# The ShanghAI Lectures

人工智能

上海授课

# The Shanghai Lectures 2022

## Natural and Artificial Intelligence in Embodied Physical Agents

**December 15th, 2022**

**From Zagreb, Croatia**

# Today's program (CET)

**08:30  sites begin connecting**
**08:55  all sites are ready**
**09:00 (Fabio) Welcome**
**09:05 Grab Bag, Summary and topics to discuss: Video is killing the radio stars.**
**10:00 Break**
**10:10 Our traditional  US Night lecture by Josh Bongard, University of Vermont, Burlington (VT), USA: Evolutionary Robotics, Xenobots and beyond**
**11:00 Wrap-up**

# US Night Lecture

**10:10 Josh Bongard**

**University of Vermont,**

**Burlington (VT), USA**

## «Evolutionary Robotics,Xenobots and beyond»

## Stay tuned!

# Lecture 7

## Grab Bag, Summary and topics to discuss: Video is killing the radio stars

Fabio Bonsignorio
Professor, ERA CHAIR in AI for Robotics

University of Zagreb
Faculty of Electrical Engineering and Computing
Laboratory for Autonomous Systems and Mobile Robotics

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 952275

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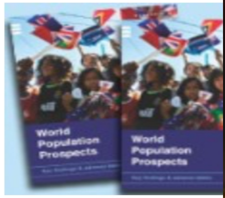
# World population projected to reach 9.7 billion by 2050

29 July 2015, New York




The current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100, according to a new UN DESA report, "World Population Prospects: The 2015 Revision", launched today.

"Understanding the demographic changes that are likely to unfold over the coming years, as well as the challenges and opportunities that they present for achieving sustainable development, is key to the design and implementation of the new development agenda," said Wu Hongbo, UN Under-Secretary-General for Economic and Social Affairs.

Most of the projected increase in the world's population can be attributed to a short list of high-fertility countrie mainly in Africa, or countries with already large populations. During 2015-2050, half of the world's population growth is expected to be concentrated in nine countries: India, Nigeria, Pakistan, Democratic Republic of the Congo, Ethiopia, United Republic of Tanzania, United States of America (USA), Indonesia and Uganda, listed according to the size of their contribution to the total growth.

NATIONAL GEOGRAPHIC

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MAGAZINE | JANUARY 2016

# See for Yourself: How Arctic Ice Is Disappearing


Since satellites began regularly
declined sharply in extent and thic
is thin stuff that doesn't survive t
entire Arctic ecosystem, from pla
think that, by altering the jet stre
around the N

Graphics and maps by **Lauren Ja**
**Esteban,**


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**Sydney**
Dispatch

## Australia's new normal ... as city temperatures hit 47C people shelter from the deadly heat

In Sydney's baking suburbs, fans have sold out – and fears about the effects of climate change are mounting

PNAS Proceedings of the National Academy of Sciences of the United States of America

Keyword, Author, or D

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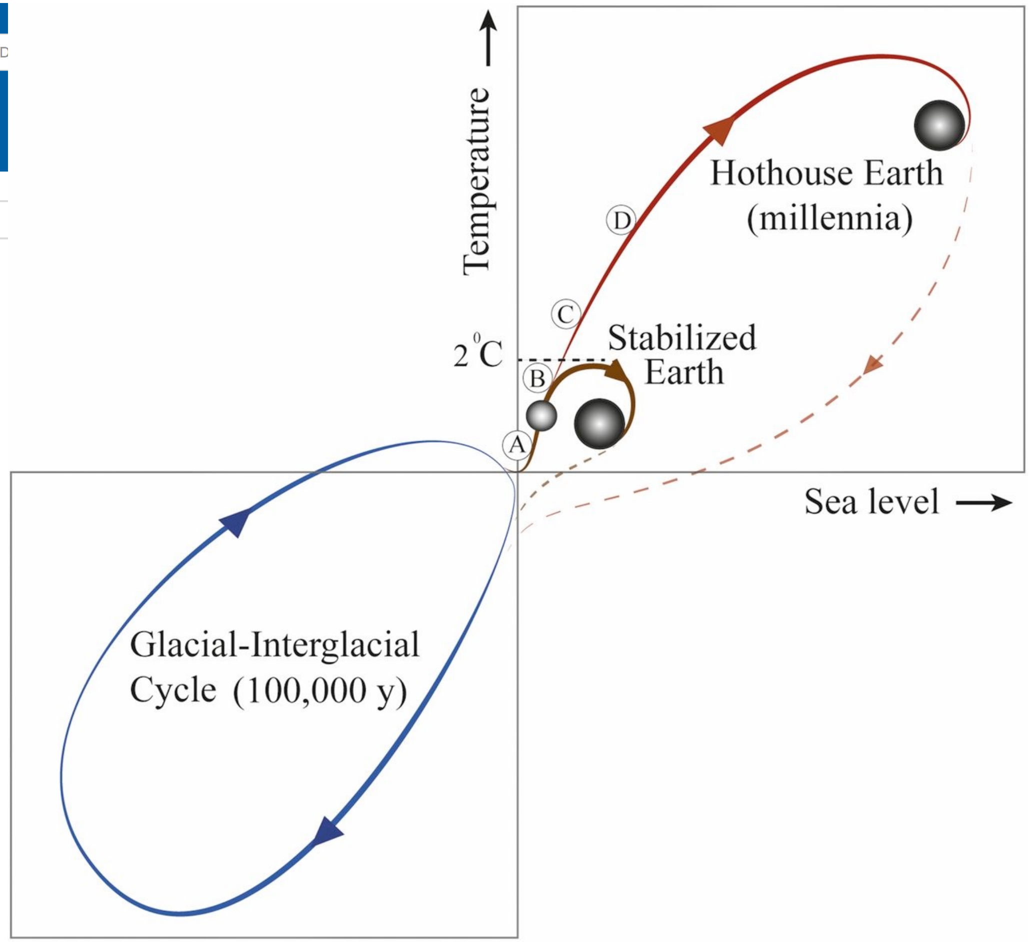
NEW RESEARCH IN Physical Sciences | Social Sciences

# Trajectories of the Earth System in the Anthropocene

Will Steffen, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin P. Summerhayes, Anthony D. Barnosky, Sarah E. Cornell, Michel Crucifix, Jonathan F. Donges, Ingo Fetzer, Steven J. Lade, Marten Scheffer, Ricarda Winkelmann, and Hans Joachim Schellnhuber

PNAS August 14, 2018 115 (33) 8252-8259; published ahead of print August 6, 2018 https://doi.org/10.1073/pnas.1810141115

Edited by William C. Clark, Harvard University, Cambridge, MA, and approved July 6, 2018 (received for review June 19, 2018)



# 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

# Not everything worked as expected!

## The second wave: the current approach shows some limitations

On the other hand the debriefing of DARPA DRC shows clearly that humanoid robots are **still far from the required level of capabilities in fact many metrics**, **such as time-to-completion, are highly application or task specific.**


**According to H.Yanco a minimum of 9 people were needed to teleoperate latest DRC's robots!!!**

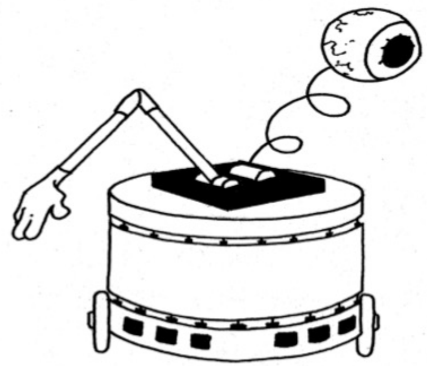
# The “frame problem” (1)

**From: Dennett*, D.C. 1987. “Cognitive Wheels: The Frame Problem in AI”, in Pylyshyn, Z.W., ed., The Robot’s Dilemma: The Frame Problem in Artificial Intelligence. Norwood, NJ: Ablex, pp. 41–64.**

## R1: (naive ☺) robot

INSIDE(R1,ROOM)
ON(BATTERY,WAGON)
PULLOUT(WAGON, ROOM)

***Daniel Dennett, American philosopher (philosophy of mind)**



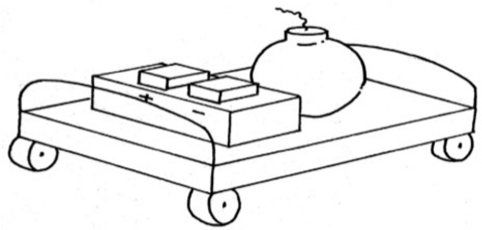


Illustration: (adapted from) **Isabelle Follath**

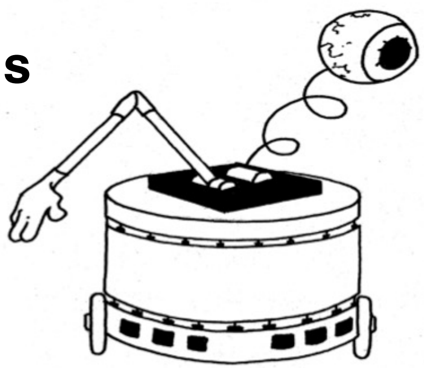
# Not as expected

# The “frame problem” (2)

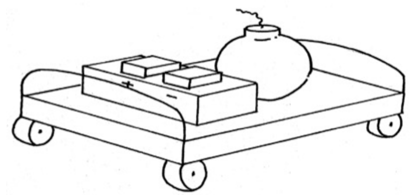
**From: Dennett*, D.C. 1987. “Cognitive Wheels: The Frame Problem in AI”, in Pylyshyn, Z.W., ed., The Robot’s Dilemma: The Frame Problem in Artificial Intelligence. Norwood, NJ: Ablex, pp. 41–64.**

## R1D1:

**Robot Deducer**
**(it deduces the implications of its own acts)**



INSIDE(R1D1,ROOM)
ON(BATTERY,WAGON)
COLOUR(PULLOUT(WAGON, ROOM))
=UNCHANGED
…
…
WHEELS(REVOLUTIONS, PULLOUT(.))=..



***Daniel Dennett,**
**American philosopher**
**(philosophy of mind)**

Illustration: (adapted from) **Isabelle Follath**

# In the meantime…

# The “frame problem” (3)

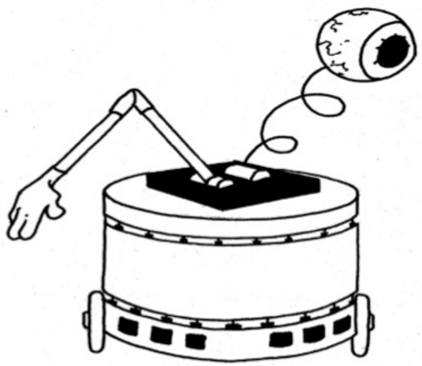
From: Dennett*, D.C. 1987. “Cognitive Wheels: The Frame Problem in AI”, in Pylyshyn, Z.W., ed., The Robot’s Dilemma: The Frame Problem in Artificial Intelligence. Norwood, NJ: Ablex, pp. 41–64.

## R2D1(aka ‘Hamlet’

**Robot Relevant**

**•Deducer**

**(it discards not relevar**
**implications**
**of its own acts)**



INSIDE(R2D1,ROOM)
ON(BATTERY,WAGON)
COLOUR(PULLOUT(WAGON, ROOM))
=NotRelevant
…
…
WHEELS(REVOLUTIONS, PULLOUT(.))=
NotRelevant
…
Not Relevant …Not Relevant…
Not Relevant….

