Ubiquitous Network Technology
A case of Ubiquitous Robotics using Small Coordinated Autonomous Machines

Enrico Pagello

President of the International IAS-Society

Intelligent Autonomous Systems Lab,
Dept. of Information Eng. (DEI), University of Padua, Italy
&
IT+Robotics Srl, Vicenza, Italy
(A spin-off of the University of Padua)

Outline of Presentation

- We consider a new perspective for Robotics applications:

  introducing robots into people's ordinary life
- We introduce *the concept of Ubiquitous Robotics*
- We refer the potential development for the Intelligent Autonomous Robots in the field of Service Robotics as forecast by the *7th EU seven-years Research Framework Program on ICT Technologies and* the *Technological platform EUROP*
- We illustrate some scientific achievements *(in perceiving, and coordinating)* developed at Intelligent Autonomous Systems Laboratory of the University of Padua

Small Evolutive Walking Autonomous Robots (SEWAR) were born in Japan

A New application area is being developed: *Introducing robots in people's ordinary life*, that requires Cheap, *Smart and Interactive Robots*, with *Sophisticated Sensors, and Coordination capability*

(a) Robovie-MS. (b) Robovie-M. (c) Robovie-V.

Vstone series of small Humanoids

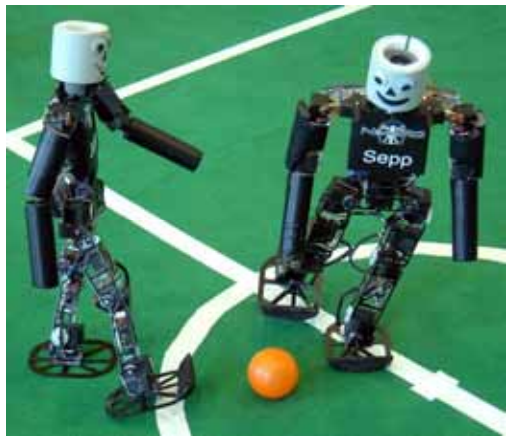
A new robot generation has appeared on the consumer market: International Robot Exhibition, Tokyo 2007

www.irex2007.jp/ENG/index.html

We call them *Small Evolutive Walking Autonomous Robots* (SEWARs)

Small Evolutive Walking Autonomous Robots (SEWAR) in Europe

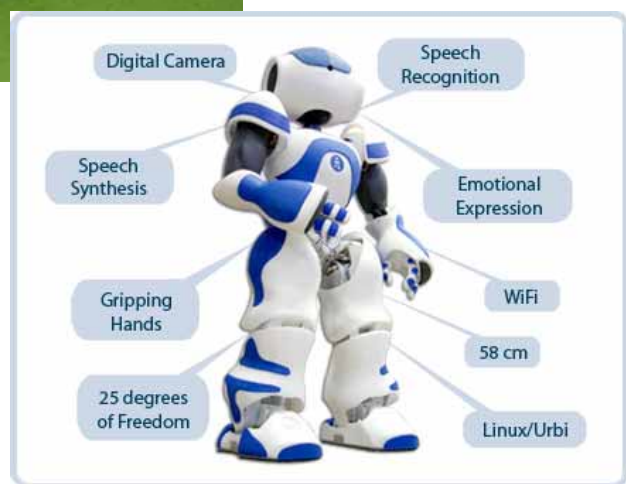
University of Freiburg (Germany) Humanoid Team



