





# **The Shanghai Lectures 2023**

**Natural and Artificial Intelligence in Embodied Physical Agents**

**October 26<sup>th</sup>, 2023**

**From Zagreb, Croatia**

# **Today's program (CEST)**

**08:30 sites begin connecting**

**08:55 all sites are ready**

**09:00 (Fabio) Welcome**

**09:15 Introductory Lecture I**

**10:00 Break**

**10:10 Introductory Lecture II**

**11:00 Wrap-up**

# Goals

- **Education and knowledge for anyone on the planet**
- **Latest technology for knowledge transfer and community building**
- **Spreading idea of “embodied intelligence” —> new way of thinking**
- **Research platform: studying collaboration — intercultural**
- **Strengthening ties between universities**
- **Informed opinion on media reports**

# **Expected results**

- **interactions with important universities from around the world**
- **new collaborations**
- **global exchange with renowned researchers from different backgrounds in the field of intelligence research**
- **new view of intelligence, ourselves, world**

# **Natural and artificial intelligence**

- **suited for wide interdisciplinary audience**
- **no specific prior training required**
- **novel ideas**
- **broad interest in public at large**

# Table of contents

- **Global challenges and State of the Art in AI and Robotics**
- **Intelligence - an eternal conundrum**
- **Cognition as computation - successes and failures**
- **Towards a theory of intelligence**
- **Design principles for intelligent systems**
- **Ontogenetic development: from movement to cognition - building brains for bodies: ANNs, ML, DL and other approaches**
- **Evolution - cognition from scratch**
- **Collective intelligence - cognition from interaction**
- **Where is human memory?**
- **How the body shapes the way we think - summary, conclusions, outlook**

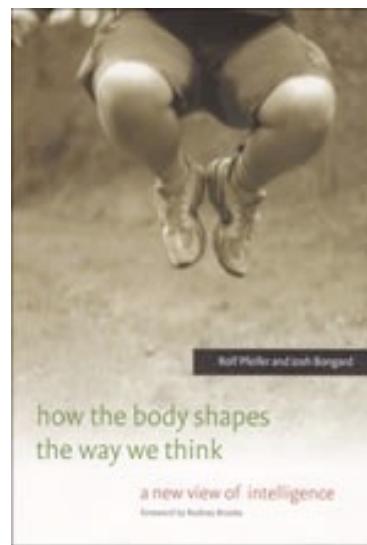
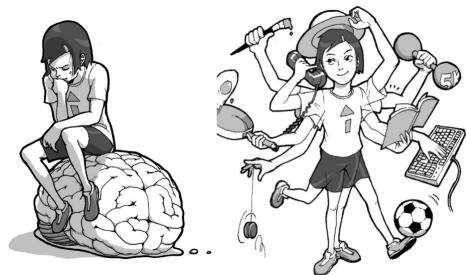
# Book for class

**Rolf Pfeifer and Josh Bongard**

**How the body shapes the way we think – a new view of intelligence**

**MIT Press, 2007**

**Illustrations by Shun Iwasawa**



# **Typical format of lectures**

- **09.00 Student presentation: one of the sites**
- **09.10 Lecture on embodied intelligence (Fabio)**
- **09.55 Break**
- **10.00 Guest speaker**
- **11.00 End of lectures**

# Lecture 0

## A New Paradigm Physical AI unifying Soft Robotics and AI

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



[www.heronrobots.com](http://www.heronrobots.com)

## Outline of the talk

- Global Challenges
- Robotics ‘waves’
- Industry 4.0
- I4.0 impact on the Circular Economy
- Another I4.0 side effect: impact on Construction Industry
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**UN** Welcome to the United Nations. It's your world

Development Departments Regions عربی 中文

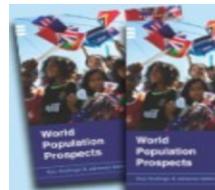
 United Nations  
Department of Economic and Social Affairs

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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 countries 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.





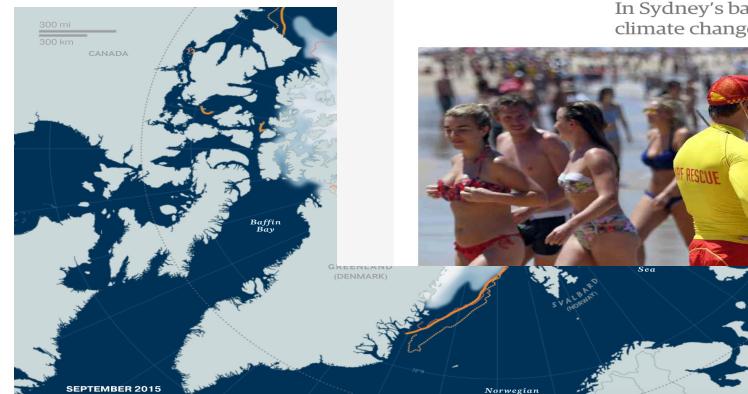
MAGAZINE | JANUARY 2016

# See for Yourself: How Arctic Ice Is Disappearing



Since satellites began regularly monitoring the Arctic in the late 1970s, sea ice has declined sharply in extent and thickness. This is thin stuff that doesn't survive the summer melt. The entire Arctic ecosystem, from plants to polar bears, depends on it. And we're think that, by altering the jet stream, we're changing the way the wind blows around the North Pole.