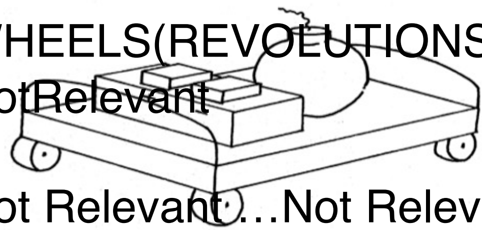


Illustration: (adapted from) **Isabelle Follath**

# You know the story…

# Summary of Dennett's points

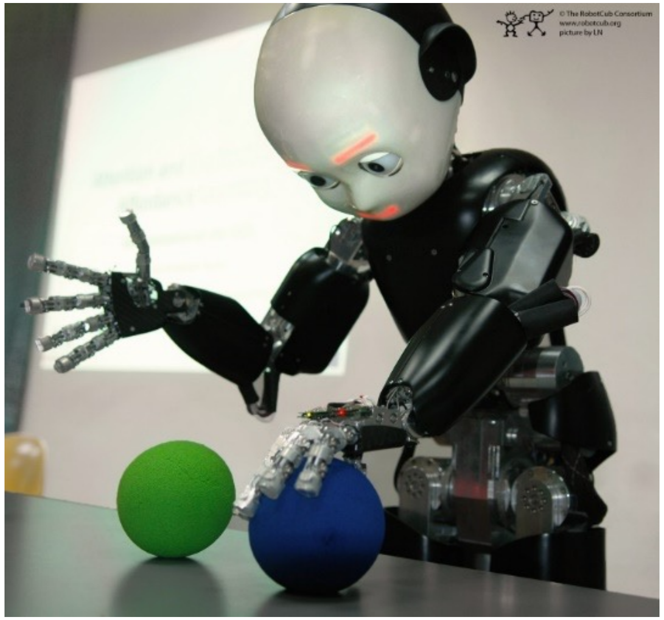
- **obvious to humans, not obvious to (GOFAI) robots (robot only has symbolic model/representation of world)**
- **vast number of potential side effects, mostly irrelevant**

**distinction between relevant and irrelevant inferences**
**must test all,** ***<u>what about 'transformers'?</u>***

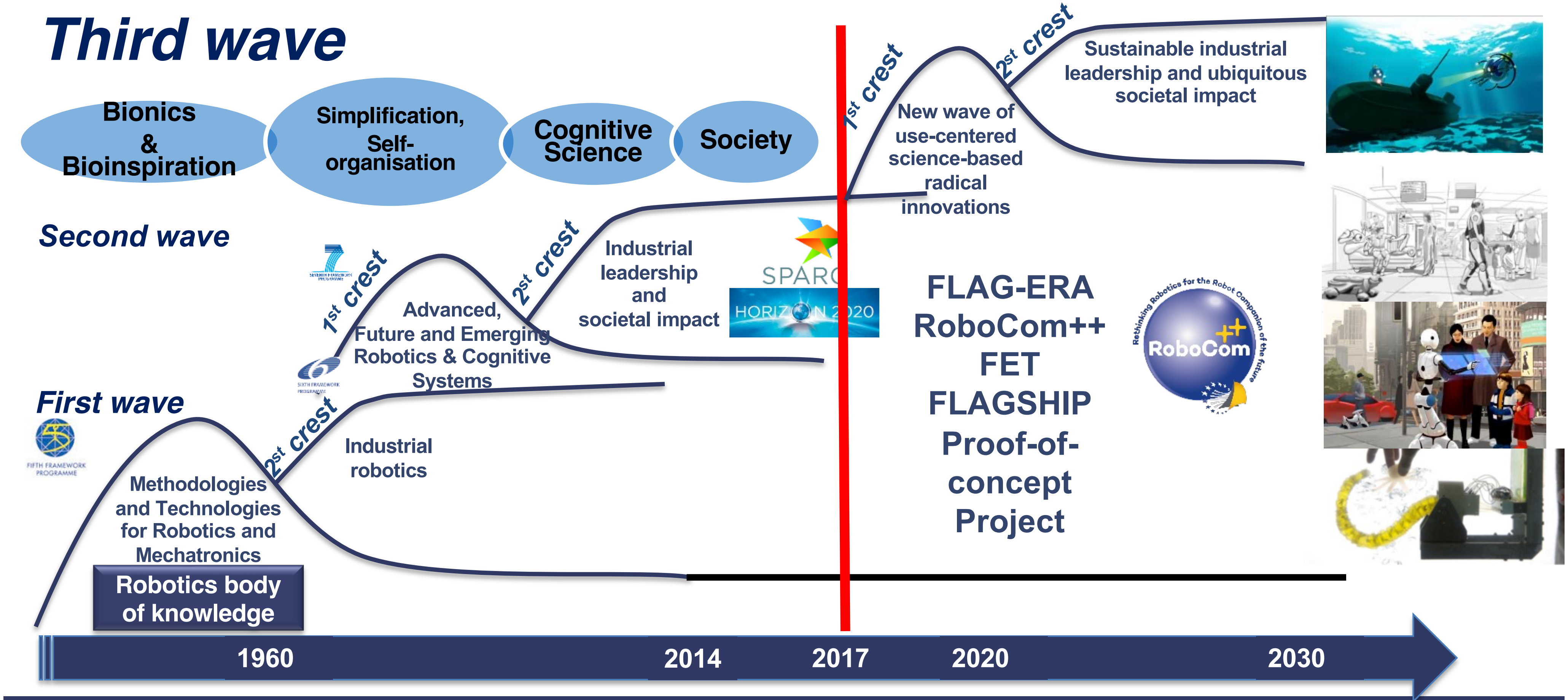
# Pursuing new frontiers:
# The robotics bottleneck

Today, more functionality means:

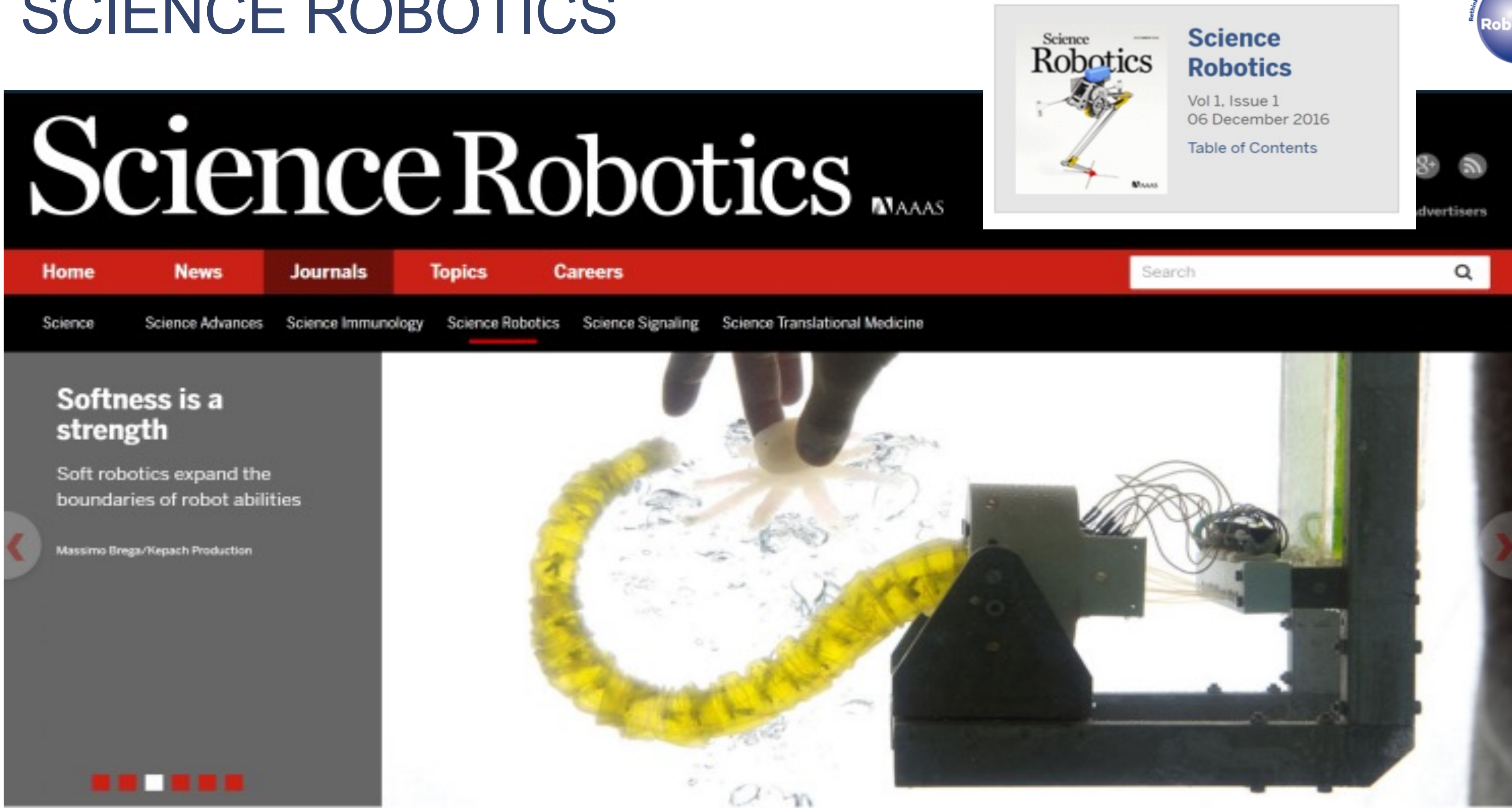
- **more** complexity, energy, computation, cost
- less controllability, efficiency, robustness, safety



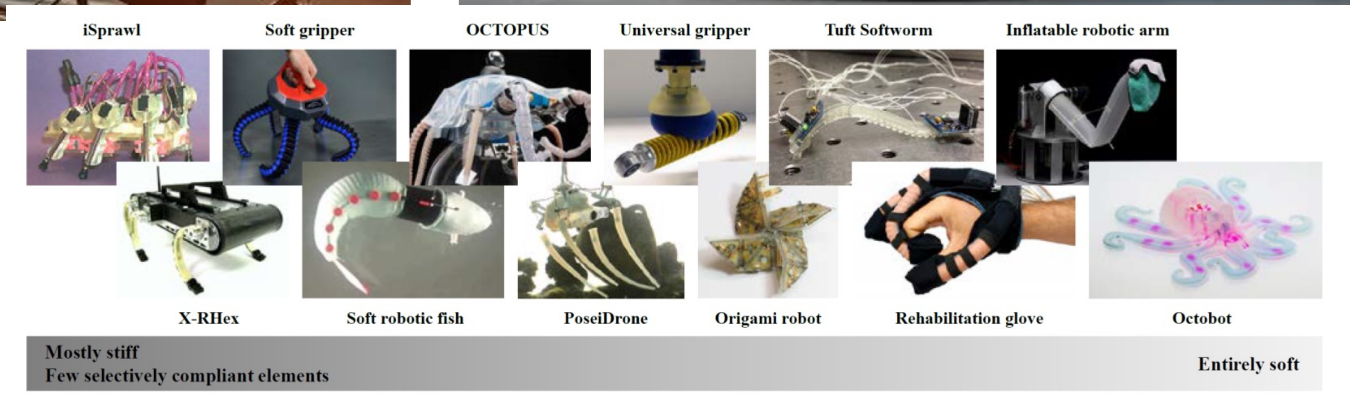
# The Robotics waves



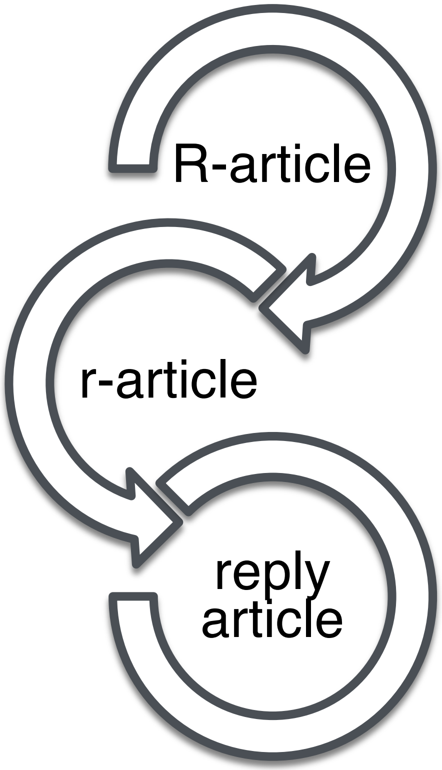
# SCIENCE ROBOTICS



The marvellous progress of Robotics and AI…'Look Ma, No Hands' syndrome?