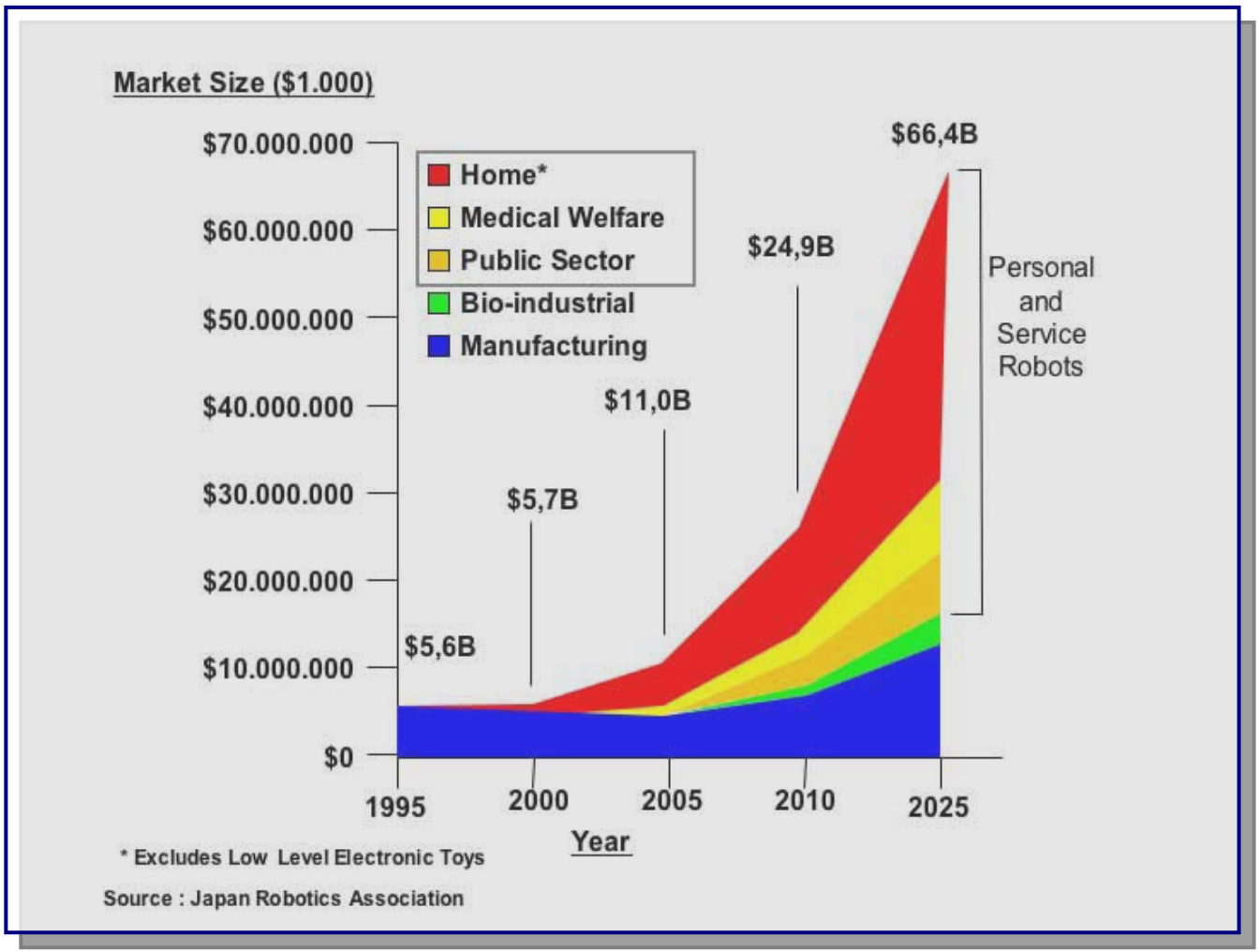
Darmstadt University new dog-robot (Germany)

(France)

Aldebaran Nao humanoid (France)



Forecast Market size



ICT and Ubiquitous Robotics: Why?

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An Ubiquitous Robot Companion is a Service Robot able to interact with an Intelligent Environment populated by Networked Sensors

It calls for applying:

- *Ubiquitous Computing*
- *Distributed Sensor Networks*
- *Advanced Human Robot Interfaces*

A new research frontier has been opened:

From a single-robot theory_and_practice to a multi-robot science_and_technology,

It requires a better understanding of *collective behaviors of Multi-Robot Systems (MRS)*

It calls for applying: Coordination Capability

T. Arai, E. Pagello, L. Parker. *Editorial: Advances in MRS.*
Special Issue on Multi-robotSystems, IEEE Trans. on Robotics and Automation, 2002

ICT and Ubiquitous Robotics: where?

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Intelligent Robotics in Europe dates more than 35 years ago

The first example was the Freddy Robot at Edinburgh School of Artificial Intelligence early 70. Nowadays, we have:

EURON www.euron.org

(the scientific European Robotics Network of Excellence)

and

EUROP www.robotics-platform.eu.com

(the European Robotics Platform,
a concerted action by industry, and academia)