Graphics and maps by **Lauren J. 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



🌐 English ▾

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Home > News > World > COP25 in Madrid: UN Secretary-General Guterres says planet is 'close to a point of no return'

SPAIN

## COP25 in Madrid: UN Secretary-General Guterres says planet is 'close to a point of no return' COMMENTS

By [Sofia Sanchez Manzanaro](#) with EFE • last updated: 03/12/2019 - 10:10



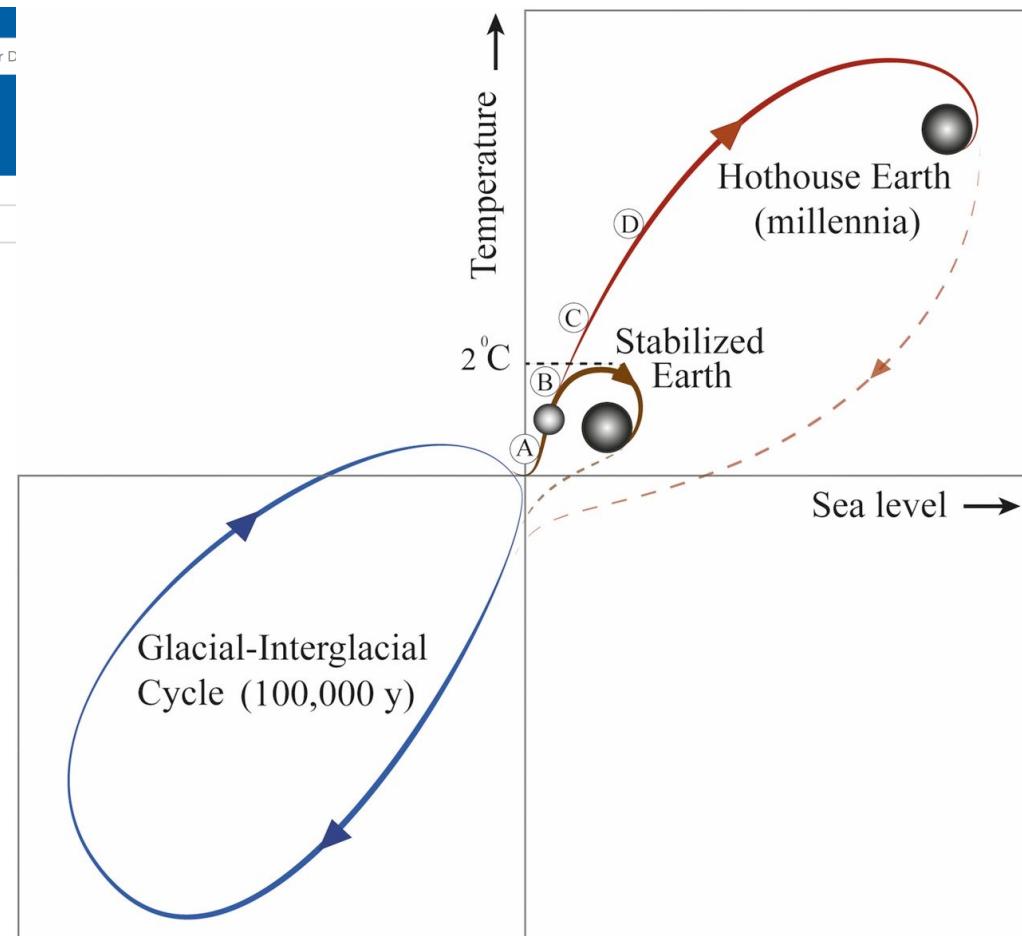
## Projected population growth, 2015-2050

Percentage of population change  
between 2015 and 2050

- 200+
- 100-200
- 50-100
- 10-50
- -10-10
- -10-20
- <-20

Data source: World Population Prospects: The 2017 Revision.

The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).





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# ‘Collapse of Civilisation is the Most Likely Outcome’: Top Climate Scientists

By [Asher Moses](#), originally published by [Voice of Action](#)

⌚ June 8, 2020



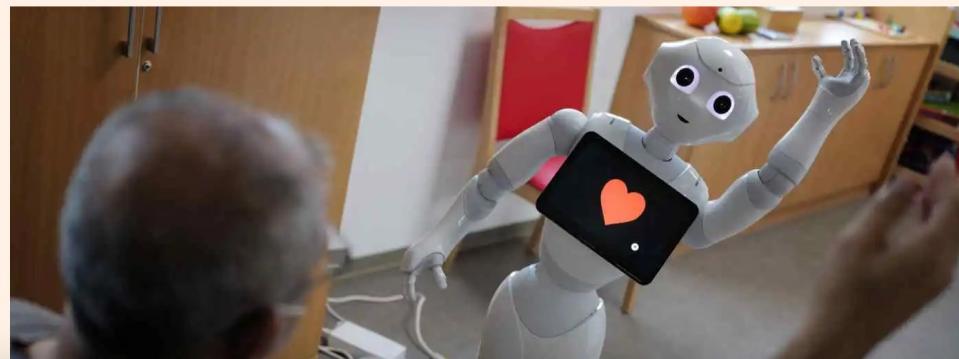
Opinion Artificial intelligence

## Robots need to move faster to save the world

Alarmists say AI will steal jobs, but underlying demographic trends foretell continuing worker shortages

