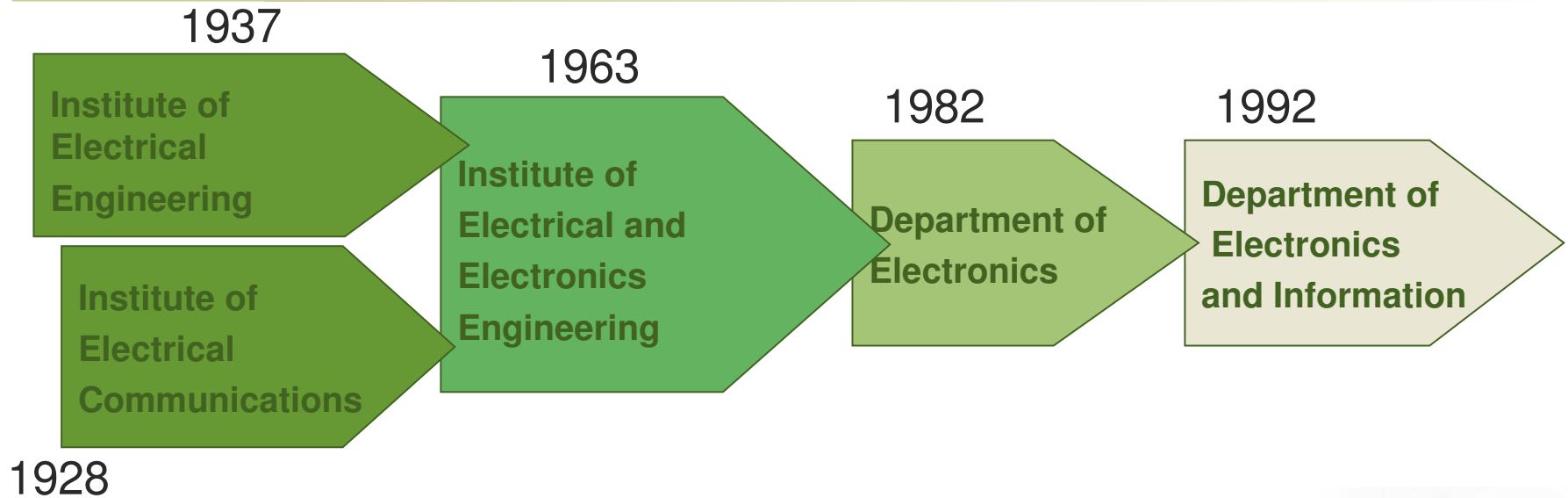# AI & ROBOTICS LAB – Politecnico di Milano

Matteo Matteucci – RoSta Meeting – 04-05/07/2007

Dept. of Electronics and Information

1937

Institute of Electrical Engineering

1963

Institute of Electrical and Electronics Engineering

1982

Department of Electronics

1992

Department of Electronics and Information

Institute of Electrical Communications

1928

- At present DEI:
  - Offers 500 courses for Bachelor and Master degrees in 6 of the 9 Politecnico Schools.
  - Supports research and teaching through more than 30 research labs and 15 teaching labs
  - More than 600 people: 157 faculty members, 45 administrative and technical staff, 105 post-doc, 134 Ph.D students, 83external professors.