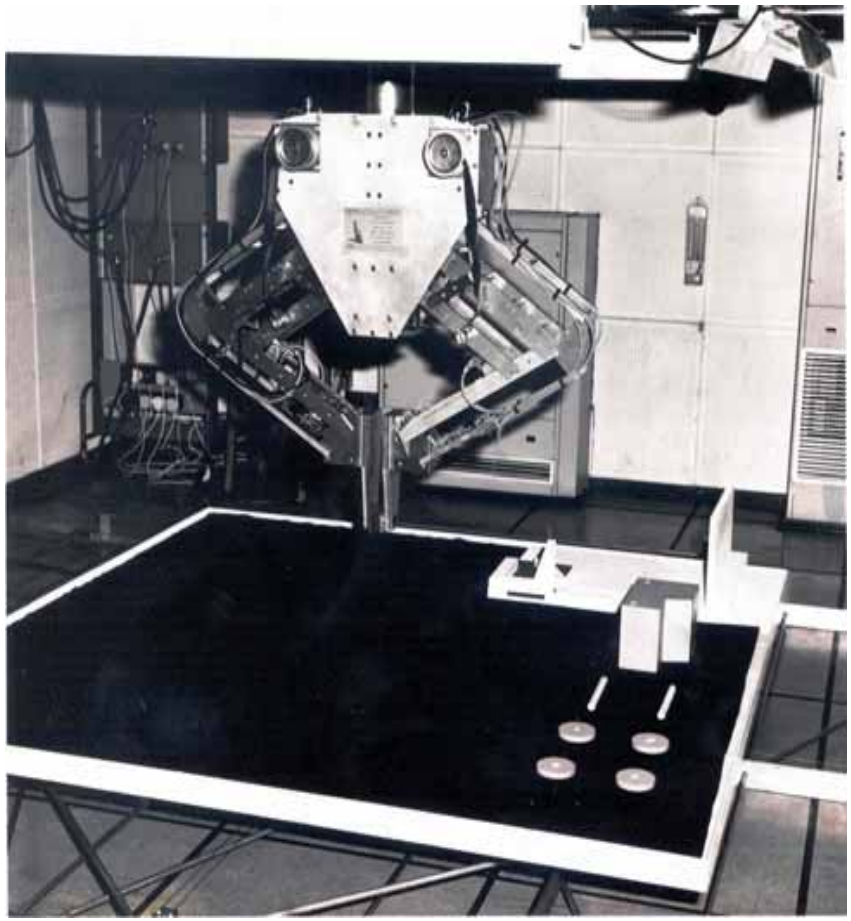
with hundreeds of academic and industrial partners

Freddy the Robot - early ‘70

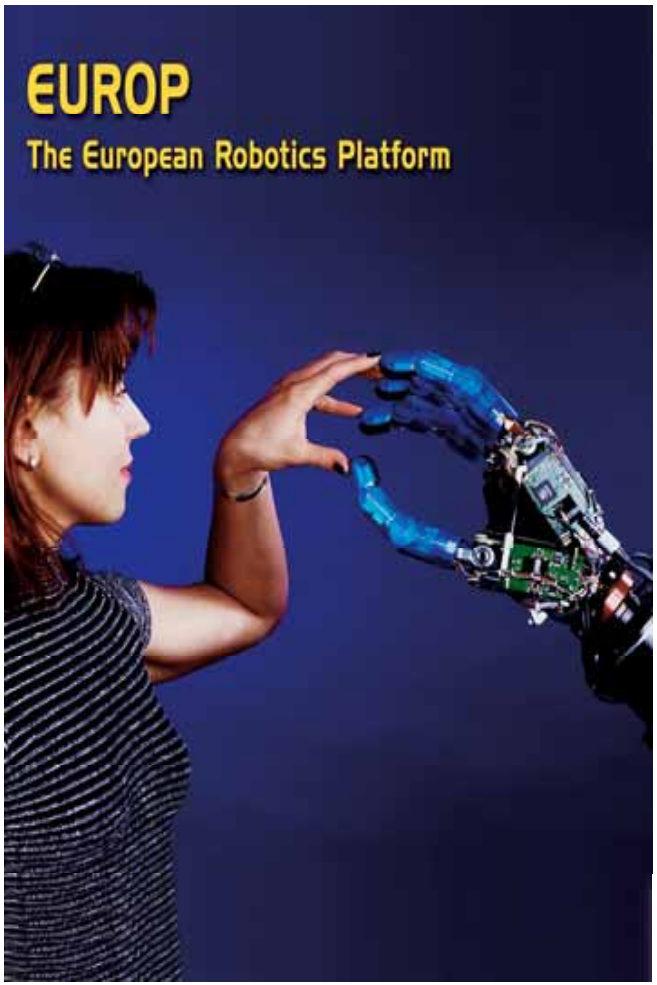
Freddy and Freddy II were the robots used in research during the 1960s and 1970s at the Dept. of Machine Intelligence and Perception (now Dept. of A.I.) at the University of Edinburgh.

