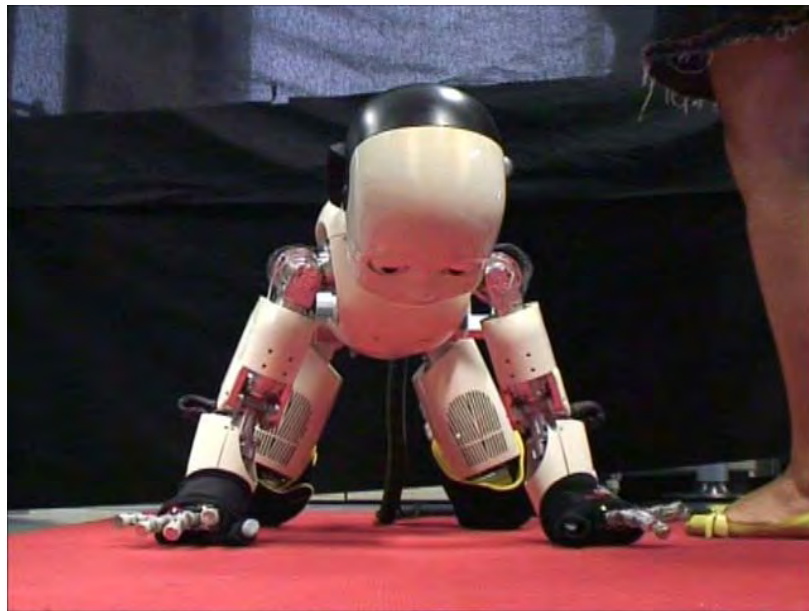
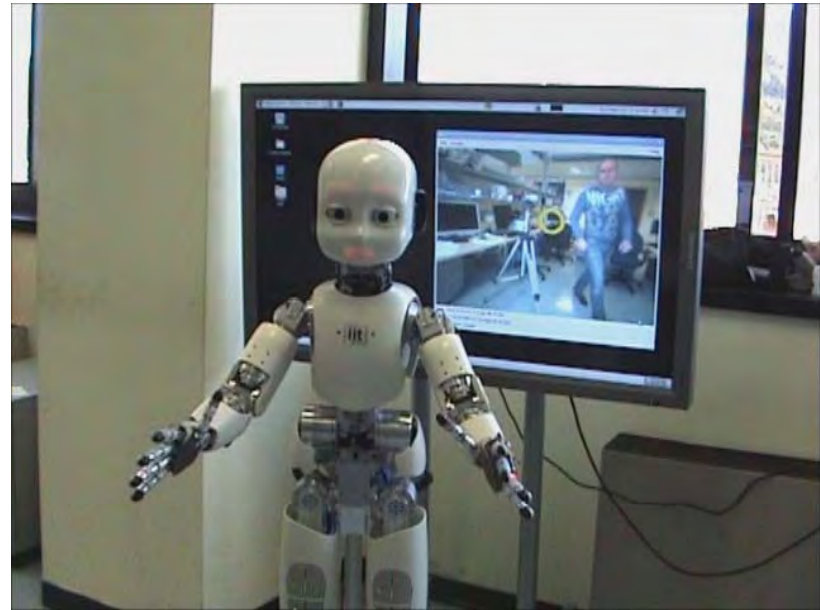
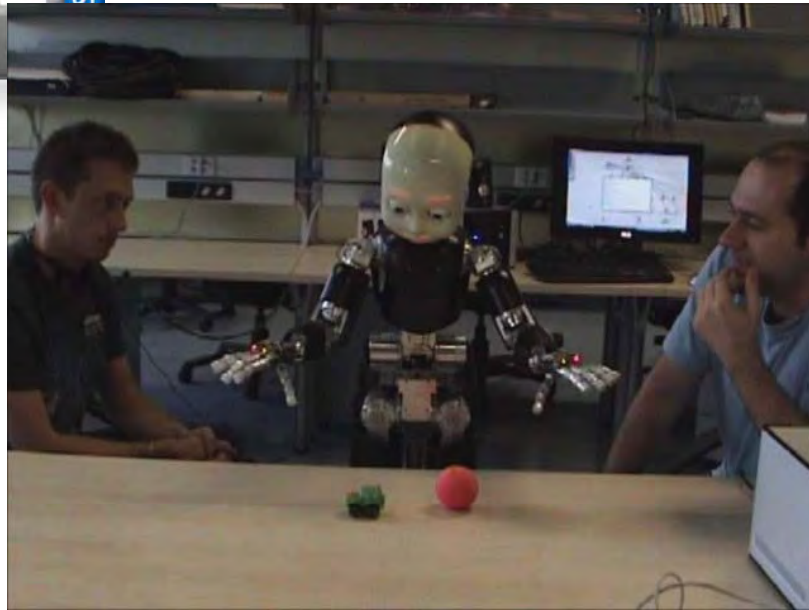


common platforms and benchmarks for cognitive systems

Giorgio Metta
and
the Cognitive Humanoids team

Cognitive Humanoids Laboratory
Dept. of Robotics, Brain and Cognitive Sciences
Italian Institute of Technology



