# Embodied AI and Soft robotics: towards animal like intelligence?

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The BioRobotics Institute, SSSA, Pisa, Italy and Heron Robots

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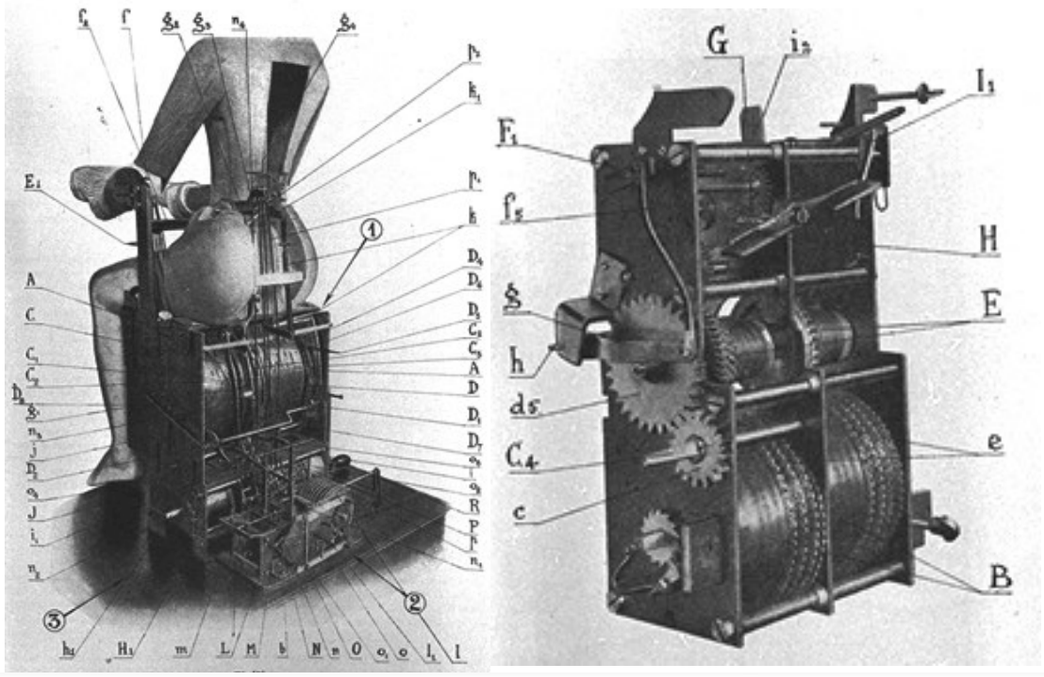
# Old attempts




Jaquet-Droz Brothers (1720-1780)

# Old attempts

Karakuri Dolls
Chahakobi Ningyo (Tea Serving Doll) by SHOBEI Tamaya IX, and plan from 'Karakuri Zuii' ('Karakuri - An Illustrated Anthology') published in 1796.

# Older and newer attempts

**Juanelo Torriano alias Gianello della Torre, (XVI century)** a craftsman from Cremona, built for Emperor Charles V a mechanical young lady who was able to walk and play music by picking the strings of a real lute.

**Hiroshi Ishiguro, early XXI century**

Director of the Intelligent Robotics Laboratory, part of the Department of Adaptive Machine Systems at Osaka University, Japan