Freddy II utilised a heavy robot arm fixed to an overhead gantry with adaptive grippers. A binocular vision system was also mounted to the fixed gantry.

The "world" consisted of a table that could be moved in two directions, giving the robot the impression of moving through its world.



EUROP The European Robotics Platform



- An organisation for the next generation robotics industries in Europe
- To develop new service and security markets
- To develop a European robotics supply chain

More than 50 leading european robotic industrials, and research institutes

see EUROP Strategic Research Agenda

www.robotics-platform.eu.com

EUROP Vision

- Maintain leadership in Industrial Robotics
- Take the leadership in service and security markets
- Develop a European robotics supply chain
- Ensure public and personal security
- Improve quality of life and expand scientific endeavours

From EUROP SRA document

ICT and Ubiquitous Robotics: How?

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How can Europe do research today I
n collaboration/competition with Japan?

- the Challenge 2 of the 2007-08 Work Program of the ICT Theme of EU FP7, has a specific target on “Cognitive Systems, Interaction, Robotics” with three targets:

- robots handling all sorts of objects and operating autonomously or in cooperation with people
- (networked) systems monitoring and controlling material or informational processes
- multimodal interfaces and interpersonal communication systems understanding people

Thus European scientists are strongly contributing to the Intelligent components of Small Evolutive Walking Robots (SEWARs)

Robot Standards and Reference Architectures
Rosta - www.robot-standards.org

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- Mission: *Being a main international contact point for robot standards and reference architectures in service robotics.*

CogSys
Cognitive Systems

- Objectives:
  - Action plan for a standard defining activity
  - Action plan for a community driven open-source activity
  - Gaining international recognition as a standardizing community
  - Coordinating a set of actions initiating and preparing a set of standard defining activities on

1. Creation of a glossary/ontology for mobile manipulation and service robots
2. Specification of a reference architecture for mobile manipulation and service robots
3. Specification of a middleware for mobile manipulation and service robots
4. Formulation of benchmarks (of components, methods, middleware an architectures) for mobile manipulation and service robots

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- Orocos (Open RObot COntrol Software project)

It aims to develop an architecture-independent component-based framework, based on a Real-Time Tool-kit, and Kinematics-Dynamics, Bayesan Filtering, and Component-oriented Libraries

- Miro- University of Ulm (Germany)

Is an object oriented midleware for cooperative robotics utilizing CORBA libraries

- Roboframe - *University of Darmstadt (Germany)*

Is a framework for allowing different heterogeneous robots to cooperate for different tasks

An Inexpensive, Off-the-Shelf Platform for Networked Embedded Robotics

Mirko Bordignon mirko.bordignon@ieee.org

Enrico Pagello epv@dei.unipd.it

Alessandro Saffiotti alessandro.saffiotti@aass.oru.se

Intelligent Autonomous Systems Lab., Dept. of Information Engineering
University of Padova, Italy

Mobile Robotics Lab., AASS Research Center
Örebro University, Sweden

Proc. of the Int. Conf. on Robot Communication and Coordination (RoboComm). Athens, Greece, 2007

The vision: towards *truly* ubiquitous robotics

What if we could *easily* equip everyday objects with computation, communication, sensing and actuation means ?

- from simple artifacts to networked robotics appliances
- enabling smart environments through cooperation

From "ubiquitous computing" to "ubiquitous robotics", *but* ...

... to further progress, we need proper experimental tools

what do we mean by "easily" ?

the ideal tool has to be:

- cheap (massive deployments !)
- small, to target even small-scale objects
- standardized, and ideally plug-and-play ...