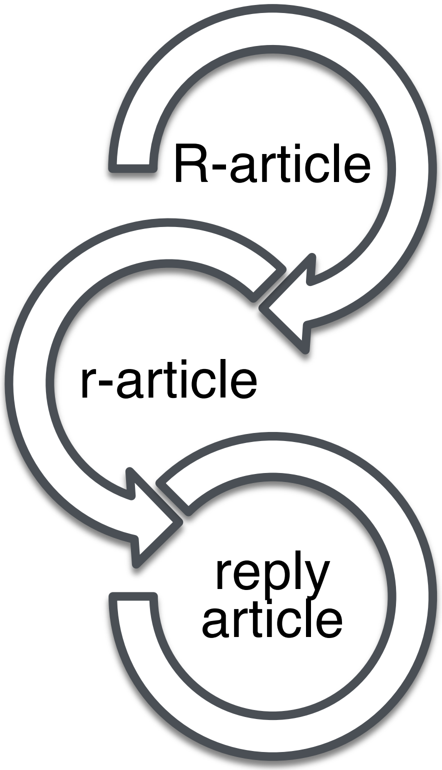
# R-article Life Cycle




It is possible to publish a short article
About the results replication of an R-article. article.
Such articles will be peer reviewed like any other RAM article and will undergo a data and code consistency check.

Similarly, the authors of the original R-article will be able to submit, again, in the form of a short peer-reviewed article, a reply to the authors of the r-article, again, with a data and code consistency check.

# R-article Life Cycle




Check:
http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8036322

and

RAM authors guidelines here (section 9.):
http://www.ieee-ras.org/publications/ram/information-for-authors
**__R(eproducibile)-articles can already be submitted!!!__**

# Introduction R-Articles

FROM THE FIELD

## A New Kind of Article for Reproducible Research in Intelligent Robotics

By Fabio Bonsignorio

The reproducibility of experimental results is a key characteristic of the scientific method. Despite that, in robotics and artificial intelligence (AI)—maybe for good reason—replicating experiments in many cases has, so far, been limited or outright lacking. This fact hampers both research progress and results exploitation [2], [10] and becomes even more relevant when new editorial initiatives, such as [14], increasingly regard (intelligent) robotics as a science.

Reporting practices and formats are a key issue if we want to have reproducible robotics and AI papers. After years of discussions in a long series of workshops [9] (Figure 1), the time is ripe for addressing this issue, and we are doing it! The first-ever special issue of a high-level, reputable robotics publication claiming the reproducibility of the published results was in this magazine in September 2015 [9] (Figure 2).

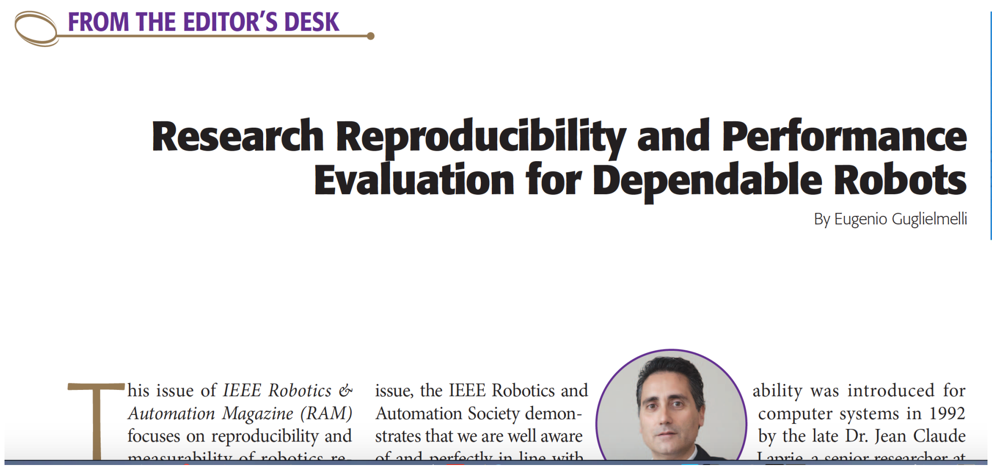
Reproducibility is now a priority for the IEEE, as shown by the fact that the organization recently decided to integrate the CodeOcean platform [15] in the websites of several magazines and journals. And we are going to do the same.

In the meantime, we are in the middle of what has been dubbed a *reproducibility crisis* hitting well-established scientific fields ranging from medicine to psychology [3]–[5], [13]. For example, a recent study [11] discovered that only about a third of psychology papers are reproducible. The situation is better in cancer research [12] but is still not optimal. However, the situation in robotics and AI is different. While, in other disciplines, a shared methodology for performing experiments has been in place for a long time and the problems might come from organizational, societal, and sometimes ethical causes, in robotics, the problems are of a methodological and even epistemological nature [9, pp. 32–35]. In the September 2015 *IEEE Robotics and Automation Magazine* (*RAM*) special issue [9], we gave authors a large degree of latitude in terms of how to define reproducibility and good reporting

*Digital Object Identifier 10.1109/MRA.2017.2722918*
*Date of publication: 13 September 2017*

http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8036322

# Reproducible Research now an IEEE priority



FROM THE EDITOR'S DESK

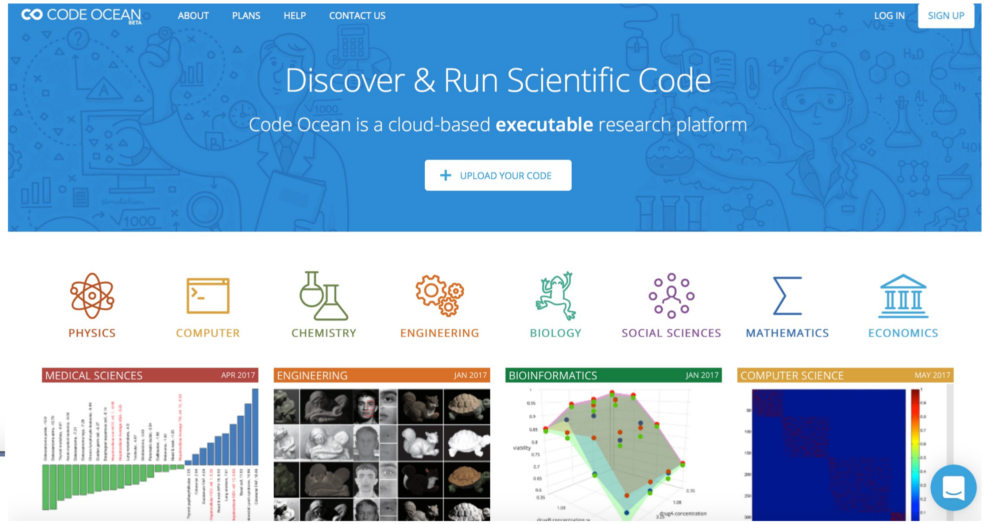
**Research Reproducibility and Performance Evaluation for Dependable Robots**

By Eugenio Guglielmelli

This issue of *IEEE Robotics & Automation Magazine (RAM)* focuses on reproducibility and

issue, the IEEE Robotics and Automation Society demonstrates that we are well aware

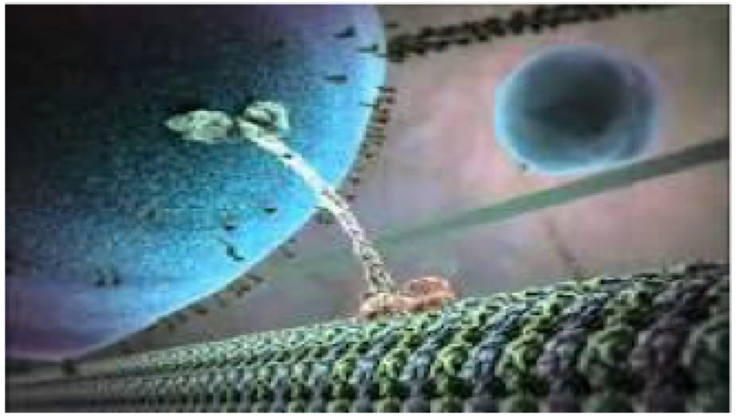
ability was introduced for computer systems in 1992 by the late Dr. Jean Claude




# R(eproducible)-Articles on IEEE R&A Magazine

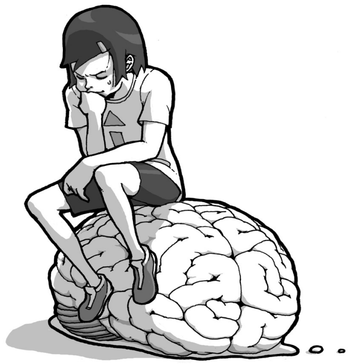
# Is It Alive?

**Big Questions lie in front of us!**



# Two views of intelligence

classical:
**cognition as computation**



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

**PARADIGM CLASHES**

# Soft Robotics: a working definition

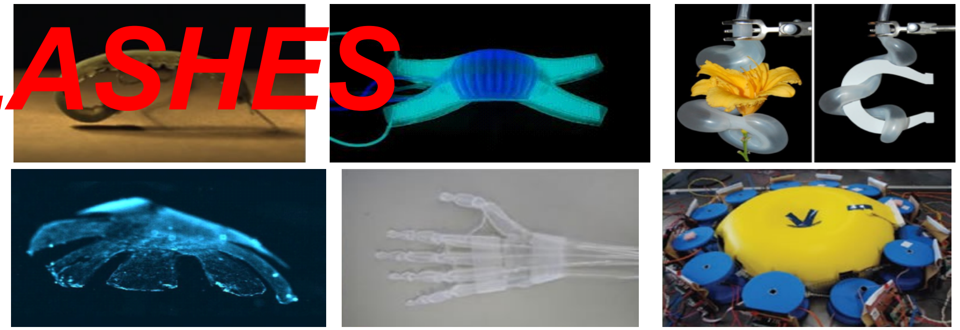
## Variable impedance actuators and stiffness control

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

## 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

**PARADIGM CLASHES**



THE BIOROBOTICS INSTITUTE
Scuola Superiore Sant'Anna

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


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)

# Challenges

*The observation of natural intelligent systems and the practice of robotics research and engineering lead us to think that 'intelligence' (and 'meaning' if not 'consciousness') are 'emerging' characteristics springing from the evolution of loosely coupled networks of intelligent 'embodied' and 'situated' agents.*

# Challenges

*1. How the dynamics of an (embodied) agent is related to its information/computing capabilities (morphological computation)?*

*2. How information/computing capabilities behave in a multi body agent system?*

*3. How 'intelligence' and 'meaning' emerge from networks of embodied agent?*

How to quantify?

