

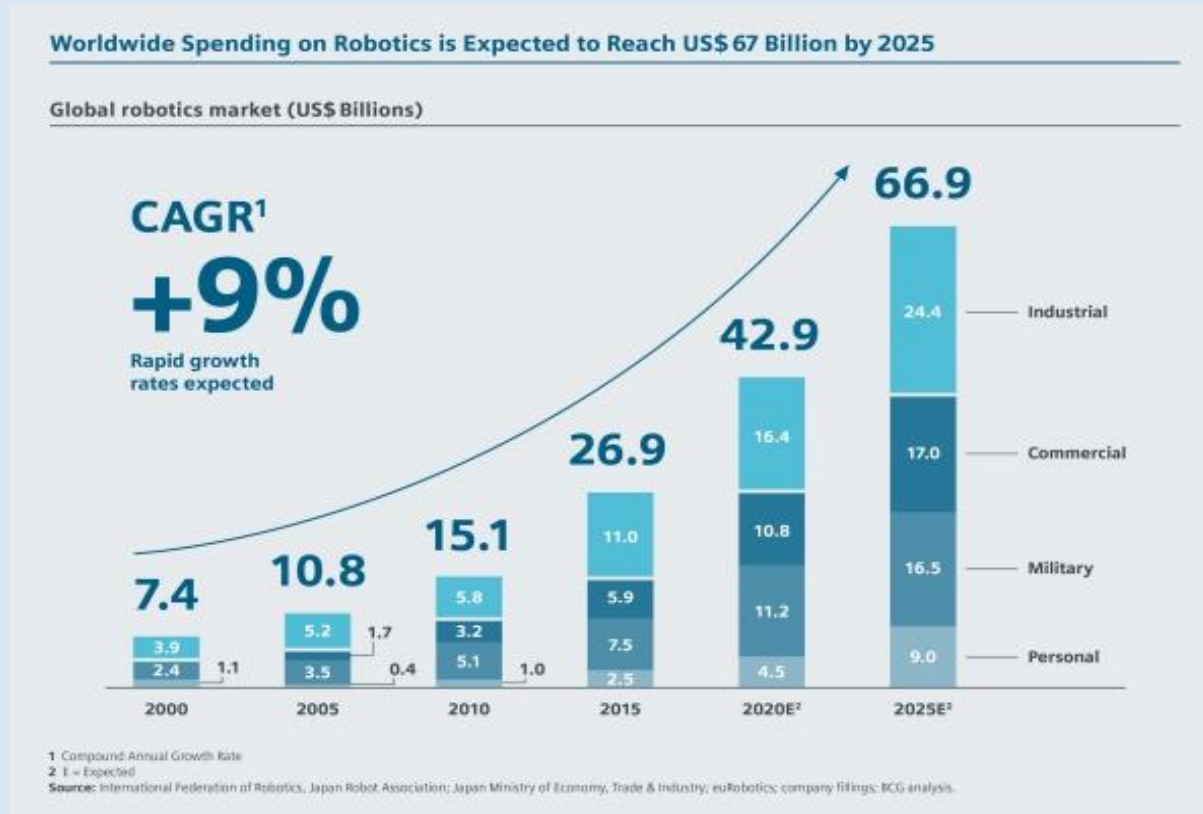
Combining IoT and Intelligent Robotics, challenges and opportunities



Mauro Dragone (Heriot-Watt University)