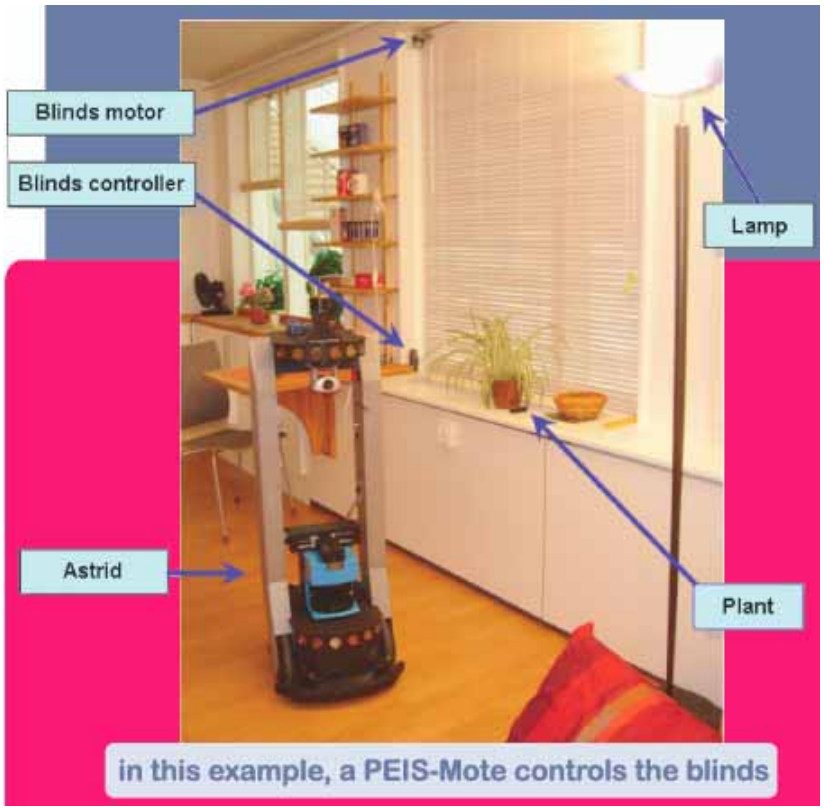
Wireless Sensor Networks (WSNs) address several of these issues ...

- small-size, low-power, low-cost platforms ("motes", "networked embedded devices")
- proper software support to cope with tight resources and complex applications

... but with some drawbacks:

- little support for actuators (limited I/O and interfacing capabilities)
- leaned towards self-contained platforms, not primarily meant for expandability

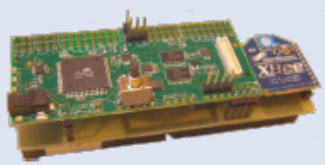
Application example in Peis Ecology

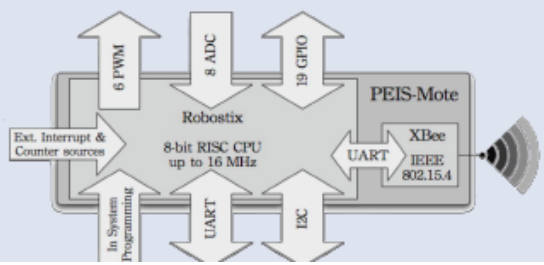


extending the scope of ubiquitous robotics beyond conventional mobile robots :

networked embedded devices controlling home appliances (*networked embedded robots*) successfully cooperate among them and with standard robots in a *robotic ecology*

Introducing the *PEIS-Mote* :
a cheap, open, general purpose sensor-actuator embedded platform





based on widely available, commercial off-the shelf HW

Gumstix Robostix (robotics breakout board)
+
MaxStream XBee (wireless transceiver)

- People: 3 faculty (1 Full Prof. , 1 Assistant Prof., 1 more Assistant Prof. in Vicenza Campus), 3 PhD Students, about 12 Master Students
- Research lines:
  - Multi-robot systems
  - Distributed vision systems
  - Humanoid robotics
- Funds: 207 KEuro (UniPD, MIUR, ENEA, Industry), in the last 5 years
- Publications: more than 20 journal papers, 50 conf. book chspters in the last 5 years

ART and Technology for people's entertainment

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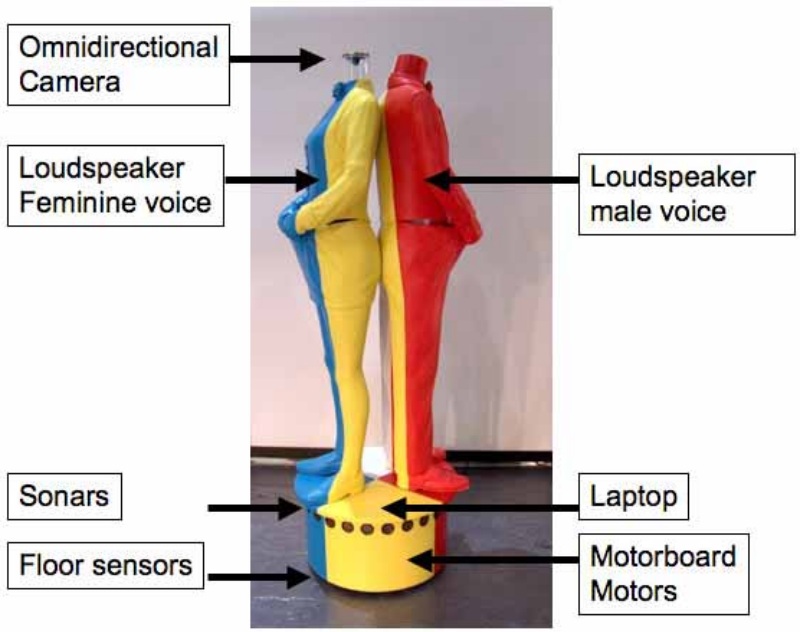
- The robot moves around looking for people for creating interaction
- It detects human skin through its vision sensors
- It avoids obstacles through its sonars and speaks with humans