Editorial | Published: 11 June 2019

# Robotics and the art of science

*Nature Machine Intelligence* **1**, 259 (2019) | Download Citation

**Bringing reproducibility to robotics.**

It is an exciting time to work in robotics. There are plenty of interesting challenges in designing machines that intelligently interact with both humans and their environment, and a range of techniques and insights from engineering, computer science, physics, biomechanics, psychology and other fields are available to help solve them. The International Conference on Robotics and Automatio[n] organized by the IEEE, is a lively affair: over 4,000 pa[r]

It is an exciting prospect that robotics can start growing as a scientific discipline, with clearly defined methods of evaluation and measurements in place.

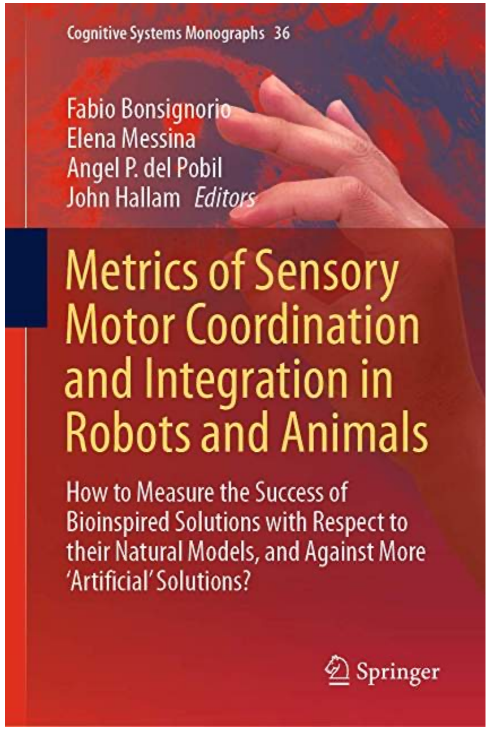
## References

1. Leitner, J. *Nat. Mach. Intell.* **1**, 162 (2019).

Article Google Scholar

2. Bonsignorio, F. & Del Pobil, A. P. *IEEE Robot. Autom. Mag.* **22**, 32–35 (September, 2015).

3. Bonsignorio, F. A. *IEEE Robot. Autom. Mag.* **24**, 178–182 (September, 2017).



# Complete agents

Masano Toda's
Fungus Eaters

# Properties of embodied agents

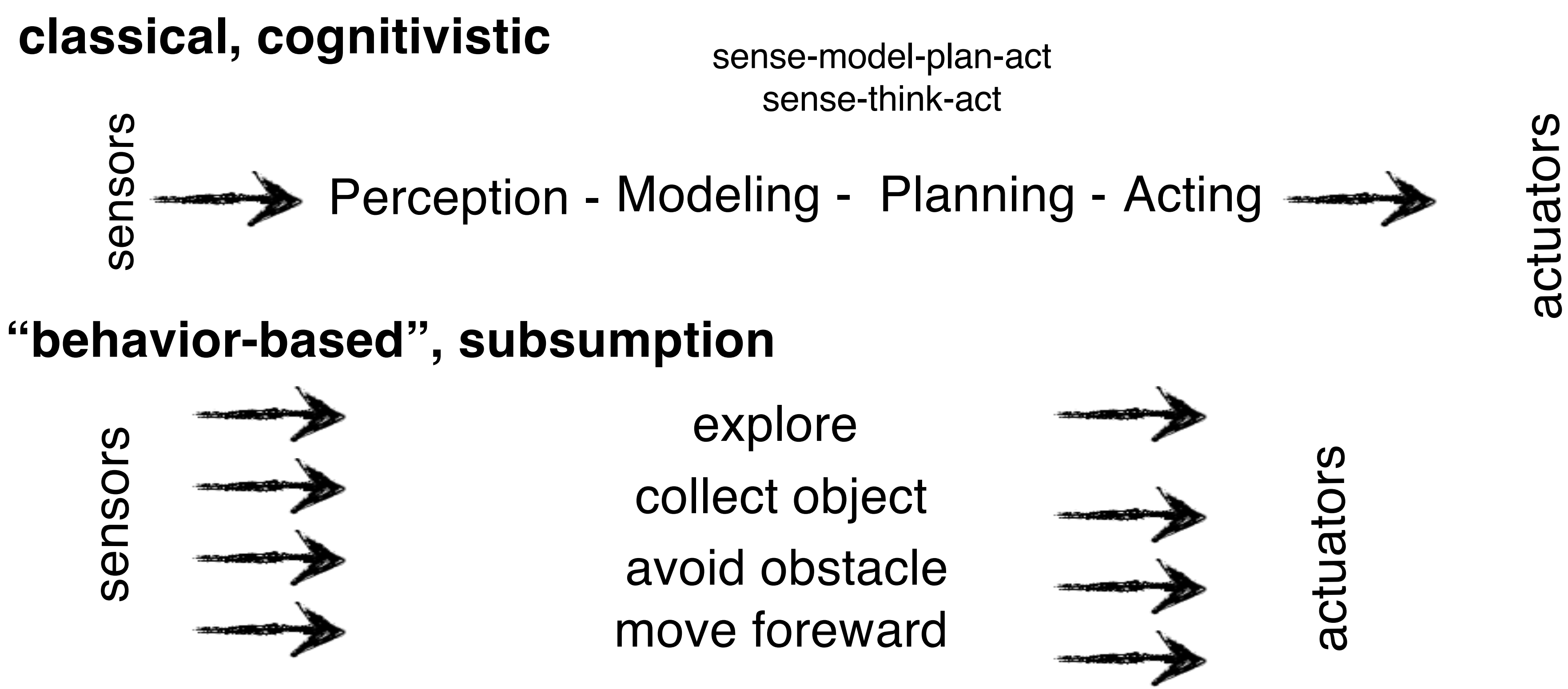
- subject to the laws of physics
- generation of sensory stimulation through interaction with real world
- affect environment through behavior
- complex dynamical systems
- perform morphological computation

# Parallel, loosely coupled processes

‘Intelligent' behavior:

- **emergent from system-environment interaction**
- **based on large number of parallel, loosely coupled processes**
- **asynchronous**
- **coupled through agent’s sensory-motor system and environment**

# The subsumption architecture: the “behavior-based” approach



# Scaling issues: the “Brooks-Kirsh” debate

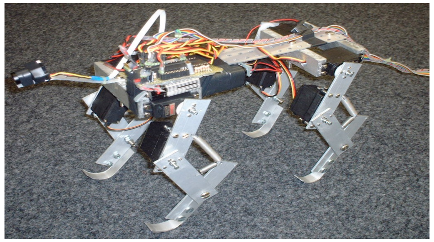
- insect level —> human level?

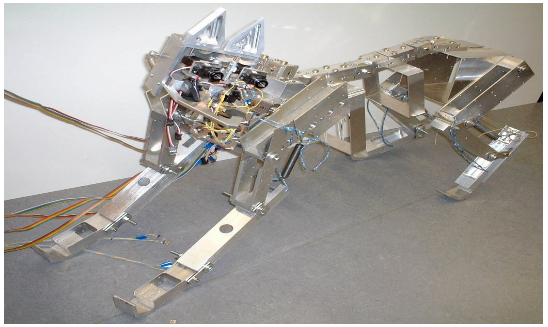
- David Kirsh (1991): “Today the earwig, tomorrow man?”

- Rodney Brooks (1997): “From earwigs to humans.”

# Iida's "Puppy's" simple control

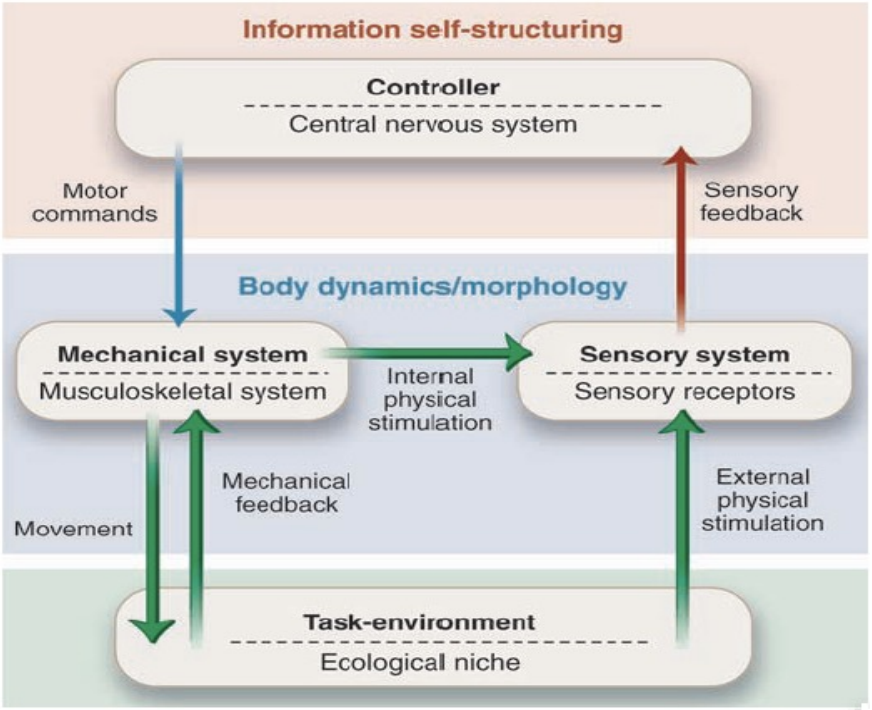
- **rapid locomotion in biological systems**
- **emergence of behavior**