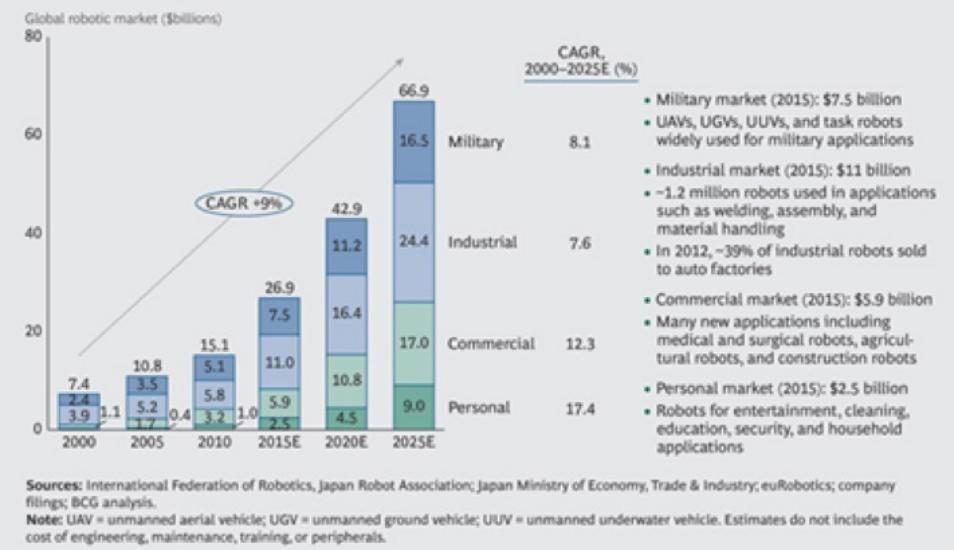
RUCHIR SHARMA

+ Add to myFT



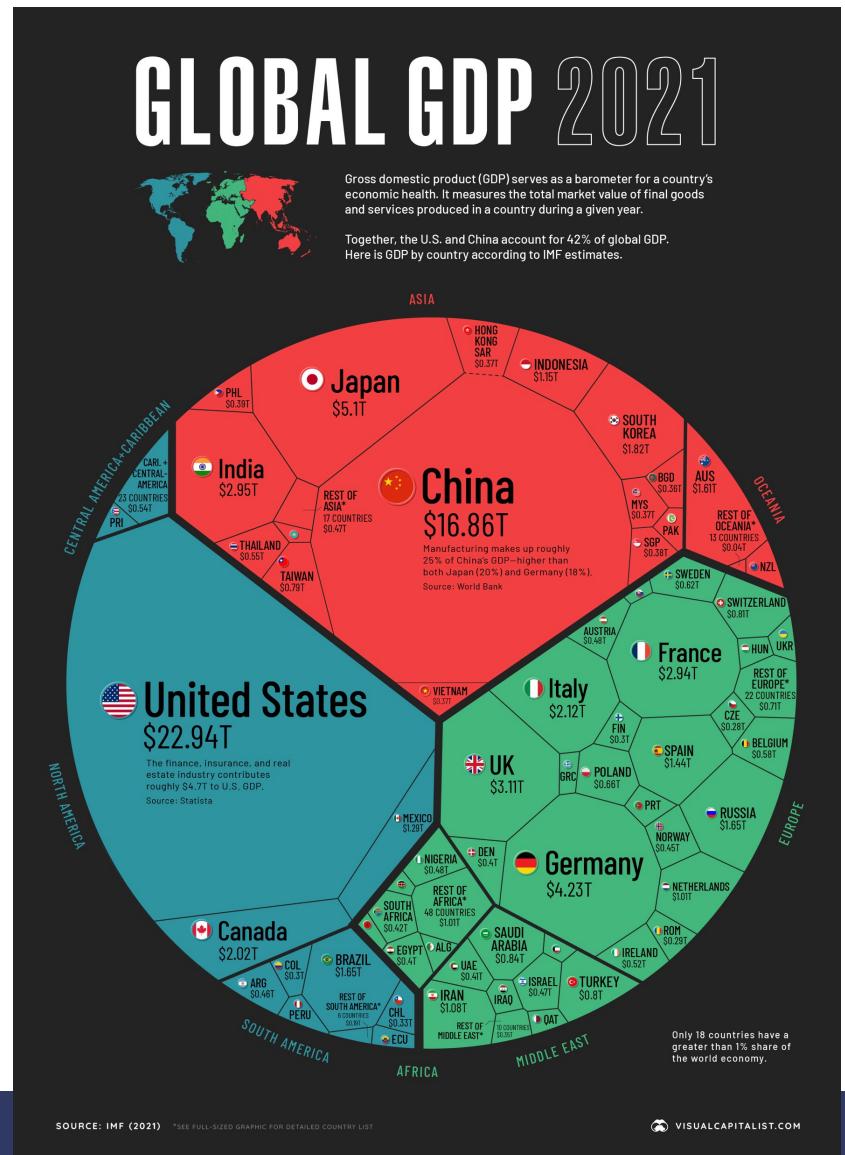
# Meanwhile...

## **EXHIBIT 1 | Worldwide Spending on Robotics Is Expected to Reach \$67 Billion by 2025**



# I / I 000!!! of Global Product

Rethinking Robotics for the Robot Companion of the future



# New Enabling Scientific Knowledge

+

## Some General Trends

- Internet of Things
- Machine Learning/Deep Learning
- ‘some’ AI (mainly Computer vision, Object recognition and Planning)

+

- Ubiquitous Large Very Large Bandwidth
- Decreasing cost of sensors, actuators
- Wright's Law\*
- ...