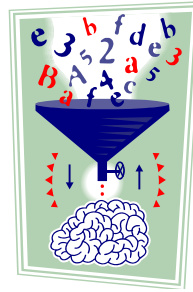


learning new actions

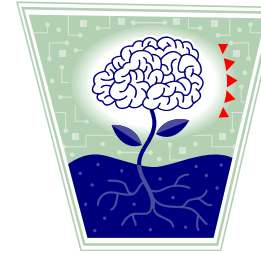


difficult benchmarking

- the development of cognitive systems as a discipline is at a **pre-paradigmatic** stage:
 - definition of what a cognitive system should do, why and how is difficult
 - multidisciplinary: with many different methods and approaches
 - no established general theory: at best partial explanations
 - and clearly, not surprisingly, difficult to benchmark



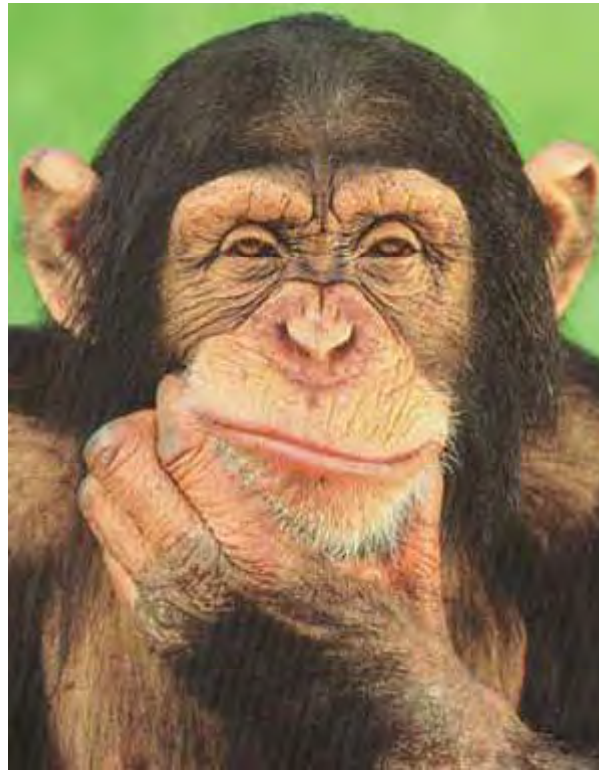
VS.



- separation of symbolic, connectionist, dynamical and enactive approaches
- different communities
- difficult to reconcile the various methods, cultural gap

D. Vernon, L. Fadiga, C. von Hofsten. *A Roadmap for Cognitive Development in Humanoid Robots*. COSMOS Vol 11 Springer 2011

to add to the confusion



human benchmarking

and from here?



pre-paradigmatic status implies:

- definition of the discipline: what is it
- scientific foundation: how to effect it



a roadmap

- definition of *Cognitive Systems* that is neutral with respect to possible approaches
- capabilities that should be exhibited by such systems
- identify competing approaches
- identify critical gaps in scientific understanding and/or technical know-how





strategy for filling the gaps

- highlight significant issues
 - e.g. embodiment, representations, learning, etc.
- difficulty in formulating the problem
 - multi-disciplinary nature of the area
 - the challenge of ensuring that the results are developed in a **formal-repeatable and reusable-fashion**
- embrace multi-disciplinary research
 - without losing the scientific focus and the formal framework of **mathematical** modeling



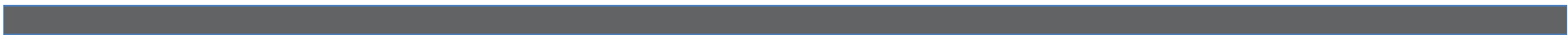
what's next?