Design and construction:
**Fumiya Iida, then AI Lab, UZH and ETH-Z**

# Implications of embodiment
# Self-stabilization



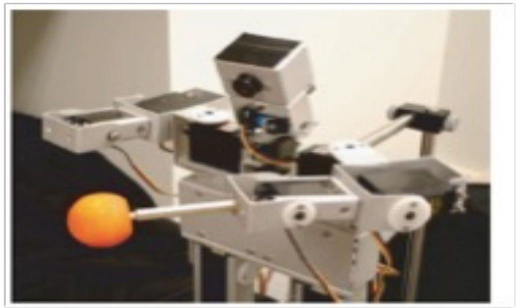

Cruse's Ant, Iida's 'Puppy', …

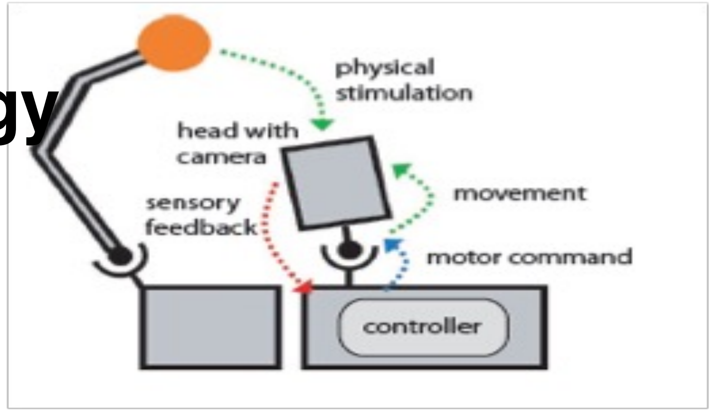
Pfeifer et al.,Science, 16 Nov. 2007

# Information self-structuring

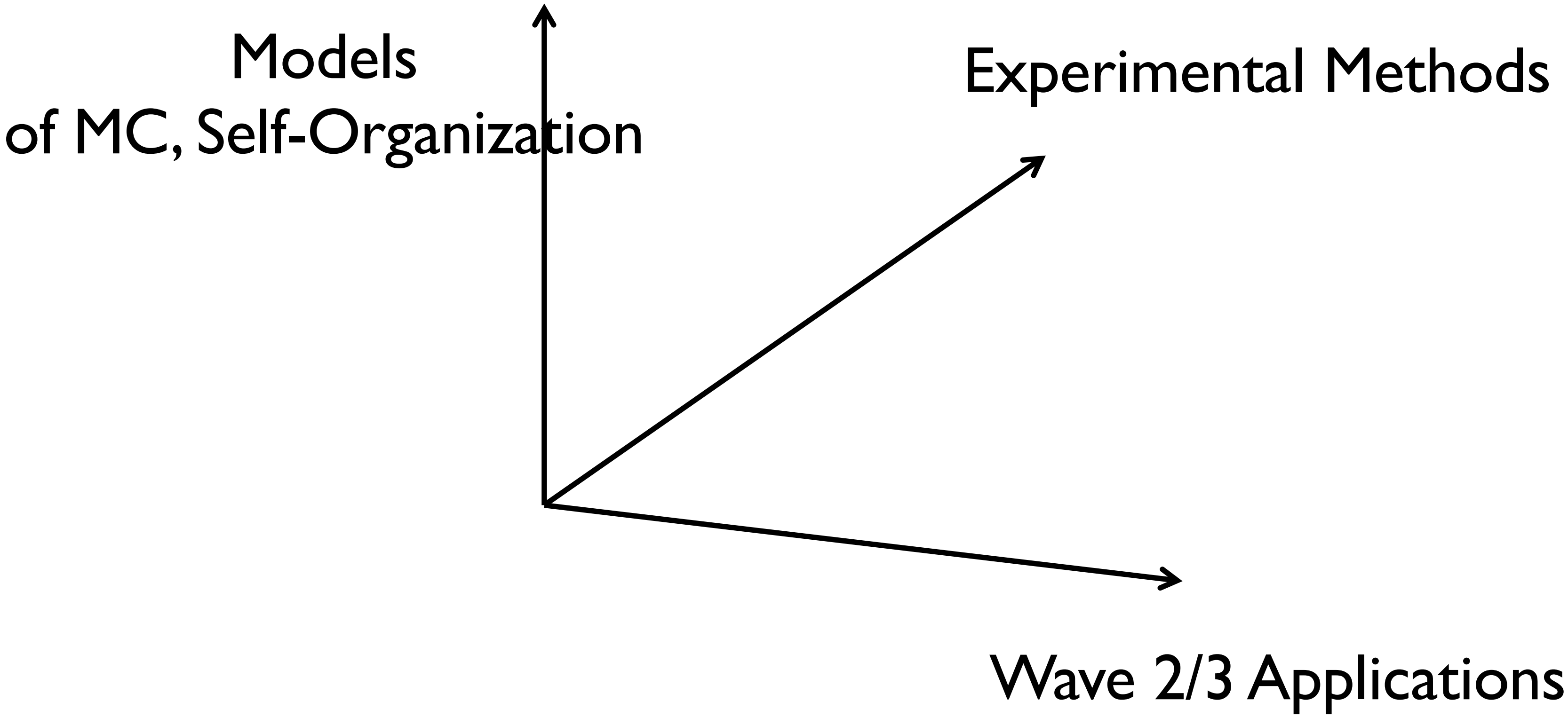
•Experiments:

•Lungarella and Sporns**, 2006**
**Mapping information flow in sensorimotor networks PLoS Computational Biology**





*The ‘research space’ we should – imo - explore (and that I have actually been exploring and I’m continuing to explore…..)*



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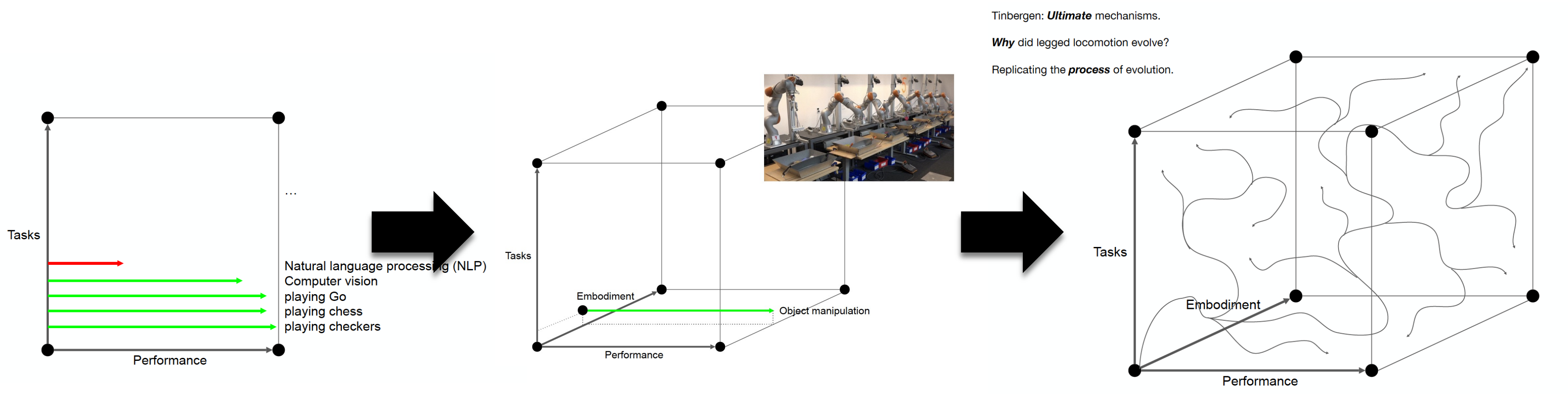
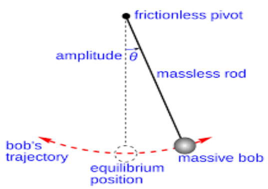
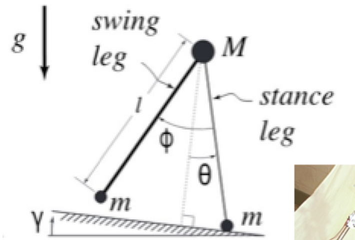



from Joshua Bongard, University of Vermont

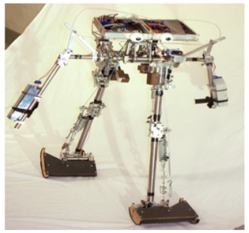
# *The link between Morphological Computation and Soft Robotics*




$$T \approx 2\pi \sqrt{\frac{L}{g}}$$

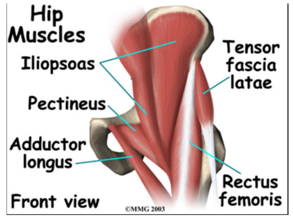


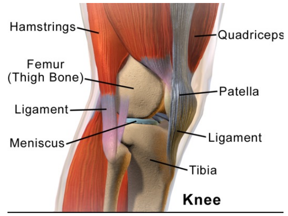

( Andy Ruina)



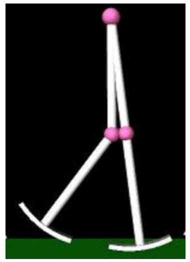
*T=f(l/g)*

*Fixed speed!*




(Wikipedia)



(Fumihiko Asano)

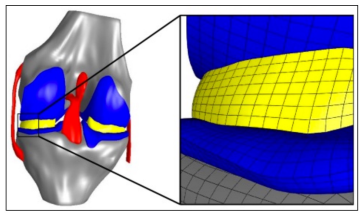
*T=f(l/g)*

*l=f(controlled input)*

*Speed can change!*

Quantitative Modelling of the <u>trade-offs</u> between <u>physical morphology</u> (and associated dynamics)
and <u>information processing</u> is crucial

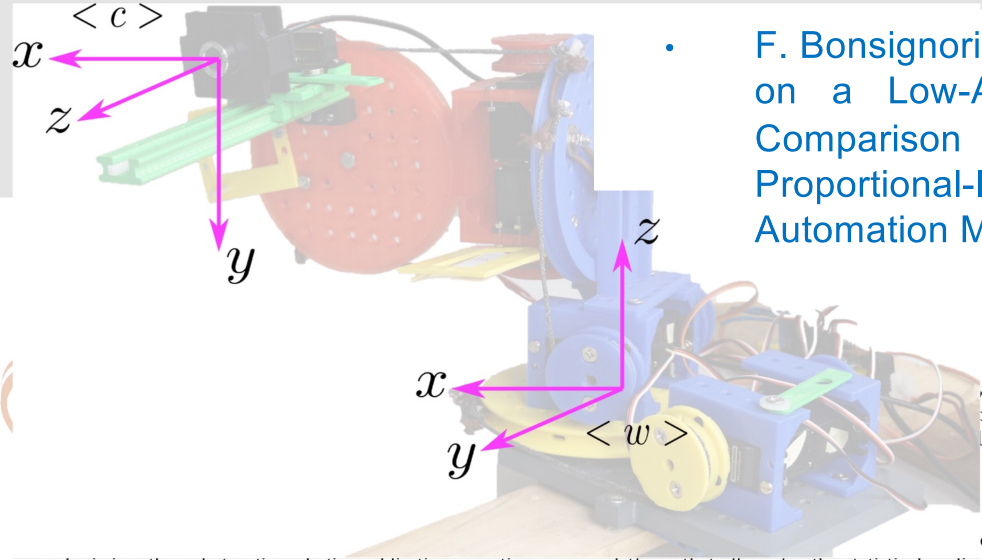
That's what Morphological Computation is about.
It explains why 'soft' components help many task performances and can provide design guidance.