\* Nagy B, Farmer JD, Bui QM, Trancik JE (2013) Statistical Basis for Predicting Technological Progress. PLoS ONE 8(2)  
Rethinking Robotics for the Robot Companion of the future

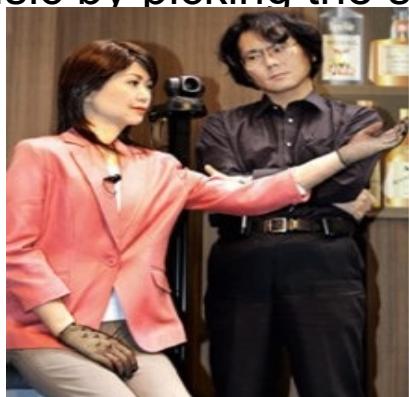


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- What to do

# 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

# Old ideas



*"If every tool, when ordered, or even of its own accord, could do the work that befits it, just as the creations of Daedalus moved of themselves . . . If the weavers' shuttles were to weave of themselves, then there would be no need either of apprentices for the master workers or of slaves for the lords."*

*Aristotle*

*(from Politics, Book 1, 1253b, 322 BC)*

# Old ideas



*The part of the quote "or even of its own accord" is elsewhere translated as "or by seeing what to do in advance"*<sup>2</sup>

*I think this is an important part of the quote, so it's good to go back to the original text:*

*Aristotle uses the word "προαισθανόμενον" – proaisthanomenon this means literally: pro = before, aisthanomenon = perceiving, apprehending, understanding, learning (any of these meanings in this order of frequency) in my view it is clearly a word that is attributed to intelligent, living agents....i.e. ones with cognitive abilities (!)*

*personal communication, Dr. Katerina Pastra*

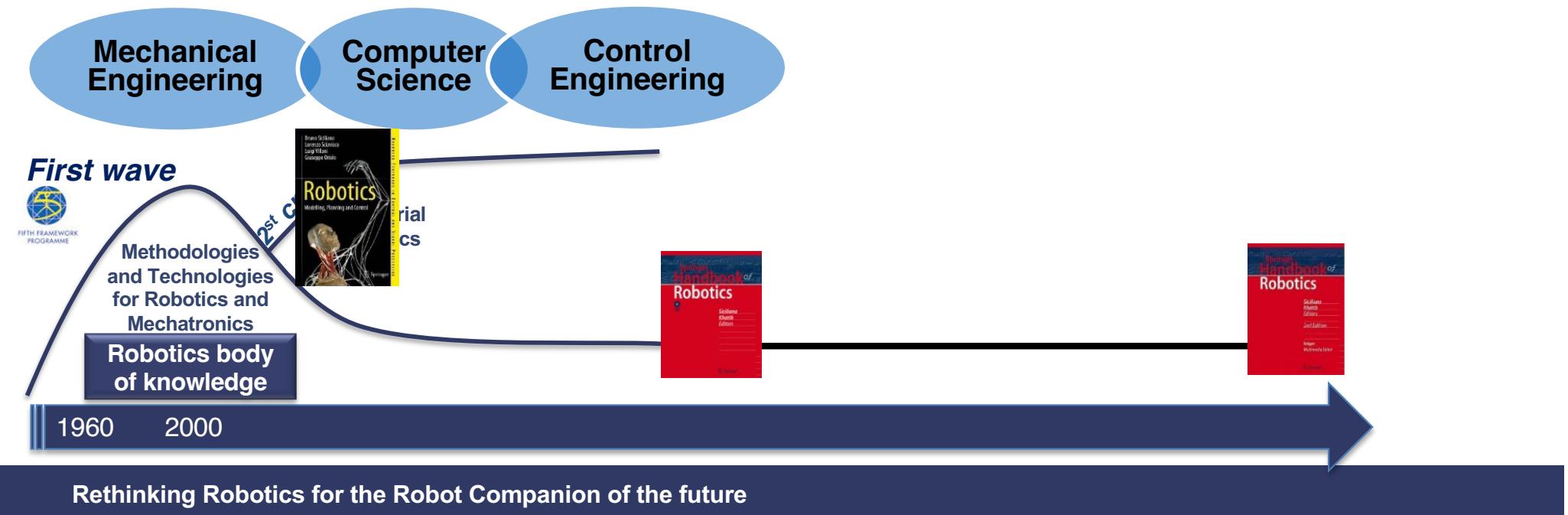
*Research Fellow*

*Language Technology Group*

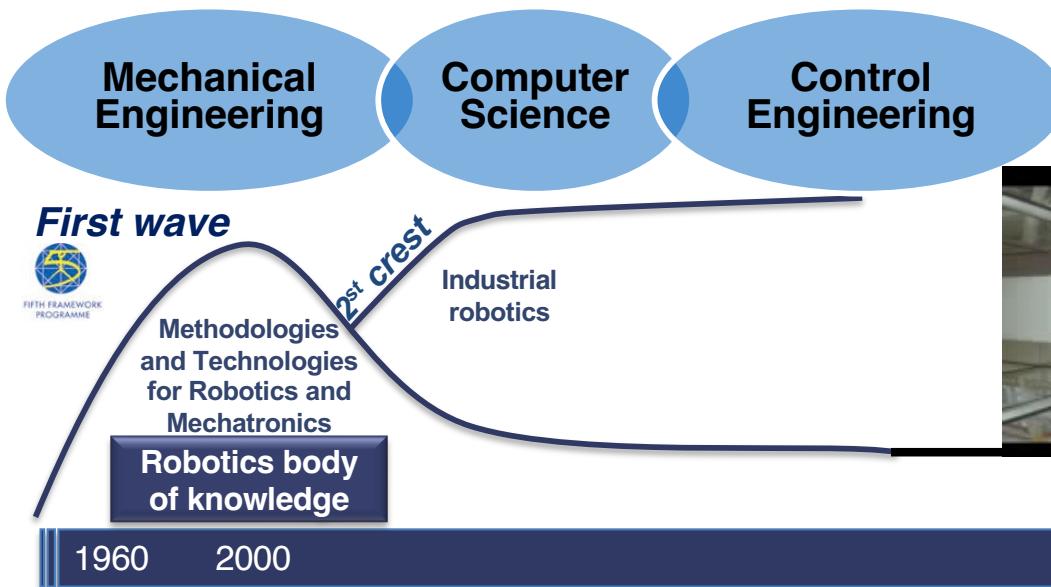
*Institute for Language and Speech Processing*