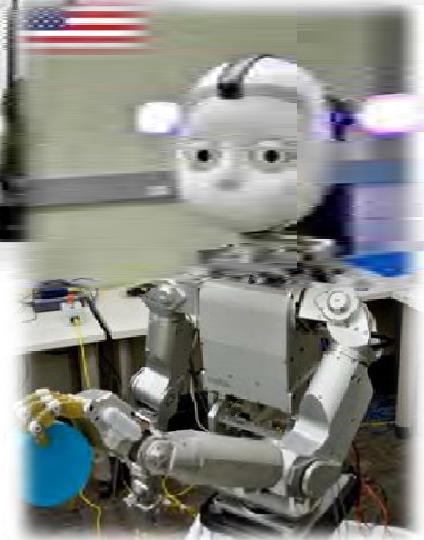
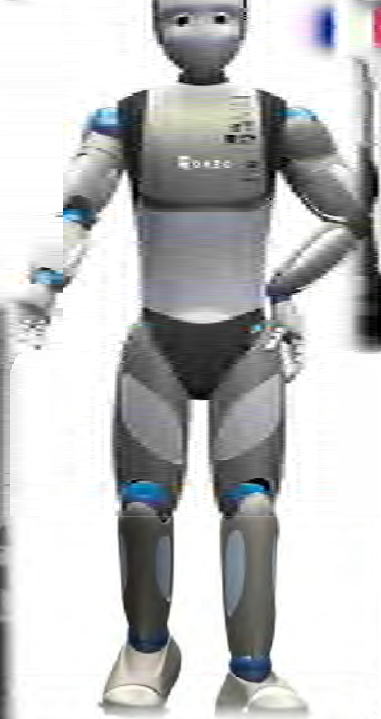
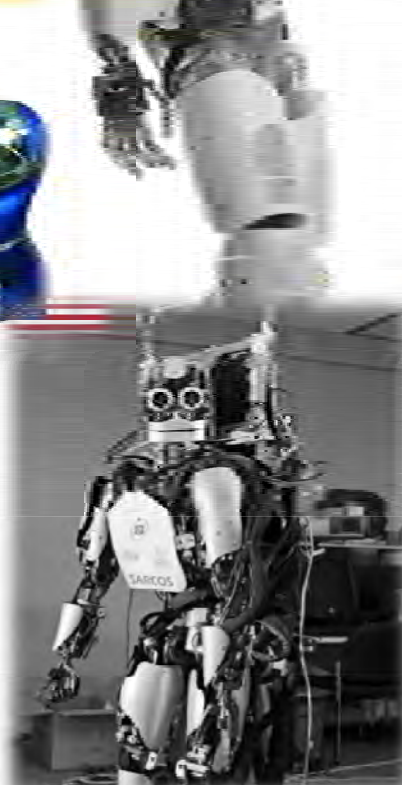
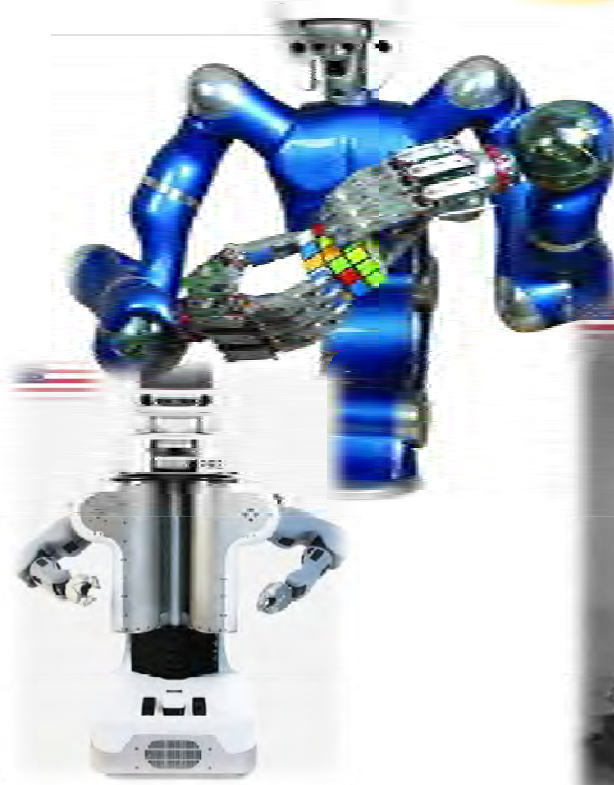
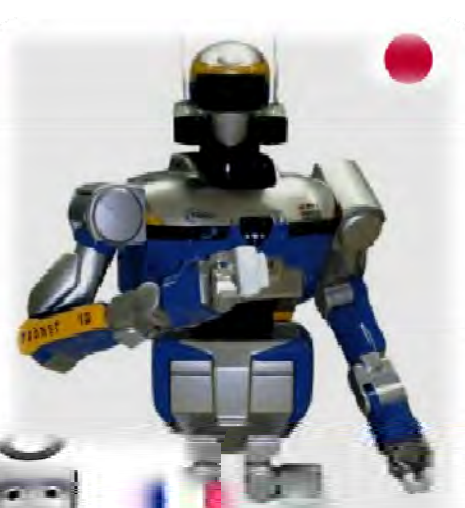




but there's "hope" in technology!