(Yale Image Finder)

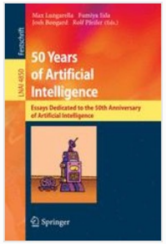
R-Article

# A Simple Visual-Servoing Task on a Low-Accuracy, Low-Cost Arm




submission, the only top-tier robotics publication accepting ware platform that allows for the statistical replication of

- F. Bonsignorio and E. Zereik. A Simple Visual-Servoing Task on a Low-Accuracy, Low-Cost Arm: An Experimental Comparison Between Belief Space Planning and Proportional-Integral-Derivative Controllers. IEEE Robotics & Automation Magazine. 2020, early access

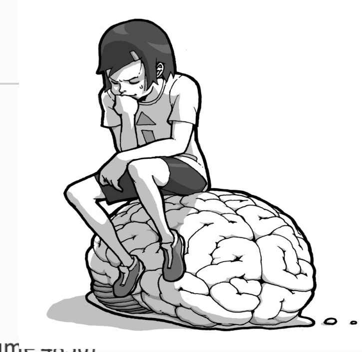


50 Years of Artificial Intelligence pp 112-123 | Cite as

# Preliminary Considerations for a Quantitative Theory of Networked Embodied Intelligence

Authors | Authors and affiliations

Fabio P. Bonsignorio





embodiment:

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

Part of the Lecture Notes in Computer Science book series (LNCS, volume 4850)

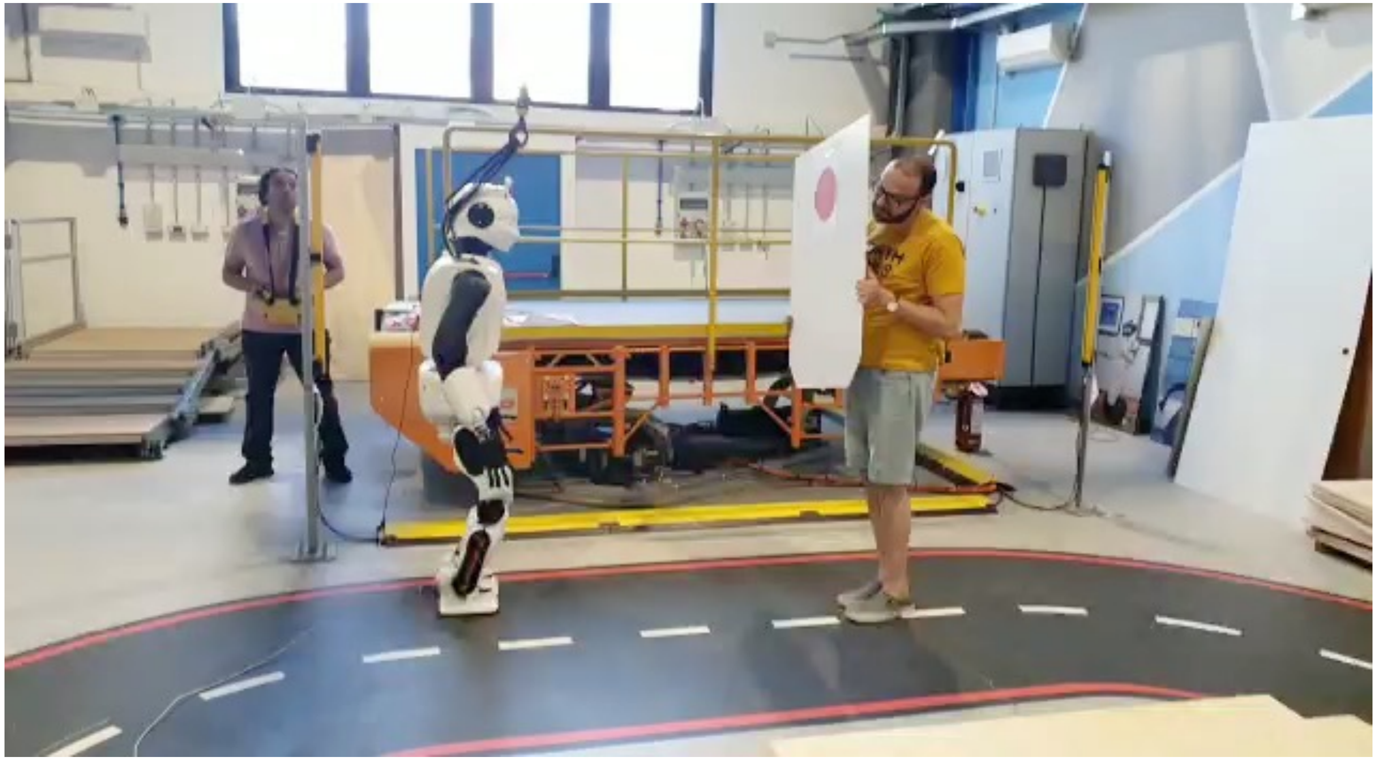
## Abstract

This paper exposes and discusses the concept of 'networked embodied cognition', based on natural embodied neural networks, with some considerations on the nature of natural collecti[...] intelligence and cognition, and with reference to natural biological examples, evolution theory [...] networks [illegible] at this could be the method of cognitive adaptation to the environment most widely used by living systems and

**www.shanghailectures.com**

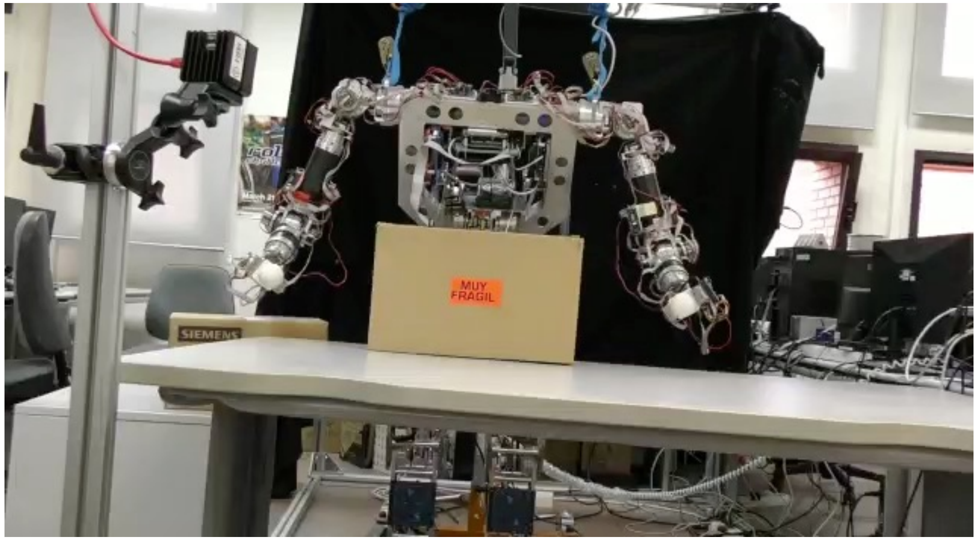
Bonsignorio, F., Preliminary considerations for a quantitative theory of networked embodied intelligence, 50 years of artificial intelligence 4850, 112-123, 2007

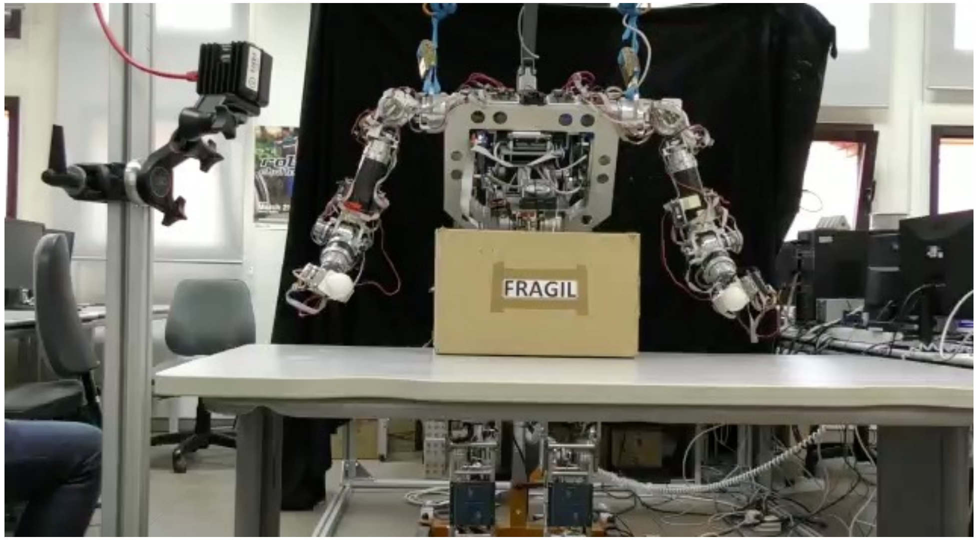
# HumaBeliefs



This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 779963

# HumaBiMan




This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 779963

**How to build a 'new paradigm' robot like the Cornell Ranger able to wave the hands like NAO?**
**(and manipulate objects…)**

a) Cornell ranger

b) Nao walking down a ramp

c) Andy Ruina's 'passive walker' walking down a ramp

# An Imitation Learning Approach for the Control of a Low-Cost Low-Accuracy Robotic Arm for Unstructured Environments

Fabio Bonsignorio[1], Cristiano Cervellera[2†], Danilo Macciò[2†] and Enrica Zereik[2*†]

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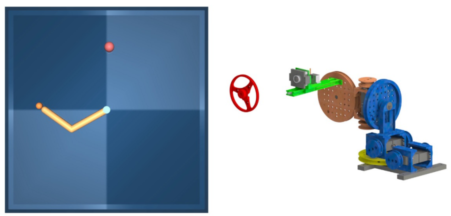
*Corresponding author(s). E-mail(s): enrica.zereik@cnr.it;
†These authors contributed equally to this work.

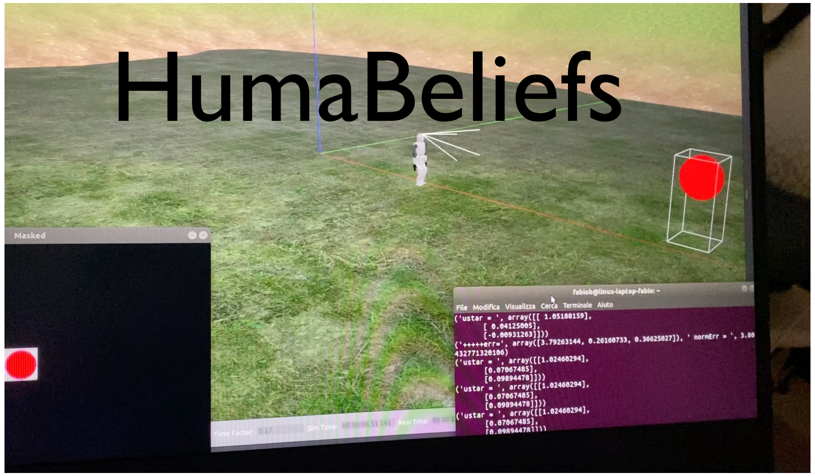
**Abstract**

We have developed an imitation learning approach for the image-based control of a low-cost low-accuracy robot arm. The image-based control of manipulation arms is still an unsolved problem, at least under challenging conditions such as those here addressed. Many attempts



(a) DeepMind Reacher (b) $H_2$Arm visual-servoing

**Fig. 9**: Comparison among the proposed H2Arm visual-servoing task and the "Reacher" task of the DeepMind Control Suite. The main characteristics of each task are: a) DeepMind Reacher – a 2-link planar structure that has to reach a target, executed only in simulation, with known proprioceptive measures, known target location, simulated scenario with known noise structure, many training data needed, AI directly on image pixels. Tasks are strongly observable, position and velocity observations depend only on the current state. Sensor readings only depend on the previous transition, see [21]. Courtesy of DeepMind. b) H2Arm – 4-link 3D manipulator, experimented in real world, without proprioceptive information (the only sensor on-board is the wrist-mounted camera), additional noise injected in some of the experiments, very few needed training data (97 BSP trajectories logged in previous tests where the arm was controlled by the BSP algorithm only, without any neural controller), images are pre-processed by a vision algorithm and AI works on measures estimated by vision.