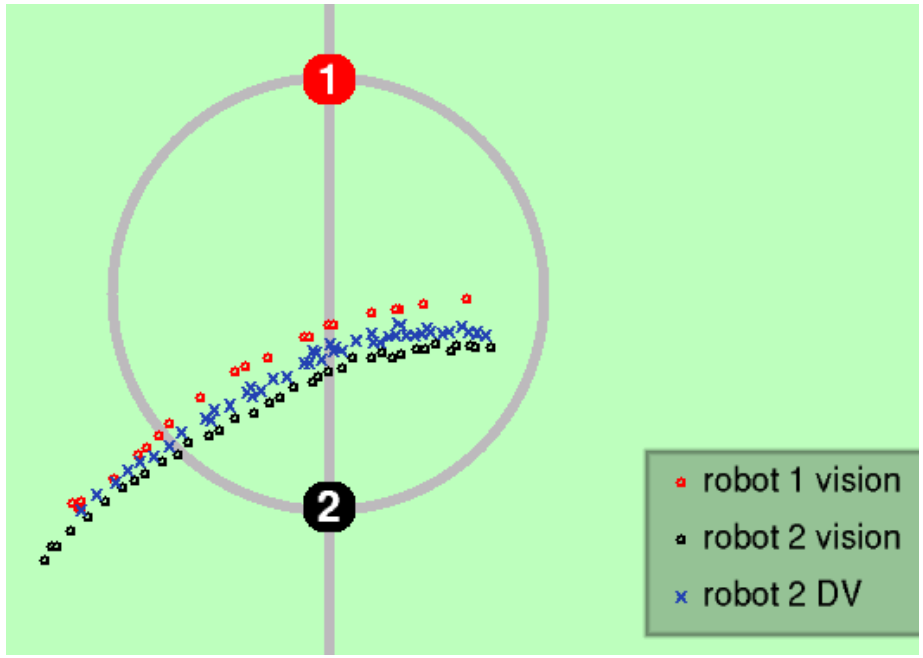
IEEE/ICRA-2007 Videoproceedings



An experiment upon a call from the artist Albano Guatti

Fusing multiple observations

- Every robot shares its measures
- Every robot fuses all measures received by teammates
- Measures can refer to different instants in time