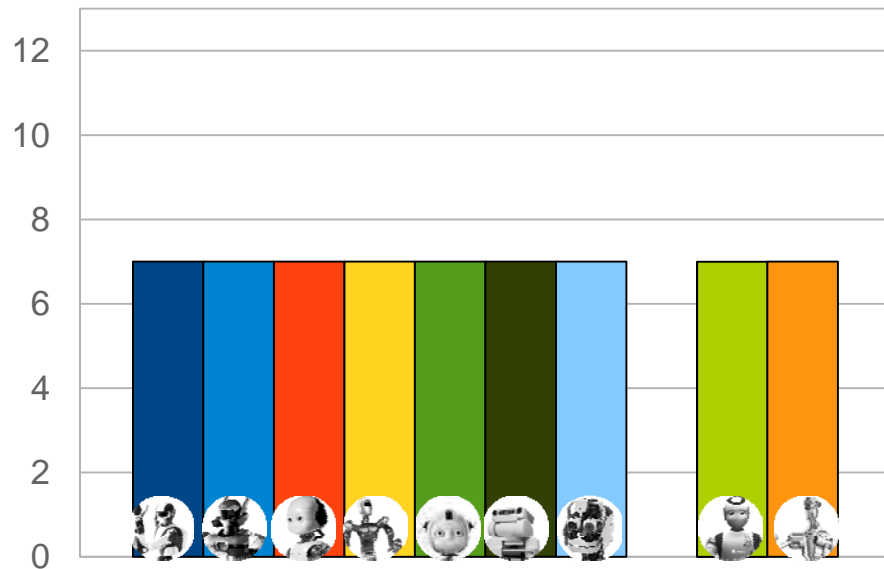
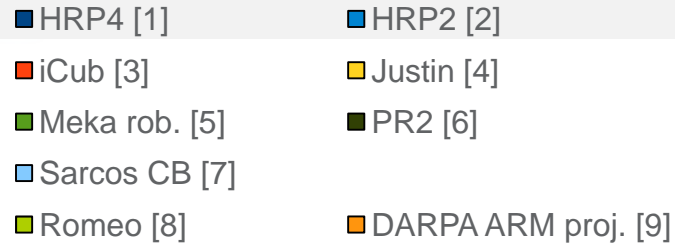


iit
RBCS



dexterity

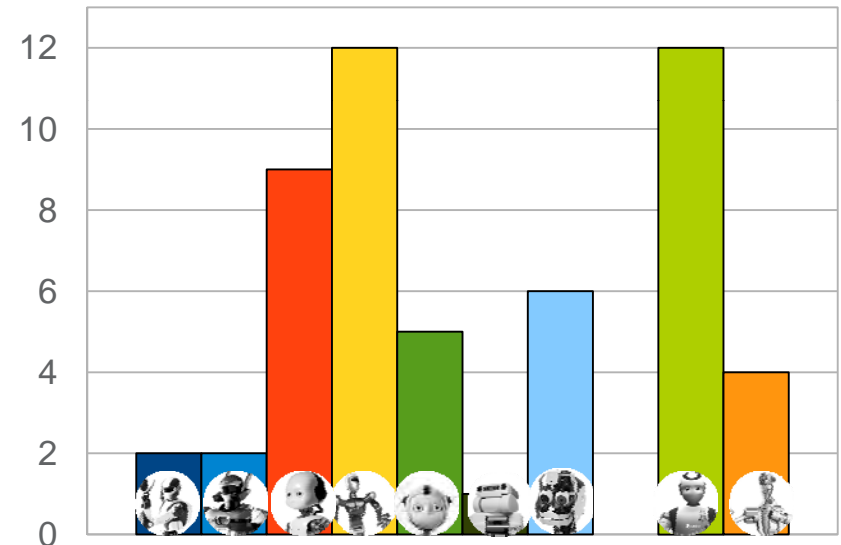
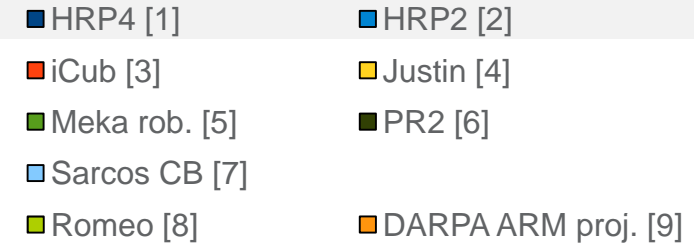
arm DOFs