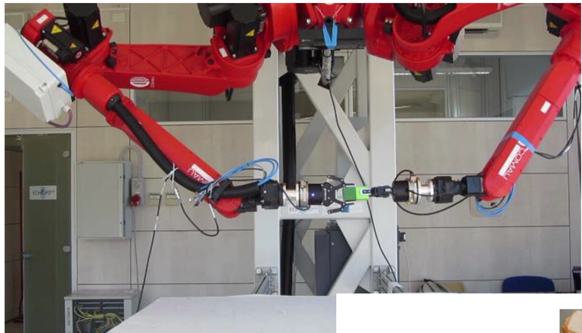



Fig. 15: After the object was picked up positioned in a suitable configuration to perf two grippers facing each other, and the fore:

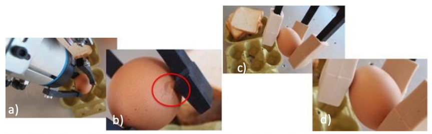
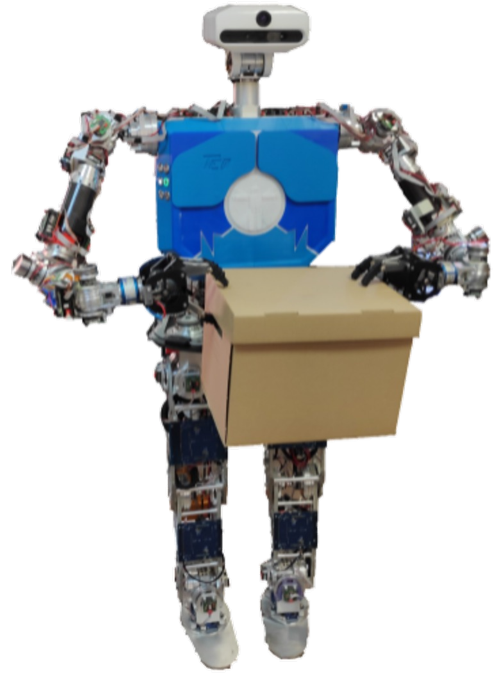


Fig. 18: View of the result of the first pick and place task using eggs. Confront between the broken egg resulted from the manipulation of the Festo grippers (a,b) and the sane egg manipulated with silicon thimbles (c,d).

Dario P., Morachioli A., Strazzulla I., Laschi C.,Bonsignorio F., "Disassembly Robotic Tasks for Circular Economy"(poster), IEEE Life Sciences Grand Challenges Conference, Abu Dhabi, UAE, 2016



# HumaBiMan

…outcome from g2Net-wg2 cooperation between Heron Robots and Astrocent (T. Bulik and team)

CONFIDENTIAL

**Network of Mobile seismic sensor**

- **to be used in inaccessible areas, possibility of characterizing seismic fields with a small number of sensors, adjustable sensor array layout, prototype ready**
- **<u>Ros on Raspberry PI: SW stack can fit to any similar robot (including 'Roomba/Create') with minimum changes'</u>**

56

Infrasound microphone

ROS

人工智能 The ShanghAI Lectures 上海授课

# …outcome from wg2 cooperation between Heron Robots and Astrocent (T. Bulik and team)

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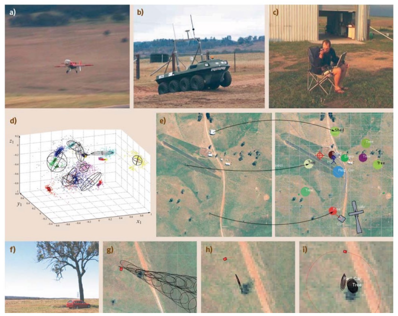
Multisensory Data Fusion in Robotics
Example: ANSER II: Decentralised Data Fusion



A synopsis of the ANSER II autonomous network and its operation.
(a–c) Main system components;
(a) air vehicle,
(b) ground vehicle,
(c) human operative.

(d–e) The perception process;
(d) top three dimensions of features discovered from ground-based visual sensor data along with the derived mixture model describing these feature properties
(e) sector of the overall picture obtained from fusing air vehicle (UAV), ground vehicle (GV) and human operator (HO) information. Each set of ellipses corresponds to a particular feature and the labels represent the identity state with highest probability.

(f–i) Sequential fusion process for two close landmarks: (f) a tree and a red car, (g) bearing-only visual observations of these landmarks are successively fused, (h) to determine location and identity (i).

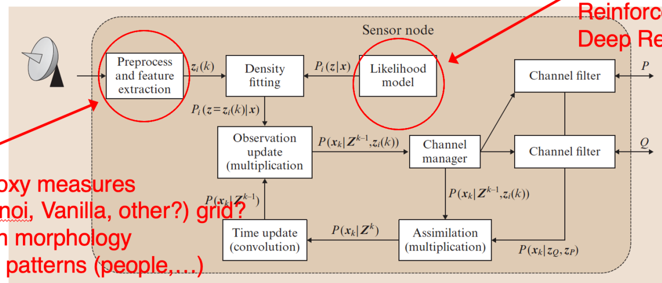
Note the Gaussian mixture model for the bearing measurement likelihood

H. Durrant-Whyte, T. C. Henderson,
Multisensor Data Fusion,
Part C, Chapter 25, in B.Siciliano, O. Khatib (eds.) Springer Handbook of Robotics, 2008

## Infrasound microphone

Decentralised Data Fusion like AnserII but with two main changes

57




Mathematical structure of a decentralized data fusion node

**Prototype ready – network to be installed in Virgo this year**

# The Blockchain in Intelligent Robotics and Automation Applications

Fabio Bonsignorio, *Senior Member, IEEE,* Aleksandr Kapitonov, *Member, IEEE,* Ivan Berman, *Member, IEEE,* Önder Gürcan, *Member, IEEE,* Sergey Lonshakov, *Member, IEEE,* and Eduardo Castello–Ferrer, *Member, IEEE*

***Abstract*—The ongoing massive adoption of robots, AI appli-** ecosystem are posing tremendous challenges

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ISSN 2379-5980 (online)
DOI 10.5195/LEDGER.2019.177

PROCEEDINGS ARTICLE

## Robotic Services for New Paradigm Smart Cities Based on Decentralized Technologies

Aleksandr Kapitonov,[*†] Sergey Lonshakov,[‡] Ivan Berman,[§] Eduardo Castelló Ferrer,[¶] Fabio P. Bonsignorio,[††] Vitaly Bulatov,[‡‡] Aleksandr Svistov[§§]

**Abstract.** This article describes different methods of organizing robotic services for smart cities using secure encrypted decentralized technologies and market mechanisms—as opposed to models based on centralized solutions based (or not) on using cloud services and stripping citizens of the control of their own data. The basis of the proposed methods is the Ethereum decentralized computer with the mechanism of smart contracts. In this work, special attention is paid to the integration of technical and economic information into one network of transactions, which allows creating a unified way of interaction between robots—*the robot economy*. Three possible scenarios of robotic services for smart cities based on the economy of robots are presented: unmanned aerial vehicles (UAVs), environmental monitoring, and smart factories. In order to demonstrate the feasibility of the proposed scenarios, three experiments are presented and discussed. Our work shows that the Ethereum network can provide, through smart contracts and their ability to activate programs to interact with the physical world, an effective and practical way to manage robot services for smart cities.

### 1. Introduction

In recent years, the demand for robotic devices for business and for personal use has significantly increased. According to various forecasts, the number of devices in the world market of Internet of Things (IoT) will be 30 billion units by 2020,[1] and by 2025 the number of connected IoT

# Secure distributed access to smart and robotics underwater resources

Fabio Bonsignorio, Enrica Zereik, Massimo Caccia

***Abstract*—Distributed ledger technologies, together with AI,** of intelligent devices. Moreover the centralization of citizen

frontiers in Robotics and AI | Computational Intelligence in Robotics



TECHNOLOGY AND CODE article
Front. Robot. AI, 28 May 2020 | https://doi.org/10.3389/frobt.2020.00070

## Trustable Environmental Monitoring by Means of Sensors Networks on Swarming Autonomous Marine Vessels and Distributed Ledger Technology

Ivan Berman[1*], Enrica Zereik[2], Aleksandr Kapitonov[1], Fabio Bonsignorio[3], Alisher Khassanov[4], Aziza Oripova[5], Sergei Lonshakov[4] and Vitaly Bulatov[6]

[1]Faculty of Control Systems and Robotics, ITMO University, Saint Petersburg, Russia
[2]Institute of Marine Engineering, Italian National Research Council, Genova, Italy
[3]Heron Robots, Genova, Italy
[4]Airalab, Tolyatti, Russia
[5]Faculty of Food Biotechnologies and Engineering, ITMO University, Saint Petersburg, Russia
[6]M2M Economy, Inc. ("Merklebot"), San Francisco, CA, United States

The article describes a highly trustable environmental monitoring system employing a small scalable swarm of small-sized marine

# Models of ‘Morphological Computation’ and ‘Self-organization’

In [59], the network of agents, where each word is initially represented by a subset of three or more nodes with all (possible) links present, evolves towards an equilibrium state represented by fully connected graph, with only single links.

The statistical distribution, necessary to determine the information managing capability of the network of physical agents and to link to equation (2) can be obtained from equations derived in the statistical physics of network domain.

From (2) it is possible to derive the relations recalled here below (these relations are demonstrated in the appendix).

$$K(X) \overset{+}{\leq} \log \frac{W_{closed}}{W_{open}^{\max}} \qquad \text{(I)}$$

As told, relation (I) links the complexity ('the length') of the control program of a physical intelligent agent to the state available in closed loop and the non controlled condition. This shows the benefits of designing system structures whose 'basin of attractions' are close to the desired behaviors in the phase space.

$$\Delta HN + \sum_{i}^{n} \Delta H_i - \Delta I \leq I(X;C) \qquad \text{(II)}$$

Relations (II) links the mutual information between the controlled variable and the controller to the information stored in the elements, the mutual information between them and the information stored in the network and accounts for the redundancies through the multi information term *ΔI*.

Relations (III) links the program complexity of the controller to the information stored in the elements, the mutual information between them and the information stored in the network.

$$K(X) = \Delta HN + \sum_{i}^{n} \Delta H_i - \Delta I \qquad \text{(III)}$$

Relations (IV) links the program complexity of the controller to the information stored in the elements the mutual information between them and the information stored in the network.

$$\Delta HN = \log \frac{\Omega_{closed}}{\Omega_{open}^{\max}} + \Delta I \qquad \text{(IV)}$$

These relations are quite preliminary, and perhaps need a more rigorous demonstration, but give an insight on how information is managed within a network of physical elements or agents interacting with a given environment in a finalized way. They suggest how the cognitive adaptation is at network level: in any environment niche it is possible with small networks of highly sophisticated individual agents, like in human societies, or with many limited autonomy individuals like in ant colonies, with a great variety of possibilities in the middle.

ALLEGATO A

Reproducing Kernel Hilbert Spaces and Applications:

Signal Theory, Machine Learning, Robotics, and AI

Sorin Dragomir[1]

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Research Topic

**Novel Methods in Embodied and Enactive AI and Cognition**

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## About this Research Topic

There has been a lot of hype on Artificial Intelligence (AI) recently. Most people identify AI with GOFAI (Good Old Fashioned Artificial Intelligence, broadly speaking ‘functionalist’ and ‘symbolic’ AI), or Machine Learning, especially, Deep Learning which represents comparatively a subset of AI research itself. This identification is favored by the recent remarkable successes in particular of Deep Learning in object and speech recognition and other tasks. Deep (Reinforcement) Learning has also been applied to robotics to some problems with remarkable success.