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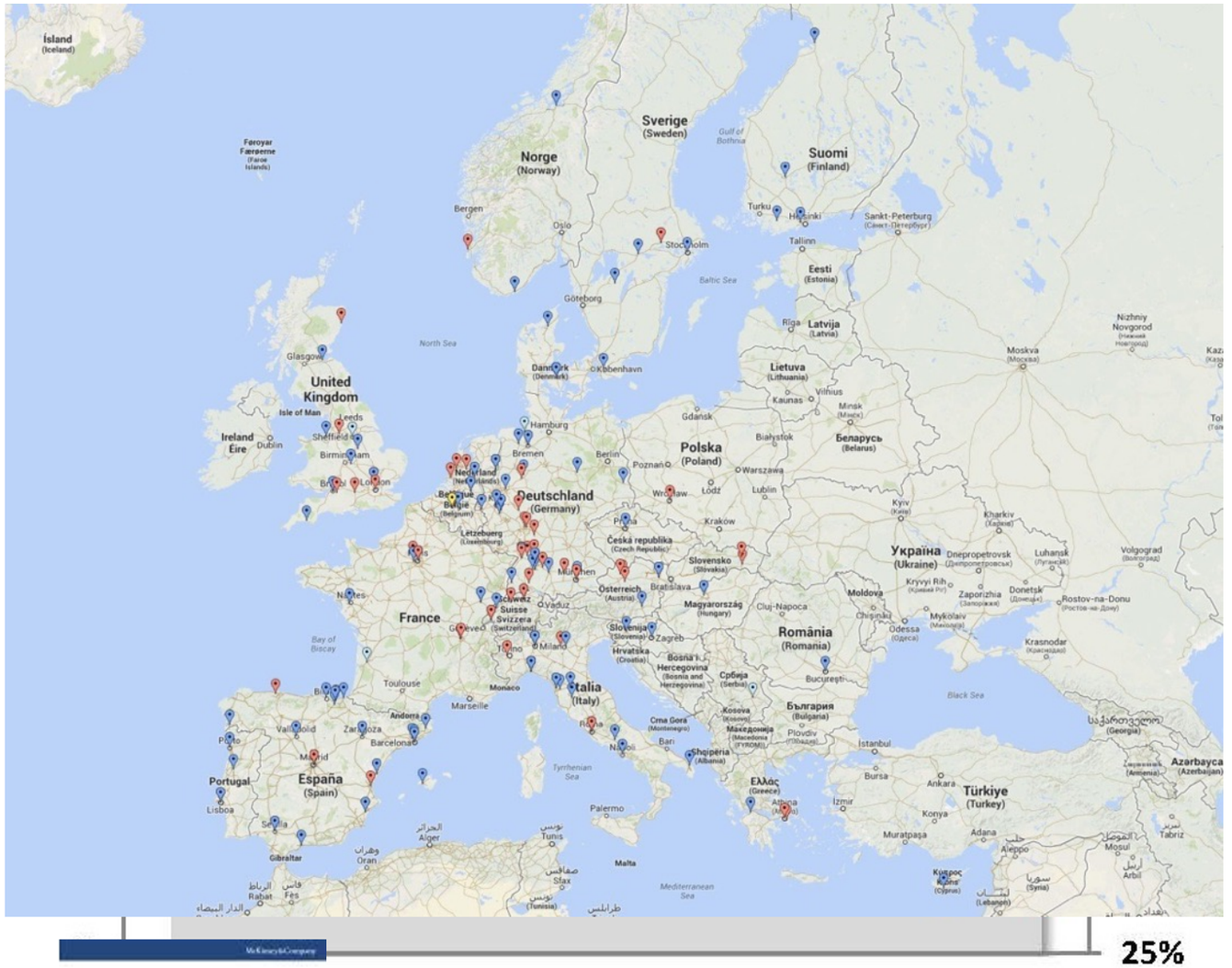
Data are very important, but they are not all in a digital economy. ACTIONS, MOBILI and STRENGTH are also needed! **Robotics**: a great opportunity to **innovate, connect** and **transform. Robotics is technology and business, but it is also creativity and fun!**

"[...] The size of the robotics market is projected to grow substantially to 2020s. This is a global market and Europe's traditional competitors are fully engaged in exploiting it. Europe has a 32% share of the industrial market. Growth in this market alone is estimated at 8%-9% per annum. Predictions of up to 25% annual growth are made for the service sector where Europe holds a 63% share of the non-military market. […]"

"[…] From today's €22bn worldwide revenues, robotics industries are set to achieve annual sales of between €50bn and €62bn by 2020. […]"