Sources

- 1 <http://www.plasticpals.com/?p=24521>
- 2 extrapolation on the basis of [1]
- 3 iCub website, Dec 2010 (<http://www.icub.org>)
- 4 DLR spec. sheet, Jan 2011 (http://www.dlr.de/rm/en/Portaldata/52/Resources/dokumente/light_weight_robot/dlr-ibrii-eng_homepage.pdf)
- 5 Meka Robotics website, Dec 2010 (http://www.mekabot.com/product_sheets/meka_a2_arm_product_sheet_10_2009.pdf)
- 6 Willow Garage website, Jan 2011 (<http://www.willowgarage.com/pages/pr2/specs>)
- 7 Cheng et al. 2007, Advanced Robotics (DOI: 10.1163/156855307781389356)
- 8 extrapolation (IEEE Spectrum, Dec 2010, <http://spectrum.ieee.org/automaton/robotics/humanoids/france-developing-advanced-humanoid-robot-romeo?>)
- 9 Barrett Technology Inc. website, Jan 2011 (<http://www.barrett.com/robot/products-arm-specifications.htm>)

hand DOFs



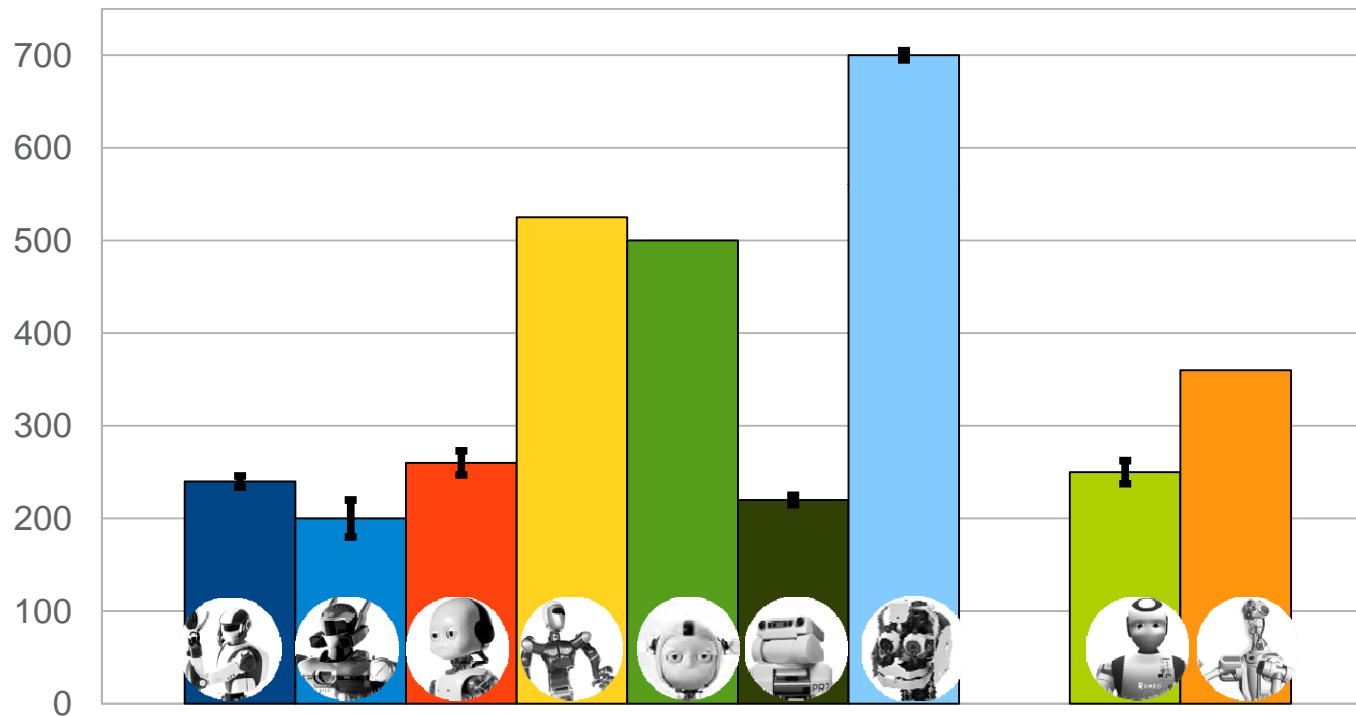
Sources

- 1 <http://www.plasticpals.com/?p=24521>
- 2 extrapolation on the basis of [1]
- 3 iCub website, Dec 2010 (<http://www.icub.org>)
- 4 DLR website, Jan 2011 (http://www.dlr.de/rm/en/desktopdefault.aspx/tabid-3802/6102_read-8918/)
- 5 Meka Robotics website, Dec 2010 (http://www.mekabot.com/product_sheets/meka_H2_hand_product_sheet_10_2009.pdf)
- 6 Willow Garage website, Jan 2011 (<http://www.willowgarage.com/pages/pr2/specs>)
- 7 Cheng et al. 2007, Advanced Robotics (DOI: 10.1163/156855307781389356)