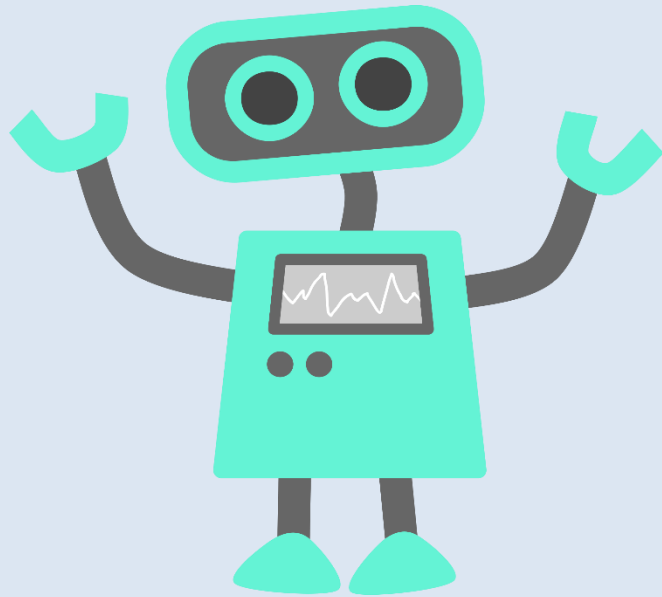


Robotics worldwide



The Boston Consulting Group estimates that more than \$67 billion will be spent worldwide, in the robotics sector by 2025, compared to only \$11 billion in 2005, reaching the compound annual growth rate (CAGR) of 9%.

A Robotic Thing?



Sensing
Perception
Actuation
Interaction
Control
Planning
Learning
Cognition

Motivation and Goals of this workshop

- **IoT and Robotics seem to have produced highly complementary approaches:**
 - one focused on enabling **pervasive and interoperable sensing and information services**,
 - the other on producing **action and interaction**
- **Goal: start answering these questions**
 1. What is the added value of integrating IoT and Robotic solutions?
 2. What are the obstacles to build integrated systems today?
 3. What technological enablers (from AI, cognition, IoT, Robotics) can be used to solve these problems?
 4. Besides technological issues, what we need to bring together results from the Robotics, IoT and AI communities to create real value and benefit society

Previously...



...

2014 – Service Robots and Smart Environments

...

2016 – Robotics & Internet of Things

...

2017 – Combining IoT, Robotics and AI

Networked Robots



NEC Paper (1997)



Simmons et. al
2001



Howard, et. al, (2006)



IEEE RAS Technical Committee on **networked robots** (2004), previously Internet and Online Robots (2001), see <http://www-users.cs.umn.edu/~isler/tc/>, Network Robot Forum, Japan, 2003

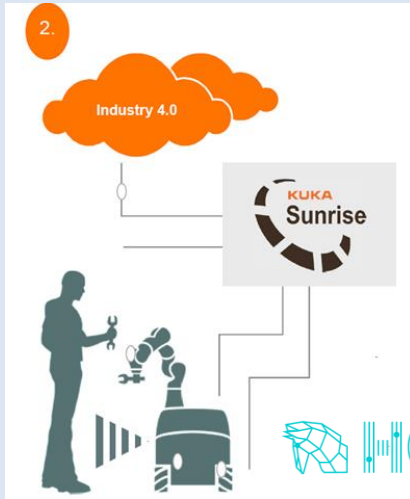
A "networked robot" is a robotic device connected to a communications network such as the Internet or LAN (wired or wireless)

- 1) **Tele-operated**, where human supervisors send commands and receive feedback via the network.
- 2) **Autonomous**, where robots and sensors exchange data via the network.

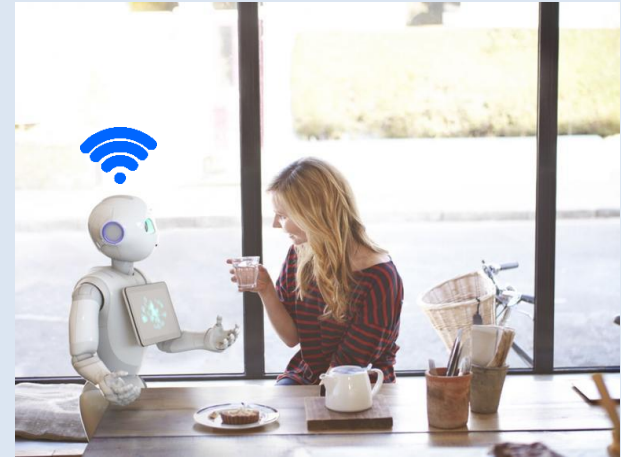
Simmons, Reid, et al. "Xavier: An autonomous mobile robot on the web." *Beyond Webcams: an introduction to online robots* (2001): 81.