*Athens, Greece*

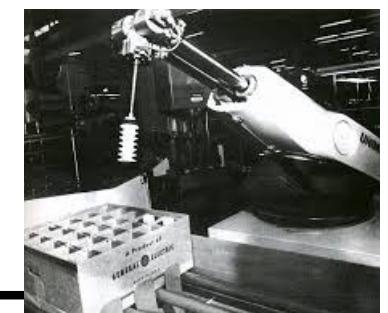
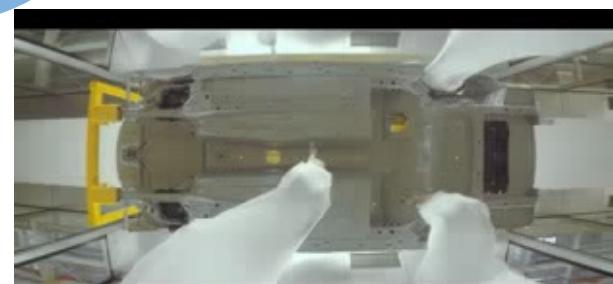
# Recent successes: the first wave



# The first wave

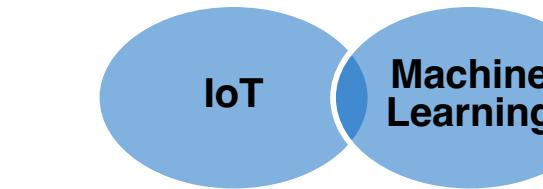


Worldwide annual supply of industrial robots 2001 – 2019\*



Rethinking Robotics for the Robot Companion of the future

# The second wave



Second wave

First wave



FIFTH FRAMEWORK  
PROGRAMME

Methodologies and Technologies for Robotics and Mechatronics

Robotics body of knowledge

7th  
FIFTH FRAMEWORK  
PROGRAMME

2nd crest

Advanced, Future and Emerging Robotics & Cognitive Systems

Industrial robotics

2014

Artificial  
Intelligence

Industrial leadership and societal impact



2nd crest

Advanced, Future and Emerging Robotics & Cognitive Systems

Industrial robotics

Industrial leadership and societal impact

2020

Rethinking Robotics for the Robot Companion of the future

Membership development

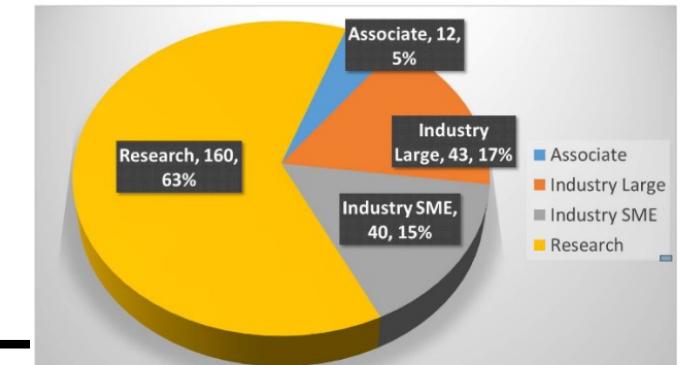


280 member organisations



Legend:

- Industry
- Research
- Associate
- euRobotics AISBL



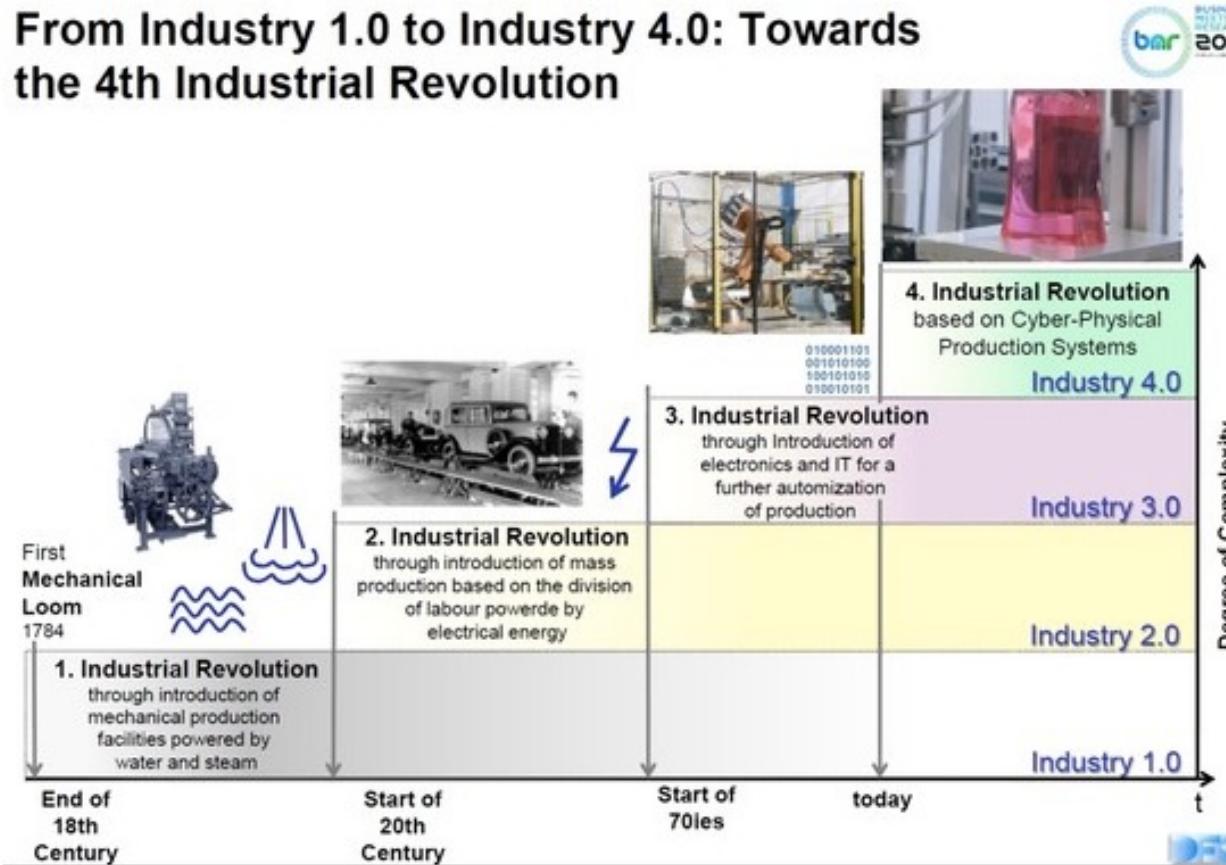
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# The second wave