- 8 extrapolation (IEEE Spectrum, Dec 2010, <http://spectrum.ieee.org/automaton/robotics/humanoids/france-developing-advanced-humanoid-robot-romeo?>)
- 9 Barrett Technology Inc. website, Jan 2011 (<http://www.barrett.com/robot/products-hand-specifications.htm>)

price

price [k€]

- HRP4 [1]
- HRP2 [2]
- iCub [3]
- Justin [4]
- Meka rob. [5]
- PR2 [6]
- Sarcos CB [7]
- Romeo [8]
- DARPA ARM proj. [9]



Sources

- 1 <http://www.physorg.com/news203756368.html>
- 2 estimated on the basis of [1]
- 3 iCub production costs, PMU, Fabrizio Larosa 12 Jan 2011
- 4 estimated on the basis of a 100k€ quotation for the DLR LWR III arms (ADVR, Nikos Tsagarakis, Sep 2008) and a 50k€ price for the hands (<http://mindtrans.narod.ru/hands/hands.htm>)
- 5 estimation based on the prices of sub-assemblies (<http://mindtrans.narod.ru/robots/robots.htm>)
- 6 Willow Garage website, 12 Jan 2011 (<http://www.willowgarage.com/blog/2010/09/07/pr2-pricing-and-open-source-discount>)
- 7 unofficial quotation (Giorgio Metta, Sep 2007)
- 8 IEEE Spectrum, 14 Dec 2010 (<http://spectrum.ieee.org/automaton/robotics/humanoids/france-developing-advanced-humanoid-robot-romeo>)
- 9 IEEE Spectrum, Oct 2010 (<http://spectrum.ieee.org/automaton/robotics/robotics-software/darpa-arm-program>)

diffusion

■ HRP4 [1]

■ HRP2 [2]

■ iCub [3]

■ Justin [4]

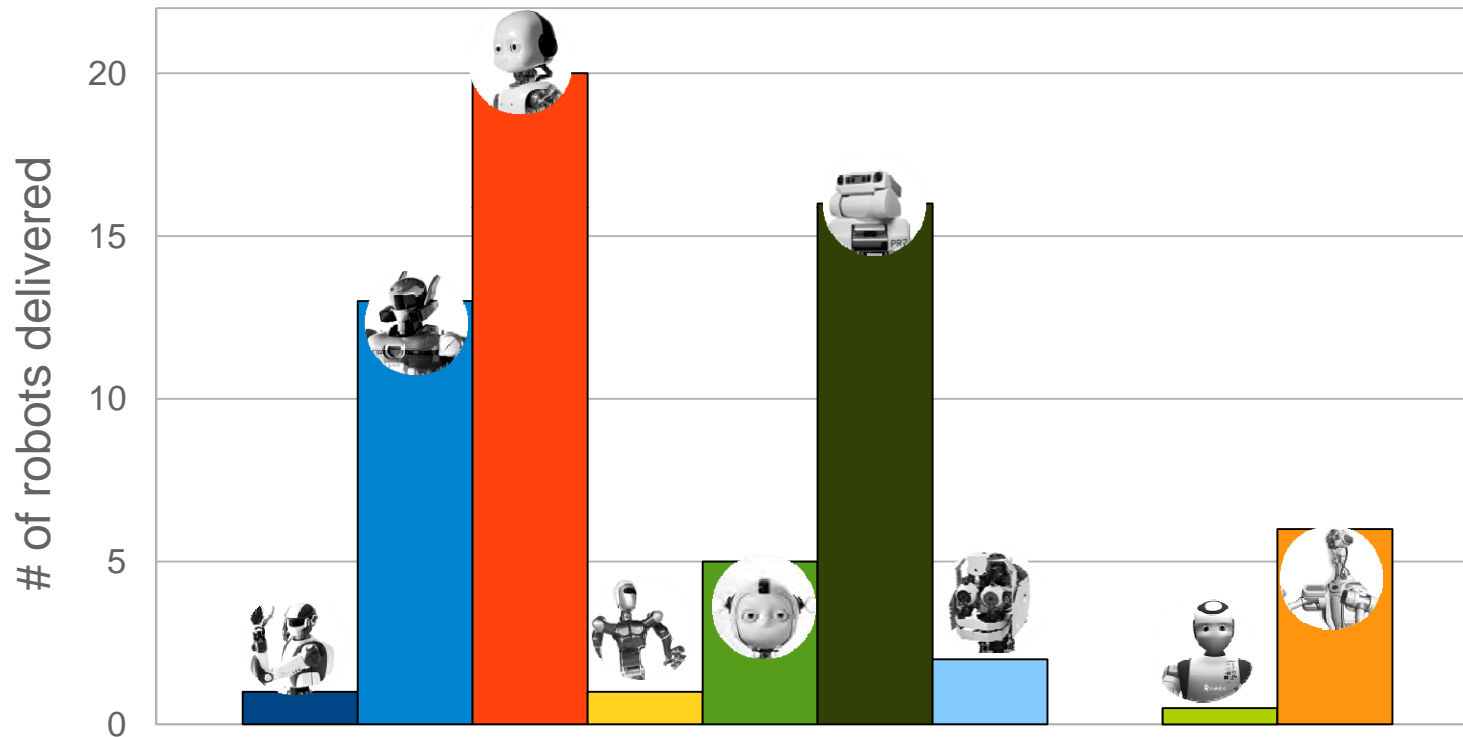
■ Meka rob. [5]