A. Howard, L.E. Parker, G.S. Sukhatme: Experiments with a large heterogeneous mobile robot team: Exploration, mapping, deployment and detection, *Int. J. Robot. Res.* **25**(5–6), 431–447 (2006)

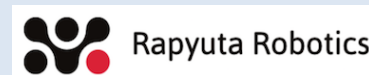
Cloud Robotics



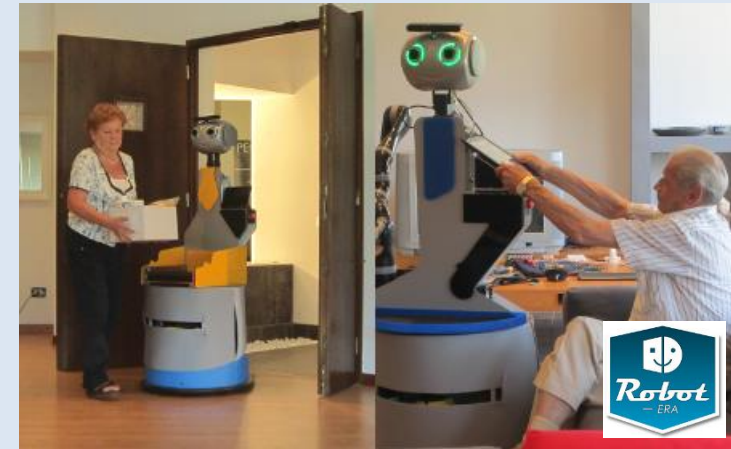
KUKA, H2020 HORSE Project, ERF-2017



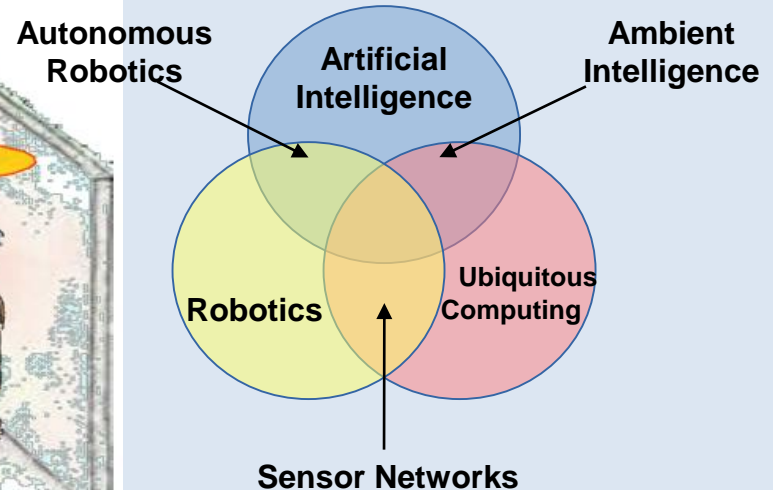
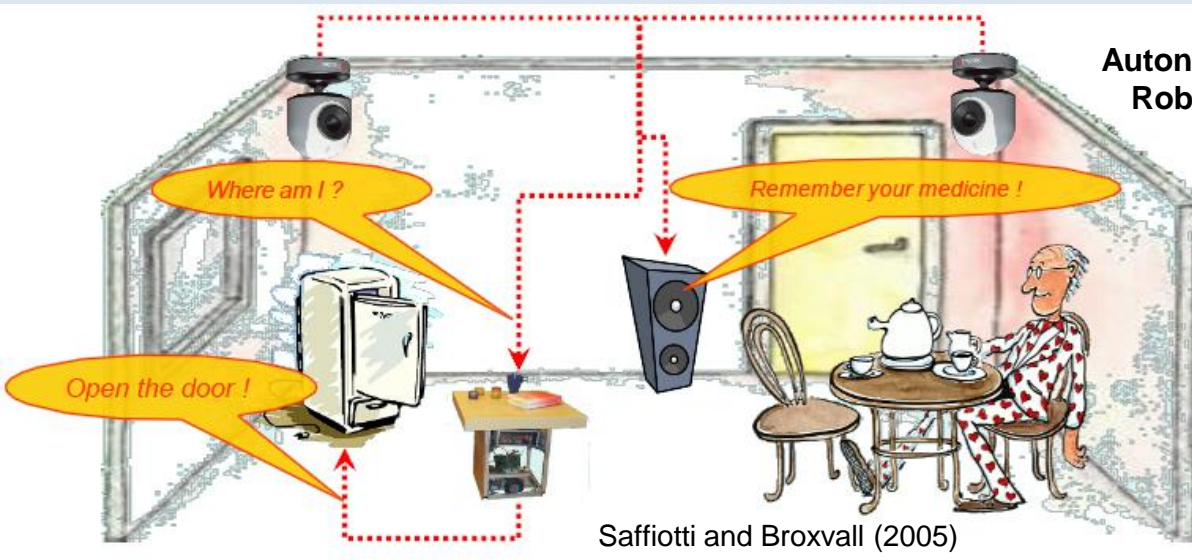
Softbank Robotics' Pepper, ERF-2017