From Industry 1.0 to Industry 4.0: Towards the 4th Industrial Revolution



## Why we need that? Today's markets are turbulent

Many market researches since many years (Zook et al., 2001, Ghemawat HBS Blog, 2007, Qin et al., 2008) show how the markets are becoming more and more ‘turbulent’: *the demand of products (shifting towards service-products) becomes more and more diversified as product mix and as product quantity variation versus time.*

# Digitalization of European Industry EU Strategy

- a. Digitalization of Products
- b. Digitalization of Services
- c. Digitalizzazione of Processes

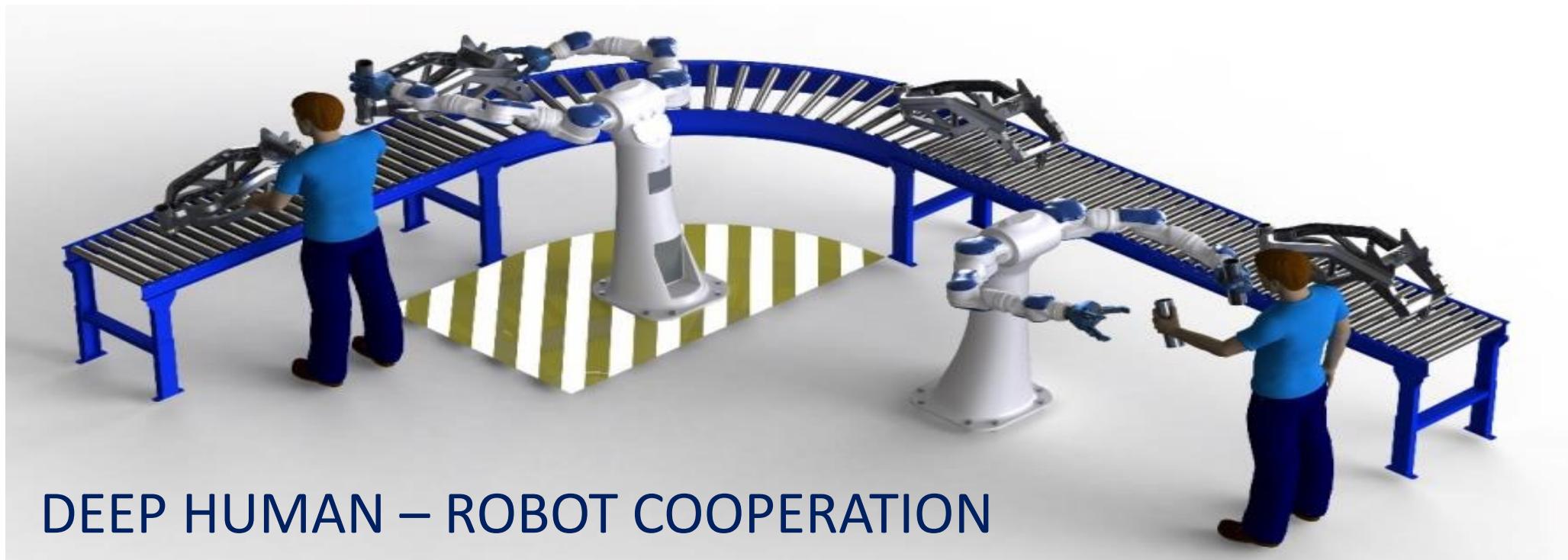
50 G€ of investments by Bruxelles should generate benefits on industry and service sectors revenue for 110 G€/year