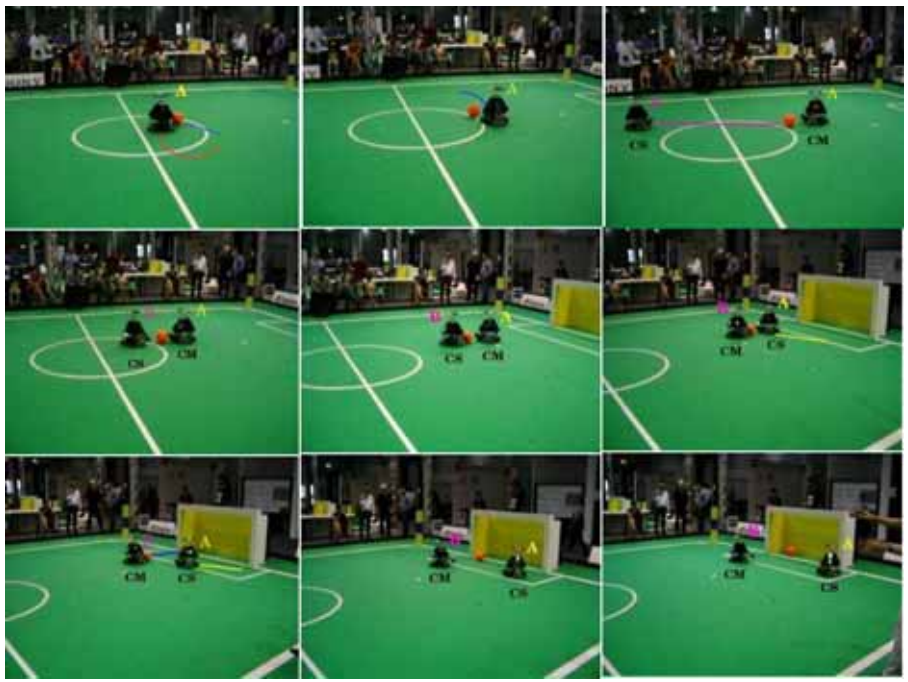


A Ball moving between steady robots

E. Menegatti, A. Scarpa, D. Massarin, E. Ros, E. Pagello
Omnidirectional Distributed Vision System for a Team of Heterogeneous Robots.
IEEE Workshop on Omnidirectional Vision (Omnivis'03),
Computer Vision and Pattern Recognition (CVPR 2003) Madison, Wisconsin (USA) 2003

MSL RoboCup Challenge Competition

A Role Exchange between attacker and supporter of Artisti Veneti Team, during MSL Challenge Competition at RoboCup-2003, in Padova



A. D'angelo, E. Menegatti, E. Pagello *How a cooperative behaviour can emerge from a robot team.* R. Alami, H. Asama, R. Chatila Eds., Proc. of Int. Conf. on Distributed Autonomous Systems (DARS-2004), Toulouse (Fr), June 2004

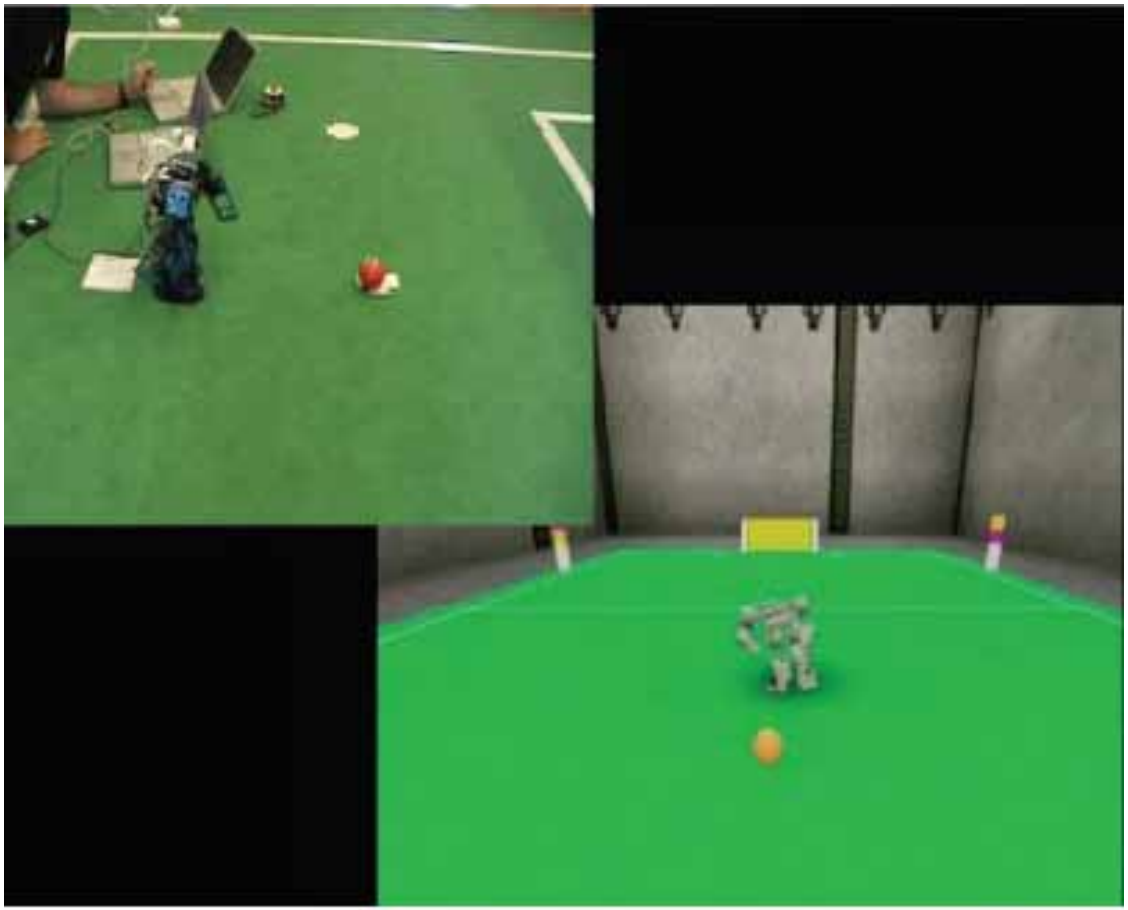
A two players coordination challenge

We can combine distributed sensoring processing with cooperation capability to perform tasks from an emergent approach