Artificial Intelligence and Robotics Lab

- Laboratory active since 1973

- 11 senior researchers, 10 Phd Students, more than 60 Master theses/year

- Master Track with more than 10 AI&R courses

- Industrial and agency funded projects

- Main research areas:
  - machine learning and intelligent data analysis
  - autonomous robots
  - artificial vision and sensors
  - autonomous agents
  - knowledge-based systems
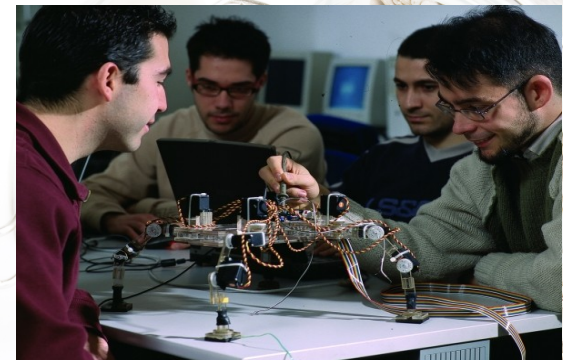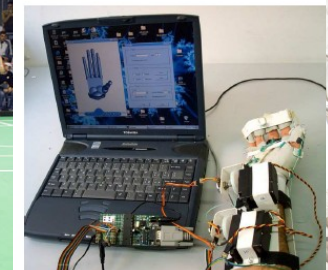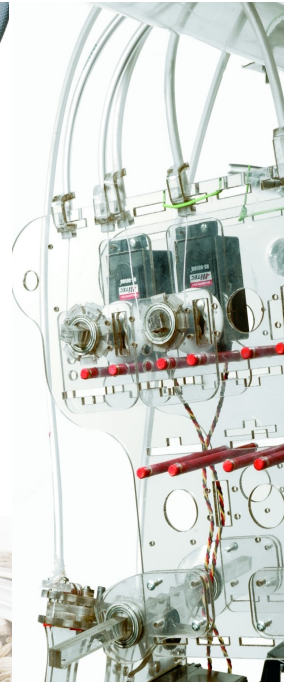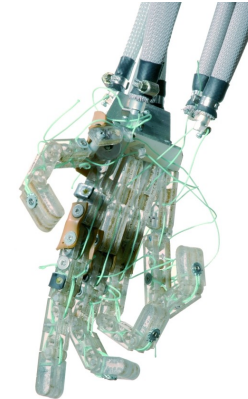
Autonomous Robots Design
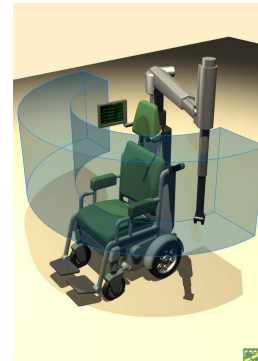
- **Development of robots**
  - Robotic arms
  - Wheeled robots
  - Bio-inspired robots (humanoids)
  - Haptic interfaces
- **Applications**
  - Service robots
    - material delivery
    - guidance
    - surveillance
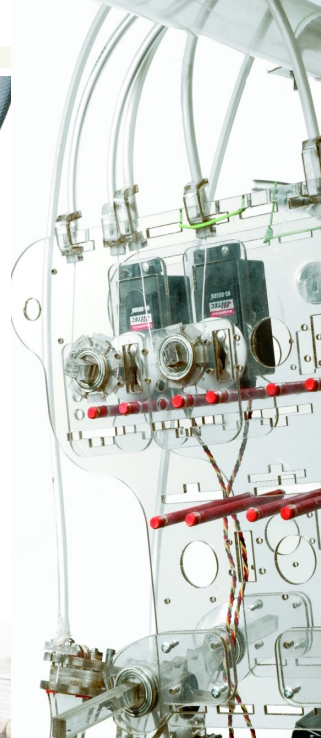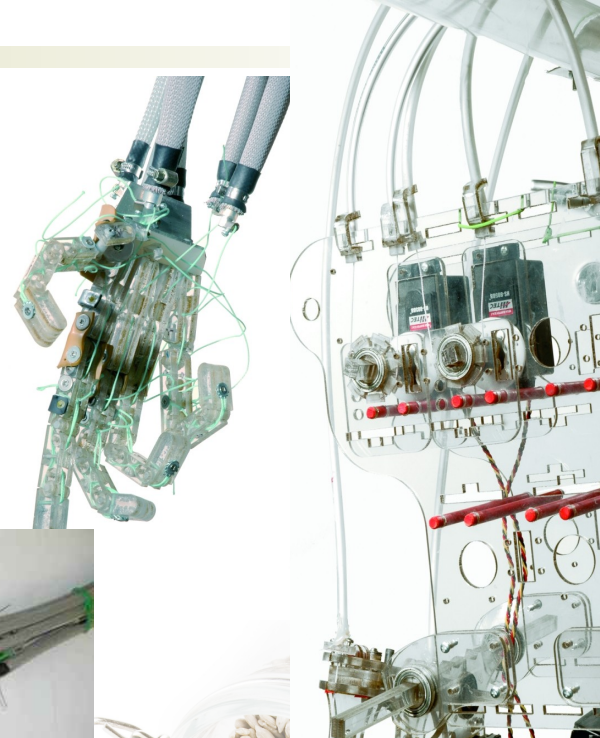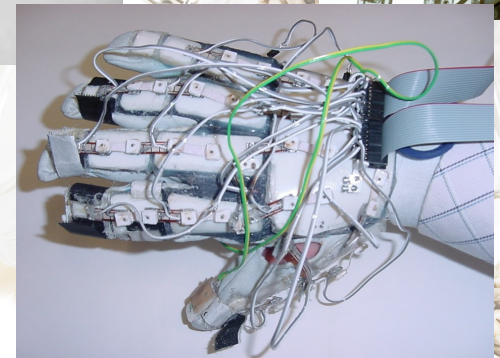   - support to impaired people
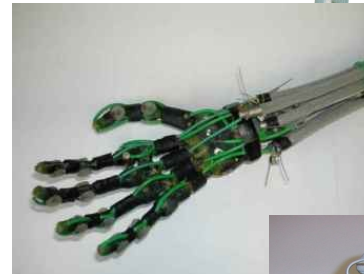   - sensor networks ...