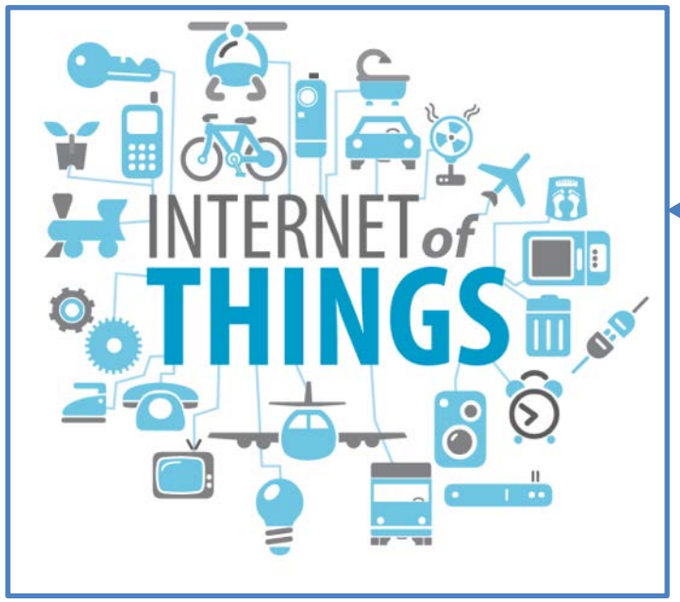




Robotics is one of the 12 disruptive technologies identified by McKinsey

**http://sparc-robotics.eu/about/**
**SPARC Strategic Research Agenda**

# Robotics: a great opportunity to **innovate, connect** and **transform**

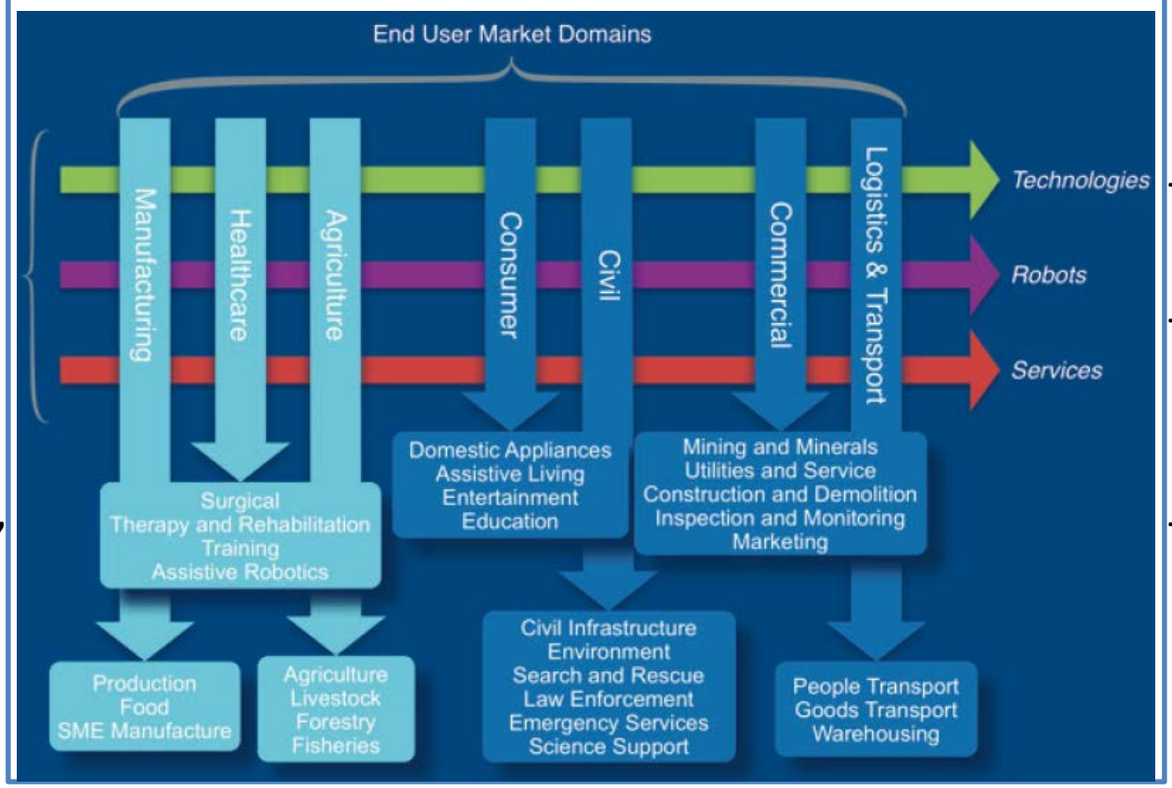



- The web and IoT pull new robotic applications
- Robotics expands the boundaries of the Web and of IoT
- The Web is an 'infrastracture' of future robotics

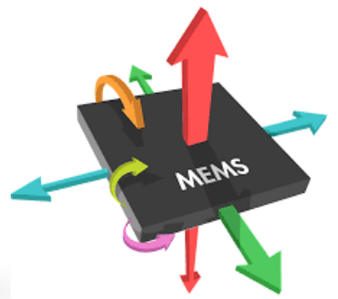
The value chain of robotics, ICT components and IoT