■ PR2 [6]

■ Sarcos CB [7]

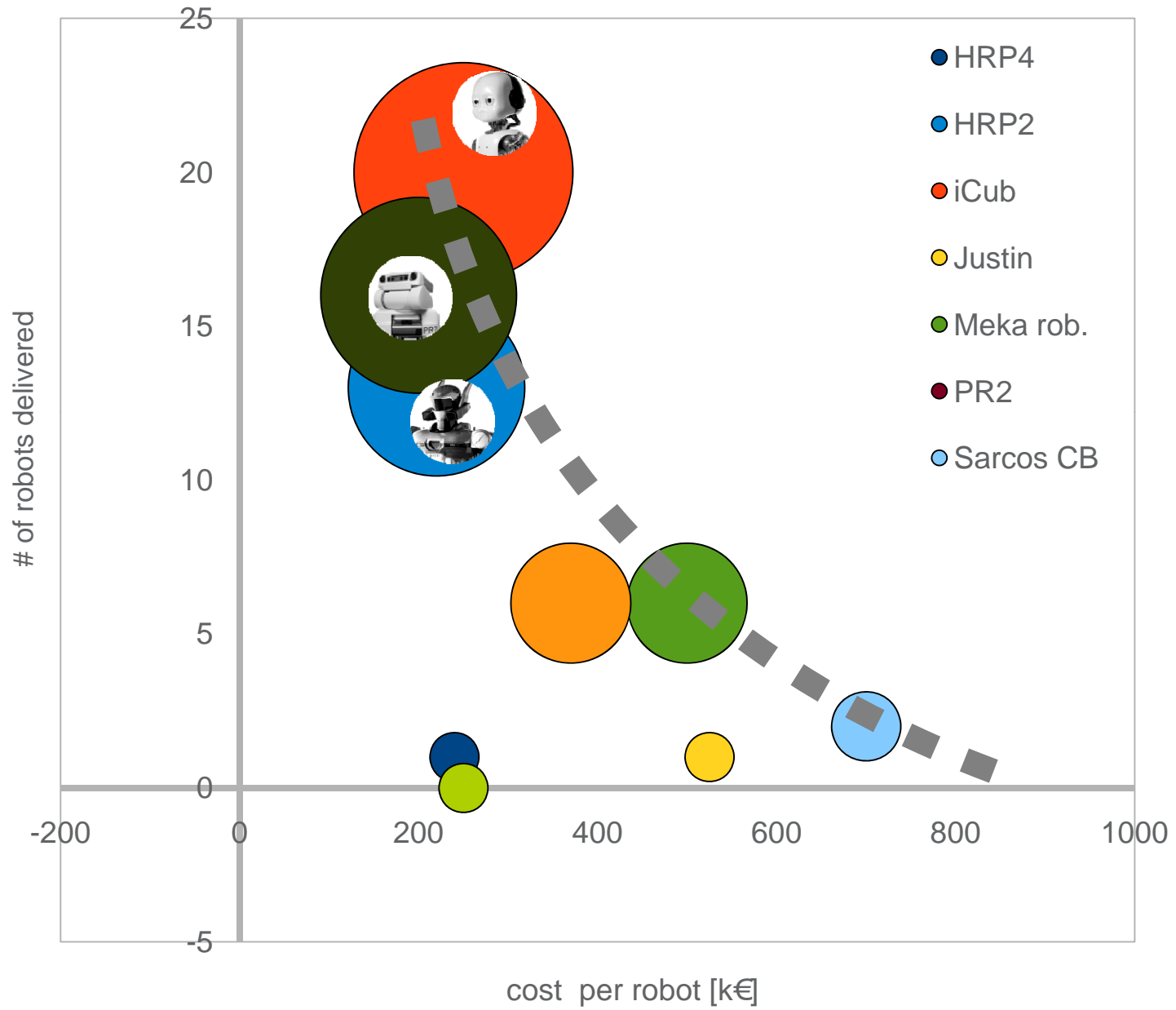
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- 1 <http://www.plasticpals.com/?p=24521>
- 2 http://www.plasticpals.com/?attachment_id=14737
- 3 iCub website, Dec 2010 (<http://www.icub.org>)
- 4 estimated
- 5 Meka Robotics website, Dec 2010 (<http://www.mekabot.com/clients.html>)
- 6 IEEE Spectrum (<http://spectrum.ieee.org/automaton/robotics/robotics-software/willow-garage-sells-first-pr2-robots>)
- 7 estimated on the basis of (<http://web.mac.com/gordoncheng/English/Research/Research.html>)
- 8 prototype
- 9 Hizook, robotics news portal, Sep 2010 (<http://www.hizook.com/blog/2010/08/31/darpa-autonomous-robot-manipulation-arm-robot>)