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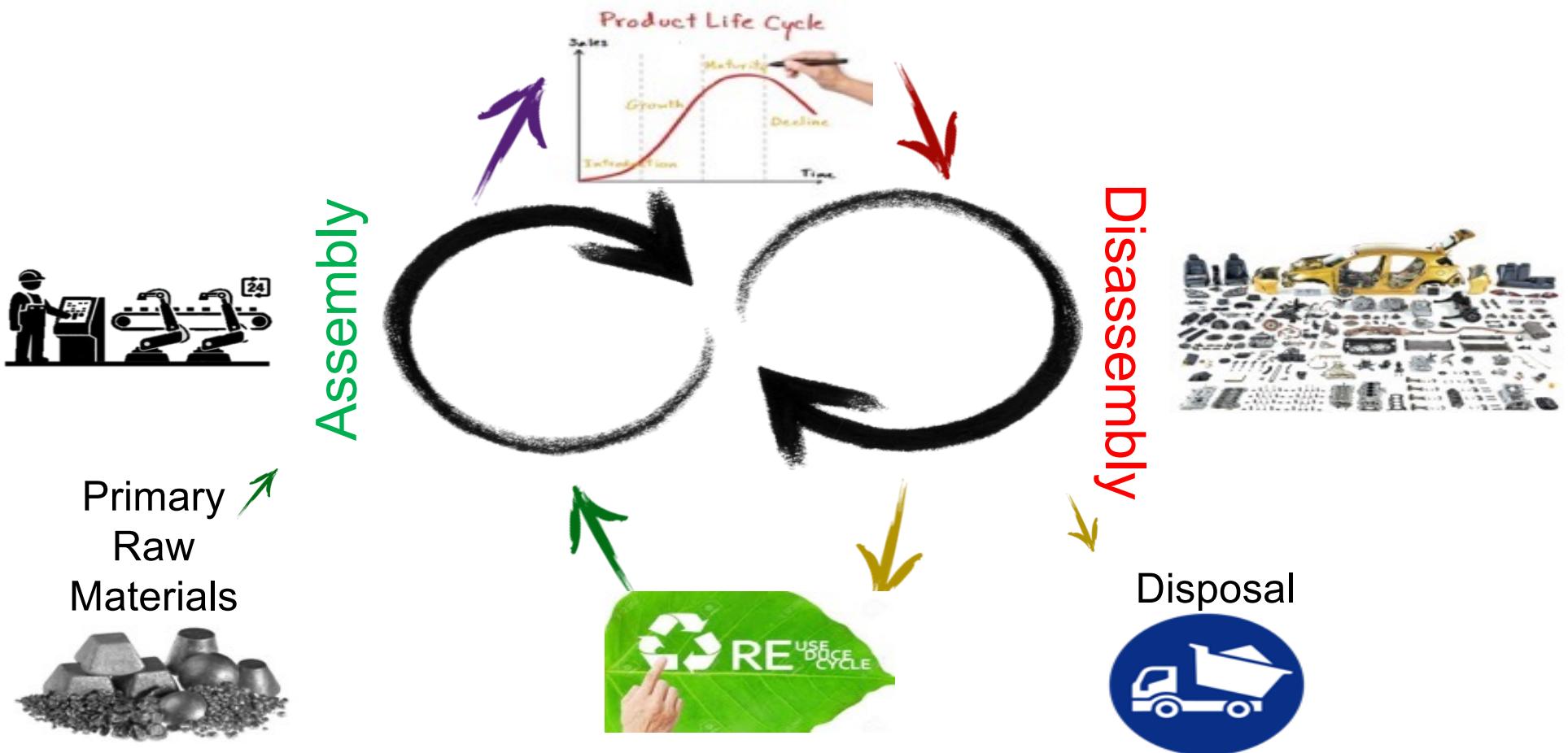
# **Robots on the Shop-floor**

**BIO-AUTOMATION:** the new frontier of automation ‘eco’, bio-inspired and human centered



**DEEP HUMAN – ROBOT COOPERATION**

## Bio-Automation: Deep Human-Robot cooperation (and workspace sharing) is needed for dismantling (and for lot of 1 artisan quality)



# Disassembly Robotic Tasks for Circular Economy

Paolo Dario, Annagiulia Morachioli, Ilaria Strazzulla, Cecilia Laschi, Fabio Bonsignori

Abu Dhabi

25<sup>th</sup> January 2016



## IEEE Life Sciences Grand Challenges Conference

25-26 January, 2016

Khalifa University, Abu Dhabi, UAE



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# A nice side-effect of Industry 4.0 and CE: Economically and eco-sustainable refurbishment of low quality urban areas



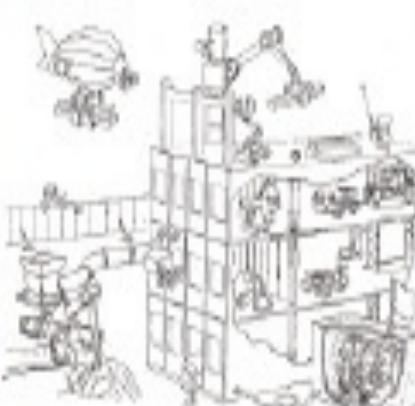
Richard and Su Rogers. Zip-Up Enclosures No. 1 and 2, 1968-71  
Model. On behalf of Rogers Stirk Harbour + Partners



KieranTimberlake Associates, Stephen Kieran and James Timberlake.  
Cellophane House (Exterior)

Pictures from: K. Tadashi Oshima, R. Waern (authors), B. Bergdoll and P. Christensen (eds). *Home Delivery*, The Museum of Modern Art, New York, (2008)

# Urban Refurbishment



- a) Ambient Innovation; b) Industrialization; c) Site Automation; d) Robotic Deconstruction ('dismantling of buildings and built environments')

from T. Block. TARSA, Teaching Automation, Robotics and Services to Architects, (2010)