**Robotics is inclusive and interdisciplinary**

Robotics market domains








**ICT enabling components and technologies, e.g., MEMS, 4G, 5G**

- Robotics integrates enabling ICT components
- Robotics will drive the development of new ICT components
- Robotics pulls the development of next generation communication networks


**Robots and Jobs**

- Creating **new jobs** in robotics (manufacturing and servicing robots)
- Creating new industrial opportunities (and **jobs**) by using robotics and automation (human-robot cooperation, circular economy)
- Taking advantage of robotics and automation to enable GDP growth while **reducing workload and even enabling more leisure and free time**

**http://sparc-robotics.eu/about/**
**http://www.mathisintheair.org**

**ECHORD++: a EU initiative to bring robotics innovation from the lab to the market http://www.echord.eu/**

# The Waves of Robotics Innovation

***Third wave***

Bionics & Bioinspiration

Multif. Nanomat.

Society

Cognitive Science

MC, Simpl., Self-org.

***Second wave***

IoT

ML

AI

***First wave***

Mech Eng

Ctrl Eng

Comp Sci

1st crest

New wave of use-centered science-based radical innovations

2st crest

Sustainable industrial leadership and ubiquitous societal impact

Robot Companions for Citizens

Coordination Action for the preparation and description of the FET flagship candidate

SEVENTH FRAMEWORK PROGRAMME

1st crest

Advanced, Future and Emerging Robotics & Cognitive Systems

2st crest

Industrial leadership and societal impact

SPARC

HORIZON 2020

FIFTH FRAMEWORK PROGRAMME

1st crest

Methodologies and Technologies for Robotics and Mechatronics

SIXTH FRAMEWORK PROGRAMME

2st crest

Industrial robotics

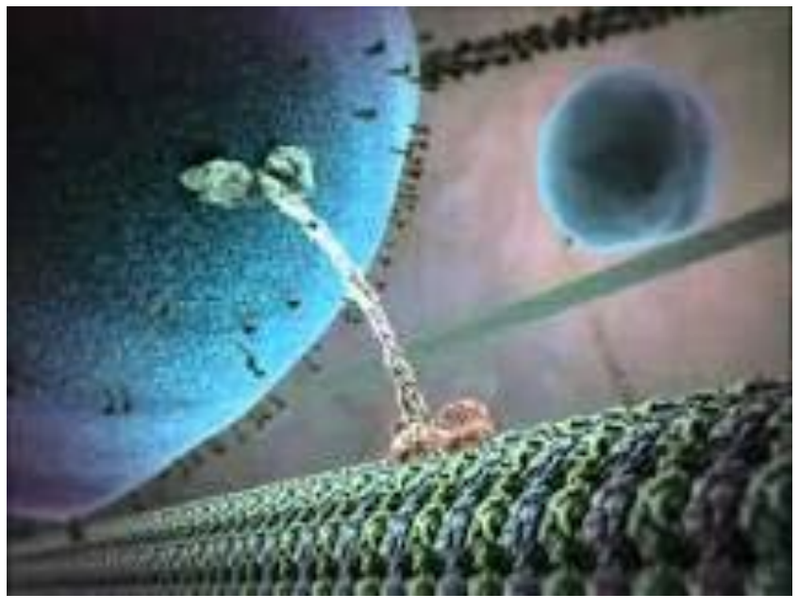
Robotics body of knowledge

**Future of Robotics**

1990 2000 2015 2020 2025 2030

# Is It Alive?

- A marvelous robot's bad day
- The inner life of a cell



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# The need for an embodied perspective

- **“failures” of classical AI**
- **fundamental problems of classical approach**
- **Wolpert’s quote: Why do plants not have a brain? (but check Barbara Mazzolai’s lecture at the ShanghAI Lectures 2014)**
- **Interaction with environment: always mediated by body**