the “market” is ripe...

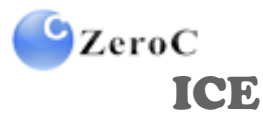
- to allow benchmarking & competitions in the field of cognitive systems
- to “run” enough examples to enable a sort of natural selection of systems & methods
- ...





software systems

ROS.org



Microsoft Robotics





iPod, iPhone, iPad... iCub?



open hardware

the ship of Theseus

- long-lived projects are like the Ship of Theseus
 - the mast gets replaced
 - the planks get replaced
 - over time, everything may get replaced
- in philosophy, this is a “paradox of identity”
- for us, it's just our job





paradigm

- publish code openly → better science expected from robotics
- license code → e.g. GPL, BSD, LGPL, etc.
- **move from peer review to peer usage: *what works matters!***
- survival of the fittest better than survival by consensus (peer review → majority might be wrong!)

Bruce G. Charlton. *The cancer of bureaucracy: How it will destroy science, medicine, education and eventually everything else*. Medical Hypotheses 74 (2010) 961–965



profitable open projects

ANDROID
open source project

Google



google and android

ubuntu[®]

CANONICAL

canonical, the ubuntu service provider company



content manager built on open source



ORACLE[®]

oracle and mysql



linux kernel development and redhat



SO...

- the **literature** of a research community both expresses its ideas, and **aids in their evolution**
 - published ideas are read, evaluated, and built upon
 - useful advances get published
- **“publication” of robots** can speed progress
 - facilitates **evaluating and comparing** approaches
 - brings **new research topics** into reach
 - accumulation of knowledge



- the ultimate benchmark is the survival of code of cognitive systems in the software “gene” pool
- we just need to define the scenario, useful code will emerge (if enough people work on it)

Fitzpatrick, P., Metta, G., & Natale, L. (2008). *Towards Long-Lived Robot Genes*. *Journal of Robotics and Autonomous Systems*, Special Issue on Humanoid Technologies, 56(1-3).



in summary

- standard open platforms are there
 - not only the iCub (unfortunately 😊)
- software is there
 - in many instances
- open source is usable
 - and profitable

- we “just” need to convince the community to embrace some of these ideas
 - the number of people working on common systems is an important parameter

sponsors

- EU Commission projects:
 - RobotCub, grant FP6-004370,
<http://www.robotcub.org>
 - CHRIS, grant FP7-215805,
<http://www.chrisfp7.eu>
 - ITALK, grant FP7-214668,
<http://italkproject.org>
 - Poeticon, grant FP7-215843
<http://www.poeticon.eu>
 - Robotdoc, grant FP7-ITN-235065
<http://www.robotdoc.org>
 - Roboskin, grant FP7-231500
<http://www.roboskin.eu>
 - Xperience, grant FP7-270273
<http://www.xperience.org>
 - EFAA, grant FP7-270490
<http://notthereyet.eu>
- More information: <http://www.iCub.org>