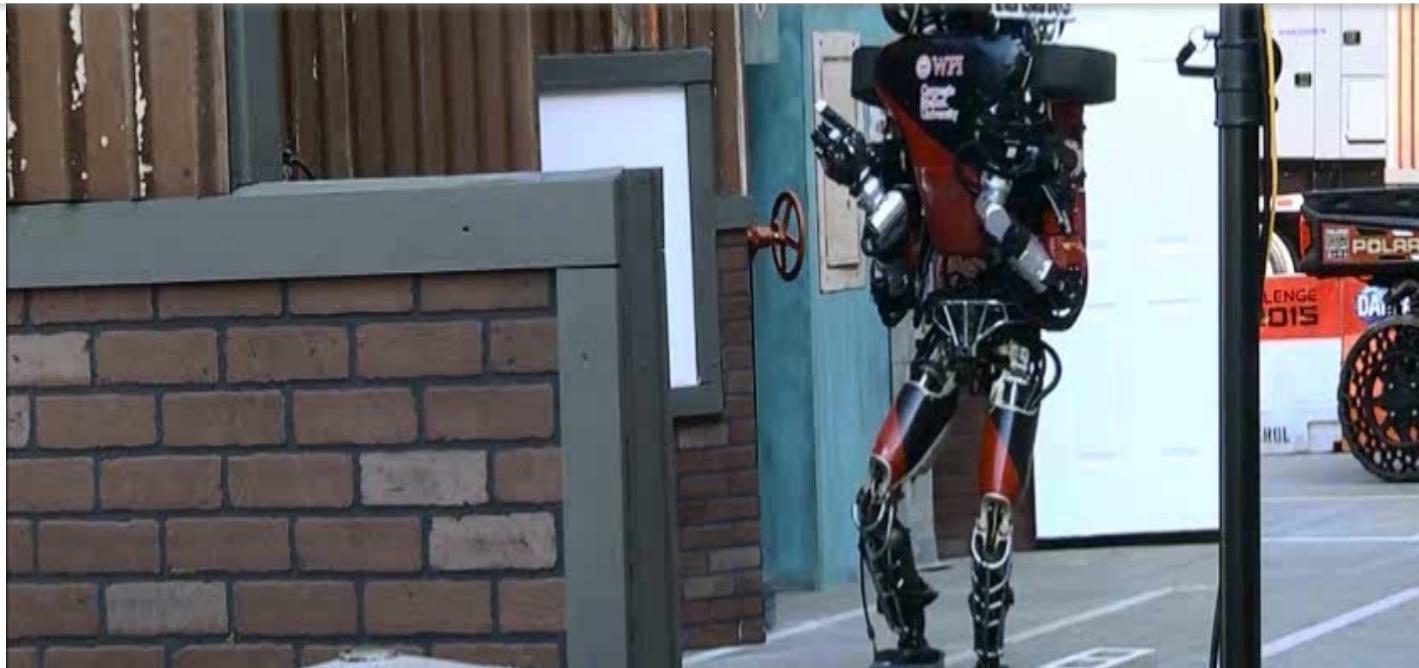
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# The second wave: the success stories



DARPA (American Defense Advanced Research Projects Agency) challenges have demonstrated how current robots are becoming **more accurate, fast and dexterous in structured and unstructured environments.**



## 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.

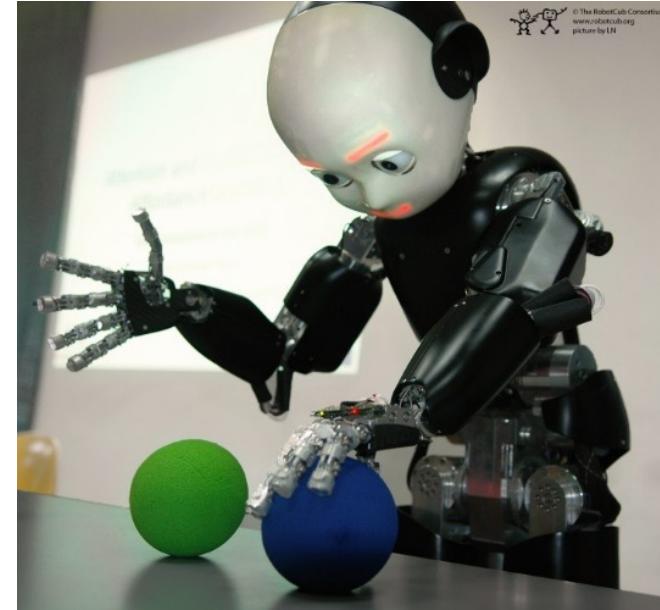


According to H.Yanco a minimum of 9 people were needed to teleoperate latest DRC's robots!!!

# Pursuing new frontiers: The robotics bottleneck

Today, more functionality means:

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



# The Robotics waves



## Third wave

Bionics & Bioinspiration

Simplification, Self-organisation

Cognitive Science

Society

## Second wave

7  
SIXTH FRAMEWORK PROGRAMME

Advanced, Future and Emerging Robotics & Cognitive Systems

1st crest  
2nd crest



Industrial leadership and societal impact

## First wave



FIFTH FRAMEWORK

Methodologies and Technologies for Robotics and Mechatronics

Robotics body of knowledge

1960

2014

2017

2020

2030

FLAG-ERA  
RoboCom++  
FET  
FLAGSHIP  
Proof-of-concept Project



Rethinking Robotics for the Robot Companion of the future

# 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](http://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 Engineering 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. alla stessa università. 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 IA (smart cities, smart land, smart logistics, circular economy)**. He coordinates Topic Group of euRobotics about **Experiment Replication, Benchmarking, Challenges and Competitions**. He is co-chair IEEE Robotics & Automation Society (RAS) Technical Committee, TC-PEBRAS (PErformance and Benchmarking of Robotics and Autonomous Systems).

He is **Distinguished Lecturer per la IEEE Robotics and Automation Society**. Senior Member of IEEE e 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 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 Petersbourg, Seoul, Rio Grande do Sul....

# Thank you!

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University of Zagreb  
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Laboratory for Autonomous Systems and Mobile Robotics



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from the European Union's  
Horizon 2020 research and  
innovation programme under the  
Grant Agreement No. 952275



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**stay tuned for lecture 1!**

**“Intelligence — an eternal conundrum”**

**on November 2, 2023, 09:00-11:00 CET**

**(no more summer time in Europe)**

**[www.shanghailectures.org](http://www.shanghailectures.org)**

