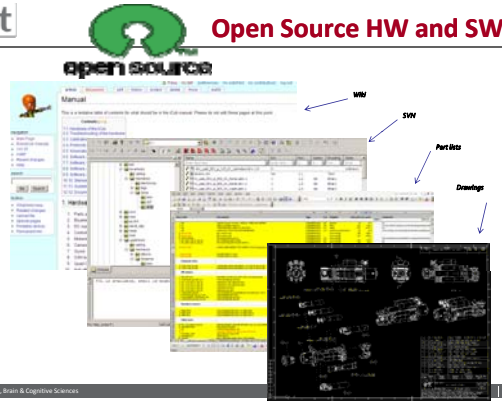
How do we ensure that the multidisciplinary groups are blended into a coherent interdisciplinary community?

1. Common Objectives ⇨ Research Issue
2. Integration Tools ⇨ Methodological Issue

iCub-like systems are essential integration tools

1. With iCub different solutions can be compared and benchmarked on the same platform
2. iCub supports the accumulation of knowledge across students (helps the survival across generations of students) and communities (geographical as well as scientific)

Open Source HW and SW



Open Source Middleware (YARP)

- YARP is an open-source (LGPL) middleware for robotics
- History
  - An MIT / Univ. of Genoa collaboration
  - Born on Kismet, grew on COG, under QNX
  - With a major overhaul, now used by the iCub project
- Exists as an independent open source project (SourceForge)
- C++ source code (some 400K lines)


2000-2001


2001-2002


2003


2004-Today

The iCub Community

Serial No.	Institution	Reference Person
1	IIT-RBCS	
2	IIT-RBCS	
3	IIT-RBCS	
4	Beckman Institute, Urbana-Champaign, USA	Stephen Levinson
5	Technical University of Munich	Michael Beetz
6	University Pompeu Fabra, Barcellona	Paul Verschure
7	METU - Ankara	Erol Sahin
8	University Pierre Marie Curie, Paris	Vincent Padois
9	Imperial College, London	Murray Shanahan
10	Instituto Superiore Technico - Lisbon	Jose Santos-Victor
11	EPFL - Lausanne	Aude Billard
12	INSERM, Lyon	Peter Dominey
13	CNR Rome	Gianluca Baldassarre
14	University of Aberystwyth	Mark Lee
15	IDSIA, Lugano	Juergen Schmidhuber
16	CITEC/CORLAB Bielefeld,	Gerhard Sagerer
17	CITEC/CORLAB, Bielefeld, 2nd copy	Gerhard Sagerer
18	University of Plymouth	Angelo Cangelosi
19	CNR Rome	Stefano Nolfi
20	University of Hertfordshire	Kerstin Dautenhahn
	Scuola Superiore S. Anna - Pisa (upper body)	Cecilia Laschi
	FIAS Frankfurt (head only)	Cornelius Weber

iCub and friends

Building a community of scientists sharing goals and results

All platforms are maintained and upgraded

Joint Experiments

MORE HERE:
www.youtube.com/robotcub

EPFL Group: Auke Ijspeert, Sara Degallier, Sebastian Gay, Ludovic Righetti,

With Peter Dominey

With IST Lisbon (Jose' Santos-Victor, Alex Bernardino)

..moreover in order to address the big scientific question of how to build systems that understand and predict what humans are doing...

we need to be able to experiment with tools "stimulating" the parts of the human brain which are activated when a human observes another human or works with another human

Humanoid Aided Design (HAD)

Humanoid robots and their development environment represent, with all their complexity, an essential tool to design systems with human-like interaction

Humanoid Aided Design System

1. Made of HW (including the humanoid itself) as well as SW components and development tools.
2. Based on a rich collection of interchangeable perceptual and motor skills with different features and/or performance
3. Include simulation tools for preliminary feasibility testing
4. Tools supporting real-life comparison, benchmarking and fine tuning of different solutions.

The overall complexity of the HAD system is (and must be) higher than the complexity of the targeted system.

The added value of HAD is to help finding the minimum set of HW and SW features solving the targeted interaction problem.

At the end we may find that we don't need a full humanoid robot but for the design phase we need to have all potentially interesting features at our disposal

HAD is an evolving system

- Body structure will evolve into softer/lighter systems
- Sensors and actuators will evolve into more flexible solutions
- Processors will change their characteristics
- ...

Yet the principles and requirements behind human-robot interaction will remain the same and if we do not want to have to reinvent the wheel every time a new technology is discovered, we need systems facilitating the migration of our "interaction solutions".

In the future we may see a family of robot bodies (certainly not as complex as our HAD systems and certainly made of different materials) where different skills and abilities could be uploaded according to needs and desires of the individual users...

We can think to extend today's solutions....

iPhone

iPad

iCub

"iCub-like" robots as a collectors of interaction apps

What's next then...

1. A lot of science and technology
2. A wider Scientific Community
3. New design and integration tools

Thank you

Videoclips of iCub here:
www.youtube.com/robotcub