GOFAI is affected by the Frame-of-Reference issue as already well explained among others by the American philosopher Daniel Dennett decades ago. Deep Learning has been initially applied for the indexing of large data sets of images, sound samples and the profiling of online customers of marketplace platforms and social networks users. Its application to physical systems and in particular robotic systems raises some issues as usually the data coming from robot sensors are in comparatively limited amounts and the robots interact and affect their environment making for example real time object recognition more problematic. Both paradigms are implicitly based on Descartes’ idea of mind body separation. The very fact that we have two distinct disciplines one for the body (Robotics) and one for the mind (AI) is difficult to justify from a philosophical and epistemological standpoint. Ideas like those of the XX century philosopher Merlau-Ponty (“the body understands”) seem more in line with what we know of perception in humans, animals and even plants. Moreover, the principles of organization of natural intelligent and cognitive agents are rather different from the mainstream design principles of intelligent robots. In nature cognition and intelligence are usually embedded in a physical system (a body), emerging bottom-up from the interaction of large numbers of loosely coupled components and is usually associated to Life, while the ‘mechatronics paradigm’ used to build mainstream robots, implements top-down controls, keeping well divided the body (usually a complex mechanical structure, made of rigid parts actuated by electric motors with sophisticated sensors and actuators) from the mind (a set of complex algorithms running on microprocessors arrays). The Fukushima accident and the recent Covid-19 pandemics have shown how current robotics solutions are still insufficiently developed to cope with real world challenges. Together with the results of the DARPA Robotics Challenge and the delayed adoption of self-driving cars this suggests that the philosophical and epistemological concerns may actually have quite practical

## Topic Editors

**Fabio Bonsignorio**
Heron Robots
Genoa, Italy
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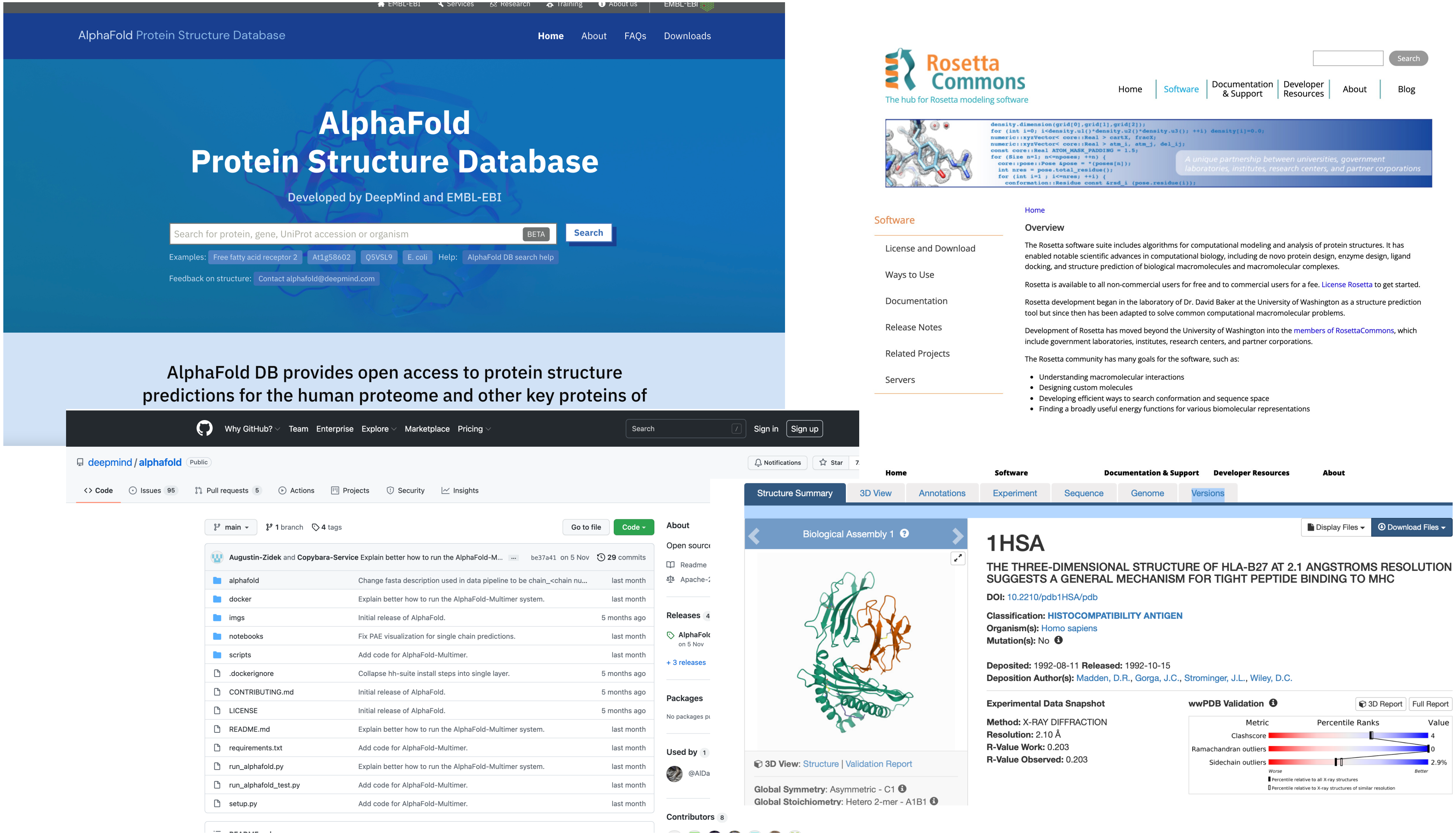
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The Rosetta software suite includes algorithms for computational modeling and analysis of protein structures. It has enabled notable scientific advances in computational biology, including de novo protein design, enzyme design, ligand docking, and structure prediction of biological macromolecules and macromolecular complexes.
Rosetta is available to all non-commercial users for free and to commercial users for a fee. License Rosetta to get started.
Rosetta development began in the laboratory of Dr. David Baker at the University of Washington as a structure prediction tool but since then has been adapted to solve common computational macromolecular problems.
Development of Rosetta has moved beyond the University of Washington into the members of RosettaCommons, which include government laboratories, institutes, research centers, and partner corporations.
The Rosetta community has many goals for the software, such as:
Understanding macromolecular interactions
Designing custom molecules
Developing efficient ways to search conformation and sequence space
Finding a broadly useful energy functions for various biomolecular representations
Why GitHub? Team Enterprise Explore Marketplace Pricing
Search
Sign in
Sign up
deepmind / alphafold Public
Notifications
Star
Code
Issues 95
Pull requests 5
Actions
Projects
Security
Insights
main
1 branch
4 tags
Go to file
Code
Augustin-Zidek and Copybara-Service Explain better how to run the AlphaFold-M...
be37a41 on 5 Nov
29 commits
alphafold Change fasta description used in data pipeline to be chain_<chain nu... last month
docker Explain better how to run the AlphaFold-Multimer system. last month
imgs Initial release of AlphaFold. 5 months ago
notebooks Fix PAE visualization for single chain predictions. last month
scripts Add code for AlphaFold-Multimer. last month
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CONTRIBUTING.md Initial release of AlphaFold. 5 months ago
LICENSE Initial release of AlphaFold. 5 months ago
README.md Explain better how to run the AlphaFold-Multimer system. last month
requirements.txt Add code for AlphaFold-Multimer. last month
run_alphafold.py Explain better how to run the AlphaFold-Multimer system. last month
run_alphafold_test.py Add code for AlphaFold-Multimer. last month
setup.py Add code for AlphaFold-Multimer. last month
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1HSA
THE THREE-DIMENSIONAL STRUCTURE OF HLA-B27 AT 2.1 ANGSTROMS RESOLUTION SUGGESTS A GENERAL MECHANISM FOR TIGHT PEPTIDE BINDING TO MHC
DOI: 10.2210/pdb1HSA/pdb
Classification: HISTOCOMPATIBILITY ANTIGEN
Organism(s): Homo sapiens
Mutation(s): No
Deposited: 1992-08-11 Released: 1992-10-15
Deposition Author(s): Madden, D.R., Gorga, J.C., Strominger, J.L., Wiley, D.C.
3D View: Structure | Validation Report
Global Symmetry: Asymmetric - C1
Global Stoichiometry: Hetero 2-mer - A1B1
Experimental Data Snapshot
Method: X-RAY DIFFRACTION
Resolution: 2.10 Å
R-Value Work: 0.203
R-Value Observed: 0.203
wwPDB Validation
3D Report
Full Report
Metric
Percentile Ranks
Value
Clashscore 4
Ramachandran outliers 0
Sidechain outliers 2.9%
Worse
Better
Percentile relative to all X-ray structures
Percentile relative to X-ray structures of similar resolution

# Carry-home messages (and remarks) (1)

We will need to dramatically increase work productivity not only to cope with a shrinking work-force and growing number of people in old and very old age, but also to mobilize resources to help the ecologically sustainable development of the global economy and provide food and infrastructures to billions of more people.

- A steep progress in Robotics and AI seems a dramatic necessity in this context.
- The Advanced Mechatronic Technologies of the 'Second Wave' will have tremendous impact
- it seems unlikely that they can provide satisfactory 'companions' or life-like robustenss and adaptation
- An evidence-based answer to this question requires a boost in the ways research is performed and reported
- To enable the 'Third Wave' of Robotics a massive effort will be needed (also in terms of dramatically improved research methodologies as existing results are 'anedoctical')

# Carry-home messages (and remarks) (2)

- We will have to structure/digitalize living spaces to be able to exploit the existing and close future available technologies
- Given the cognitive/perception limits of current robots teleoperation, scalable autonomy and in general human-in-the-loop solutions will work better
- Non obvious human-in-the-loop solutions: prosthetics, body-augmentation, artificial organs, high-bandwidth BCI/BRI
- We should take care of the disciplinary interfaces with traslational genomics, connectomics, brain sciences, digital medicine, emerging rejuvenating technologies, to pursue successful holistic solutions for late age healthy and independent living
- We will still (sometimes remotely operating) need human caregivers: we should not leave elders andd impaired persons alone with deceptive robot ‘companions’(it would/will make sense iff/when we will have conscious robots, that would open a huge number of different issues, though). Hopefully Industry 4.0, Robotics and AI ( and what will follow) will free human resources!

*the promise of robotics….*

# US Night Lecture

**10:10 Josh Bongard**

**University of Vermont,**

**Burlington (VT), USA**

## «Evolutionary Robotics,Xenobots and beyond»

## Stay tuned!

# Short Bio

The ShanghAI Lectures 2013-

Prof. Fabio Bonsignorio is **ERA Chair in AI for Robotics** at FER, University of Zagreb, Croatia. He is **Founder and CEO of Heron Robots (advanced robotics solutions),** see **www.heronrobots.com**. He has been visiting professor at the **Biorobotic Institute of the Scuola Superiore Sant'Anna in Pisa from 2014 to 2019**. He has been a professor in the Department of System Enginering and Automation at the **University Carlos III of Madrid until 2014**. In 2009 he got the **Santander Chair of Excellence in Robotics** at the same university. He has been working for some 20 years in the high tech industry before joining the research community.

He is a **pioneer and has introduced the topic of Reproducibility of results in Robotics and AI**. He is a **pioneer in the application of the blockchain to robotics and AI (smart cities, smart land, smart logistics, circular economy). He coordinates the Topic Group of euRobotics about Experiment Replication, Benchmarking, Challenges and Competitions. He is co-chair of the IEEE Robotics & Automation Society (RAS) Technical Committee, TC-PEBRAS (PErformance and Benchmarking of Robotics and Autonomous Systems)**.

He is a **Distinguished Lecturer** for **IEEE Robotics and Automation Society,** Senior Member of IEEE and member of the Order of the Engineers of Genoa, Italy.

He coordinates the task force robotics, in the G2net,an EU network studying the application of **Machine Learning and Deep Learning (Apprendimento Profondo) to Gravitational wave research, la Geophysics and Robotics**.

**Has given invited seminars and talks in many places: MIT Media Lab, Max Planck Institute, Imperial College, Politecnico di Milano in Shenzhen, London, Madrid, Warsaw, San Petersburg, Seoul, Rio Grande do Sul.…**

# Thank you!

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University of Zagreb
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