Robots and smart environments



Robotic Ecology



Many specialized, pervasive “robotic” devices

Embedded sensors, cameras, manipulators, appliances, mobile robots

=> Complex abilities achieved through cooperation

Intrinsically modular and expandable (just add new devices...)

2004—2008
Initial concept



2011—2014
Add learning



2012—2015
From home to town



2013—2016
Add social behavior



Highlights from ERF2017



We need:

- Increase awareness of relevant technologies and integration enablers
- Common language/models, theories and meta-languages
- Common middlewares and general-purpose, open source platforms
- Community: working groups, conferences/journals
- Large demonstrators and test-beds
- Common policies

Highlights from ERF2017 – EC Robotic Unit

Cecile Huet pointed out the gap between the level of financial investment and global success experienced by AI R&D in the US, and the fragmentation of research and business fronts in EU R&D. In order to address these problems, the Commission recommends the creation of a European “AI-on demand platform”.

This should become a “**one-stop shop**” platform to support integration of diverse AI solutions and to promote the re-use and incorporation of AI technology in multiple applications, both in research and industry.

Presentations – expert statements

- Address (some of) the following questions

Q1: Added Value	What is the (observed or potential) added value of integrating IoT and Robotics solutions in your experience? Give ONE specific example
Q2: Enablers	What AI and cognition enabler - if any - have you used in your experience?
Q3: Platforms	What IoT and/or Robotics platforms you consider mature for your needs?
Q4: Obstacles	What are the obstacles to build integrated IoT-Robotics-AI systems today?
Q5: Lessons learned	Can you share ONE single lesson learnt in your experience about integrating IoT, Robotics and AI

10 minutes



Program

16:15 Introduction (Mauro Dragone, Heriot-Watt University)

16:25 Presentations
10 minutes each

Davide Bacciu	(University of Pisa)
Filippo Cavallo	(Scuola Superiore S. Anna)
Georges Michalos	(University of Patras)
Pieter Simoens	(Ghent University, IMEC)

17:10 Q&A +
Plenary discussion

17:45 Conclusion

18:00 Workshop ends

Questions



1. What is the (observed or potential) **added value** of integrating IoT and Robotics solutions, in your opinion? Can you give specific examples?
2. What are the **obstacles** to build integrated IoT-Robotics-AI systems today?
3. What **technological enablers** (from AI, cognition, IoT, robotics...), would you consider in order to address these obstacles, and why?
4. Besides technological issues, **what we need to bring together** results from the Robotics, IoT and AI communities to create real value and benefit society?