- Dynamic Role Allocation makes a collective behavior to emerge inside a a robot team
- Attacker, Supporter and Defender Roles are allocated among the team members by arbitrating among competitive behaviors
- Team coordination is obtained by incorporating some conditions depending on messages coming from other robots, when the condition is evaluated based on distributed sensors interpretation

E.Pagello, A. D'Angelo, E. Menegatti Cooperation Issues and Distributed Sensing for Multi-Robot Systems IEEE Proceedings

Applying Simulated Program to the Real World



Penalty kick in open look (no vision feedback)

Ego-centric versus exo-centric views

It is possible to watch:

- the robot walking from an ego-centric view *(small window)*
- the robot's itself view from an exo-centric view *(small window)*

N. Greggio E. Menegatti, G. Silvestri, E. Pagello *Simulation of Small Umanoid Robots for Soccer Domain,* submitted on 2007 to Journal of Franklin Institute

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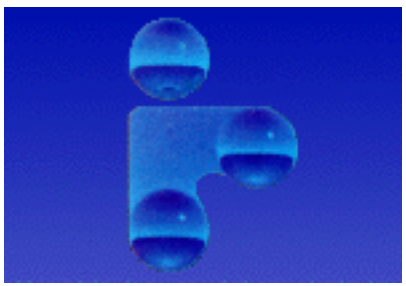
IT+Robotics

A Spin-off of the University of Padua, Italy



ASSOCIAZIONE ITALIANA DI ROBOTICA E AUTOMAZIONE

TELECOM ITALIA FUTURE CENTRE

IAS-Lab, University of Padua, Italy

IsIB cnr ingegneria biomedica

Scientific cooperation with Japanese Universities

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IAS-Lab exchanged scientitists and students with:

Tokyo-Yokohama area

- University of Tokyo, Dept. of Systems Innovation, Tamio ARAI and Jun OTA (since 1994 up today)
- Keio University, Systems Design Dept., Kohei ONISHI (on 1991), Kazuo YOSHIDA (since 2001 up today)
- Tokyo Institute of Technology, Graduate School of Science and Engineering, Daisuke KURABAYASHI (since 2006 up today)
- Toyo University, Dept. of System Robotics, Akihiro MATSUMOTO (on 2004)

Other regions

- University of Osaka, Dept. of Adaptive Machine Systems, Minoru ASADA (on 2003), Hiroshi ISHIGURO (since 2001 up today)

International Meetings organized in collaboration with Japanese Universities

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IAS-Lab and University of Padua organized the following meetings in Italy with the help of Japanese partners:

- IAS-6-2000, Sixth Int. Conference on Intelligent Autonomous Systems, held at Giudecca Island, in the city of Venice, and Padua, July 2000 - 108 paper + 32 posters - 200 part.
- RoboCup-2003, VII Int. RoboCup Competitions and Symposium, held at Padova Fiere and at Padua University, on July 2003 - 1243 part., 42 Teams
- JSPS/CNR Italy-Japan 2003, A Italy-Japan Bilateral Seminar on "Emergence of Intelligent Behavior and Cognitive Develpoment through Multi-robot Interactions", Padua, July 2003 - 20 part.
- Humanoid/Soccer-2006, First Workshop on Humanoid Soccer Robots, Genoa Dec. 4, 2006 - 20 part.
- Mobiligence-2007, Int. Workshop on Emergence of Adaptive Motor Function through Interaction among the Body, Brain, and Environment, Vicenza Campus of University of Padua, April 4-6, 2007
- SIMPAR-2008, Int. Conference on Simulation, Modelling and Programming for Autonomous Robots, Venice Nov.3-7, 120 participants expected (Invited Speakers prof.s Ishiguro and Yoshida)

Thanks for Your Attention!

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IAS-Lab, University of Padua, Italy

The Artisti Veneti Team

www.dei.unipd.it/~robocup