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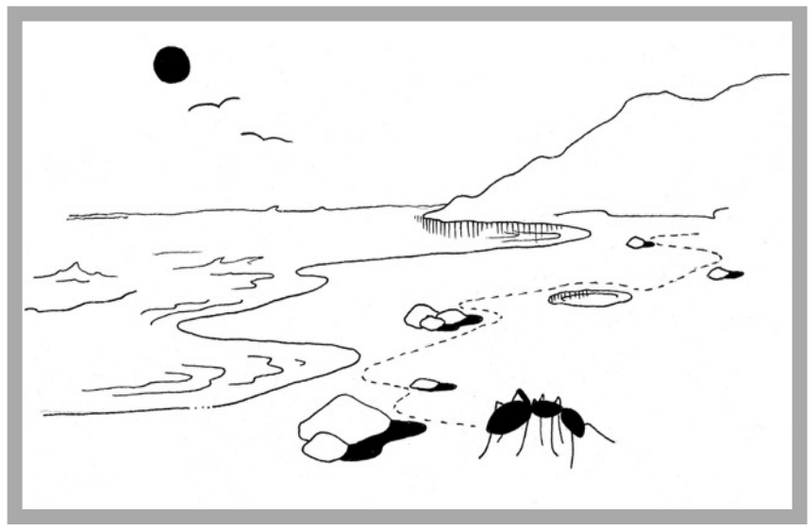
# Two views of intelligence

classical:
**cognition as computation**

embodiment:
**cognition emergent from sensory-motor and interaction processes**

# “Frame-of-reference” Simon’s ant on the beach

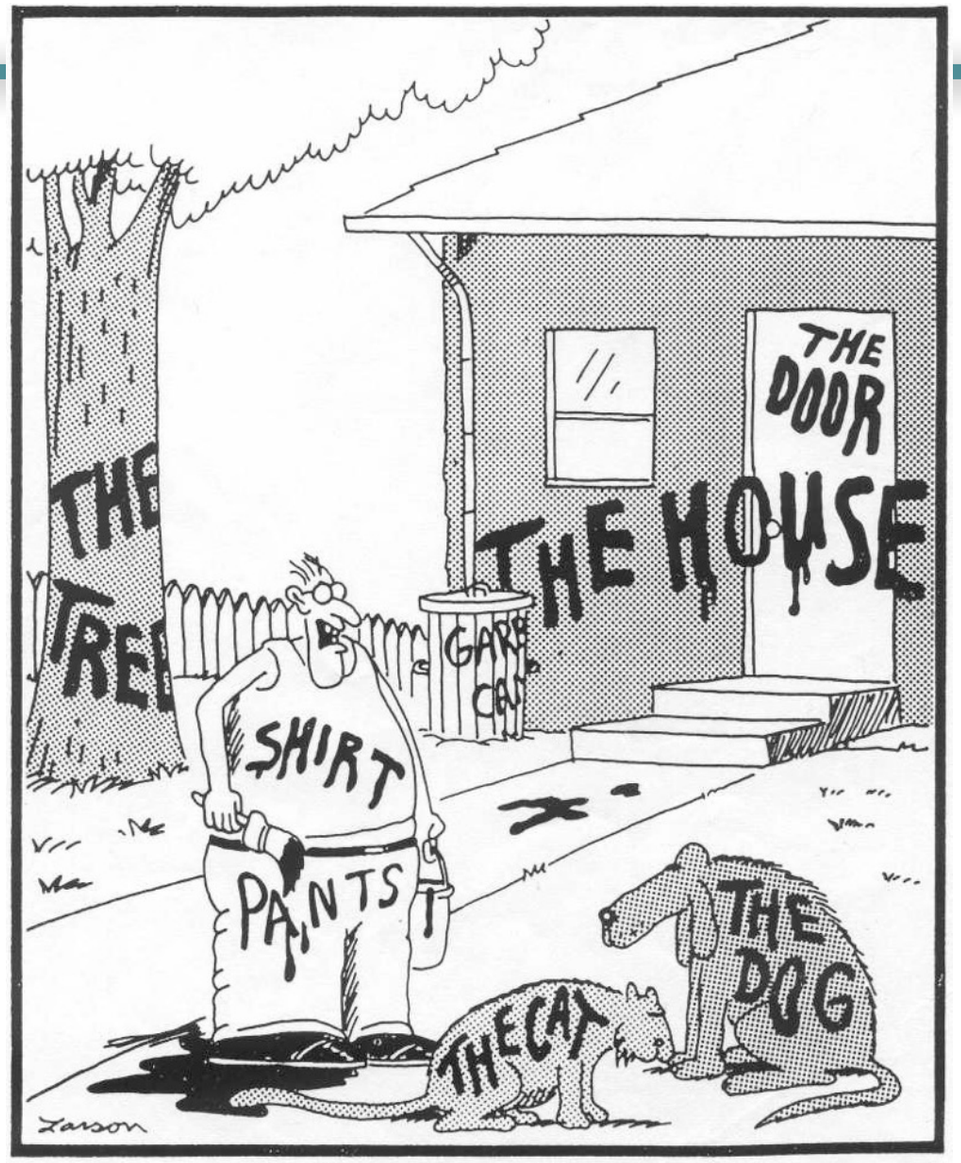


- **simple behavioral rules**
- **complexity in interaction, not — necessarily — in brain**
- thought experiment: **increase body by factor of 1000**

# The “symbol grounding” problem

**real world: doesn’t come with labels …**

**How to put the labels??**




"Now! ... *That* should clear up a few things around here!"

Gary Larson

# The real world is surprising

**Columbus discovering America while looking for a short route to Asia (wikipedia)**

**Traders looking at screens during the global market crash of 2008 (seekingalpha.com)**

**There are unexpected events that change the F-O-R (at many levels)**

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# Goals

- What is intelligence? Natural and artificial?
- conceptual and technical know-how in the field
- informed opinion on media reports
- things can always be seen differently
- new ways of thinking about ourselves and the world around us

# Embodied Intelligence or Morphological Computation: the modern view of Artificial Intelligence

**Classical approach**

The focus is on the brain and central processing

**Modern approach**

The focus is on interaction with the environment. Cognition is emergent from system-environment interaction

***PARADIGM CLASHES***

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Rolf Pfeifer and Josh C. Bongard, *How the body shapes the way we think: a new view of intelligence*, The MIT Press, Cambridge, MA, 2007

# Soft Robotics: a working definition

## Variable impedance actuators and stiffness control

* Actuators with variable impedance
* Compliance/impedance control
* Highly flexible (hyper-redundant or continuum) robots


**PARADIGM CLASHES**

*IEEE Robotics and Automation Magazine*, Special Issue on Soft Robotics, 2008
A. Albu-Schaffer et al. (Ed.s)

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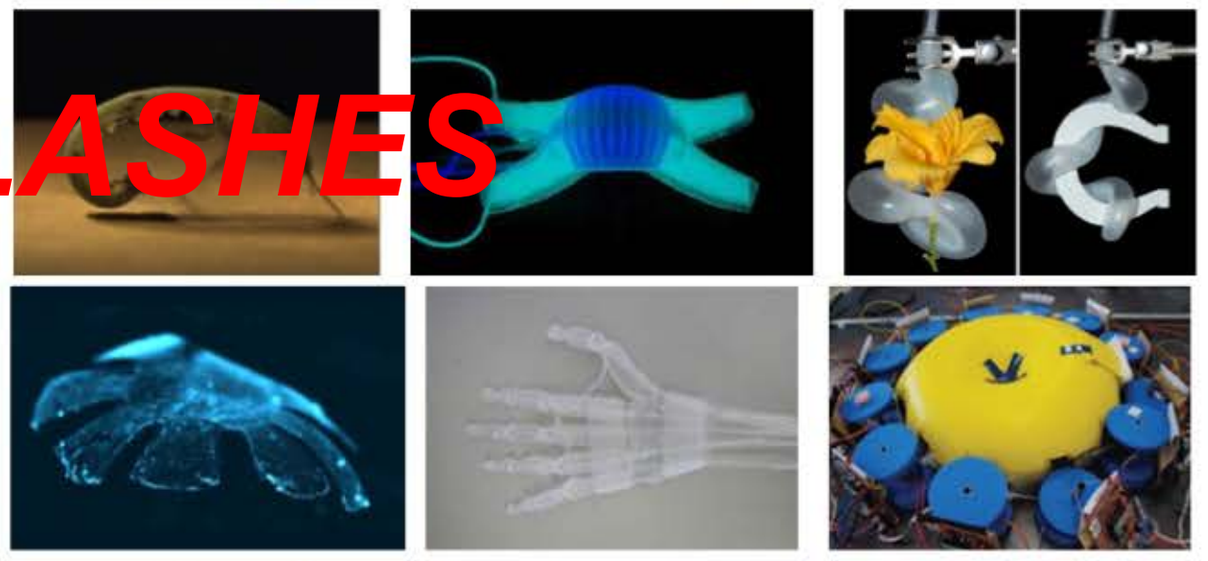
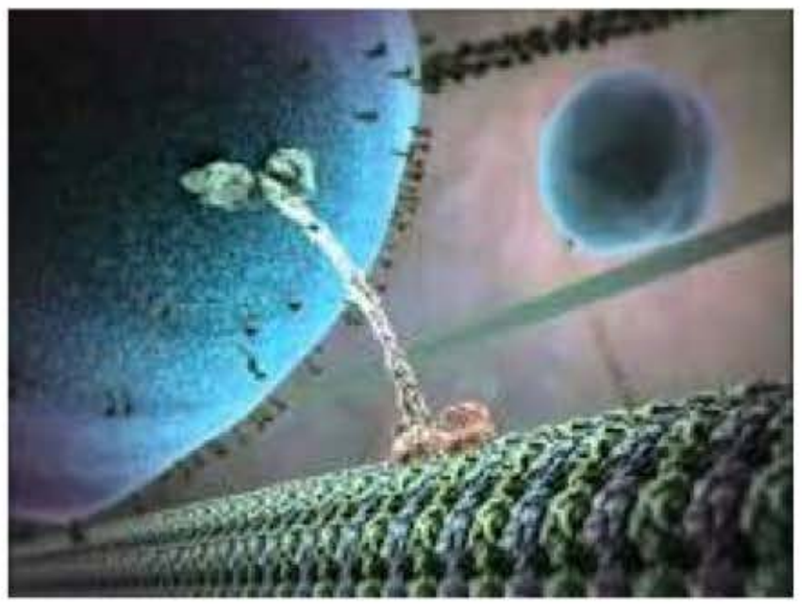
## Use of soft materials in robotics

* Robots made of soft materials that undergo high deformations in interaction
* Soft actuators and soft components
* Control partially embedded in the robot morphology and mechanical properties



Kim S., Laschi C., and Trimmer B. (2013) Soft robotics: a bioinspired evolution in robotics, *Trends in Biotechnology*, April 2013.
Laschi C. and Cianchetti M. (2014) "Soft Robotics: new perspectives for robot bodyware and control" *Frontiers in Bioengineering and Biotechnology*, 2(3)

# Is It Alive?



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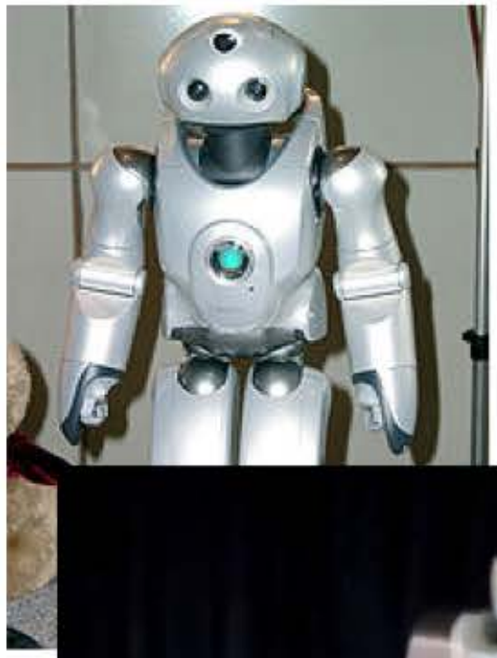
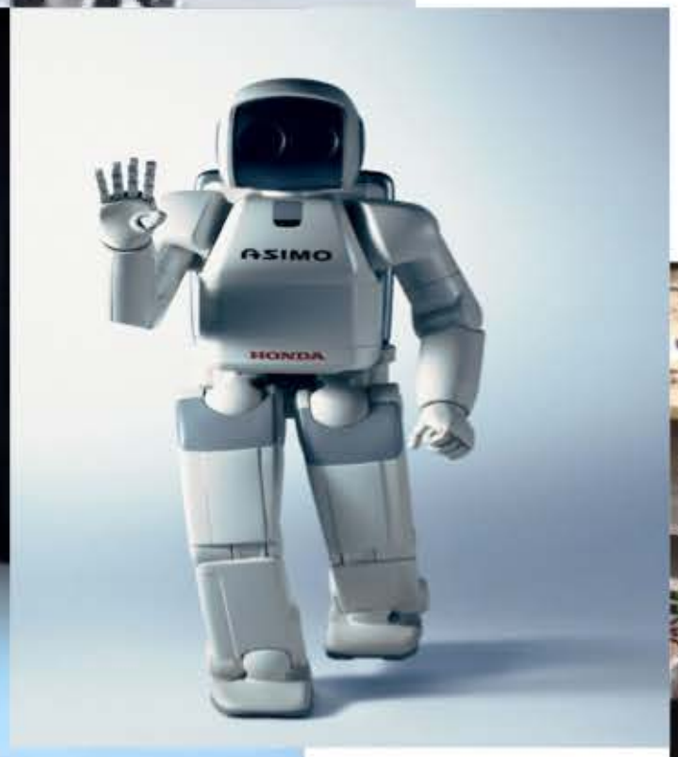
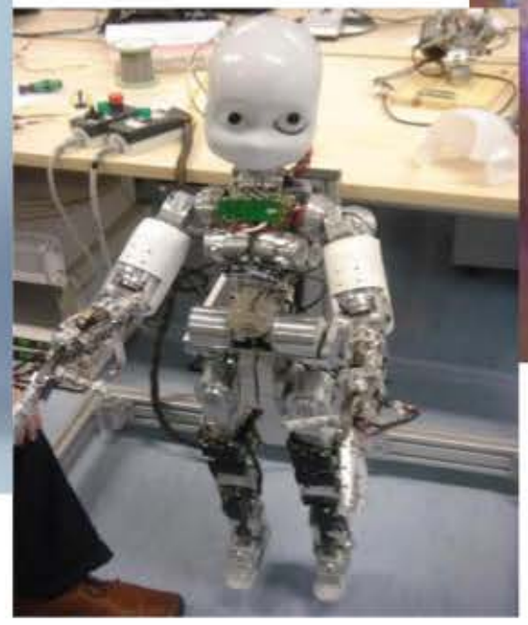
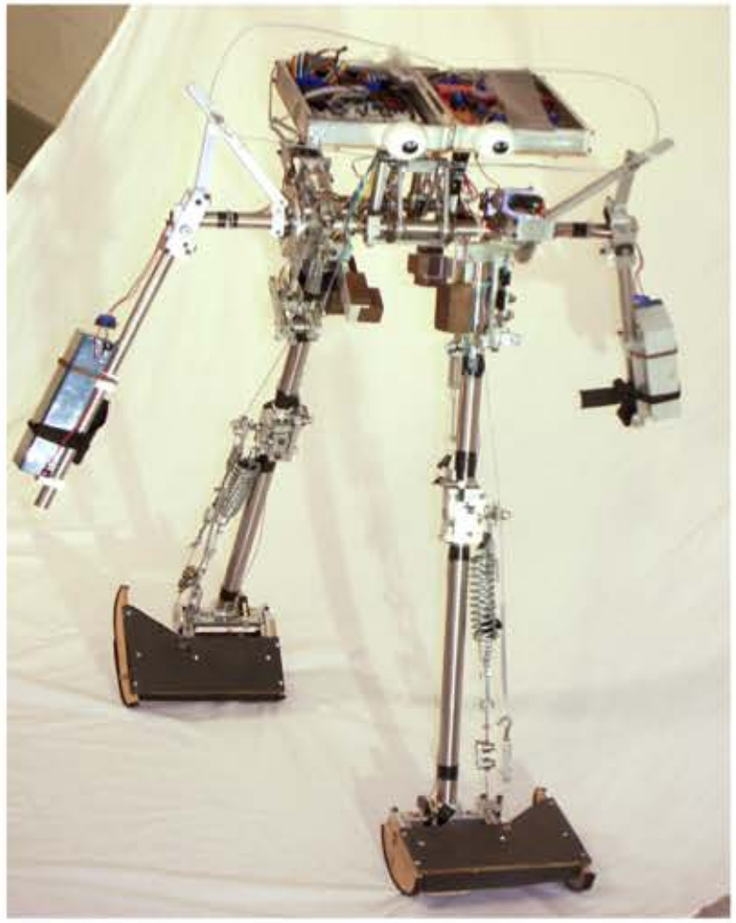
# Today's humanoids





# Conceptually different humanoid designs (mainly research)



# How to build a ‘new paradigm’ robot like the Cornell Ranger able to wave the hands like NAO? (and manipulate…)

a) Cornell ranger

b) Nao walking down a ramp

# Thank you for your attention!

www.shanghailectures.org