- **Edutainment**
    - Robocup (soccer robots)
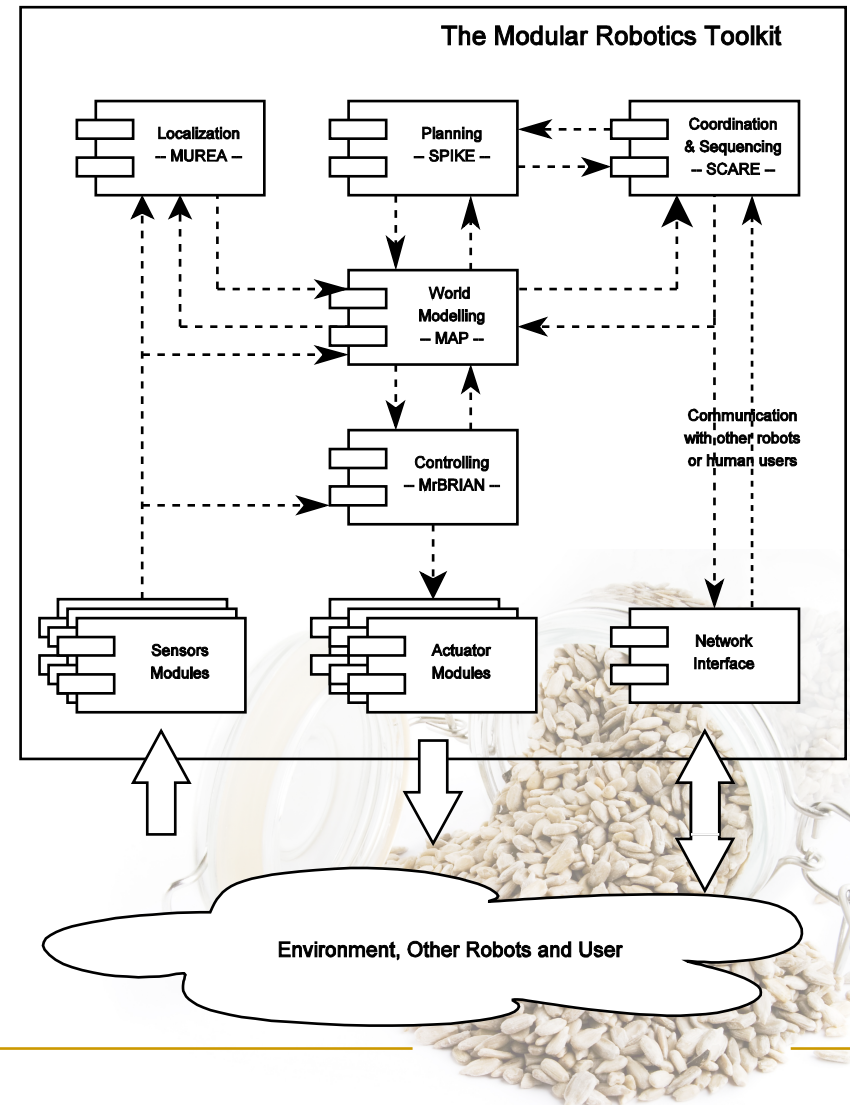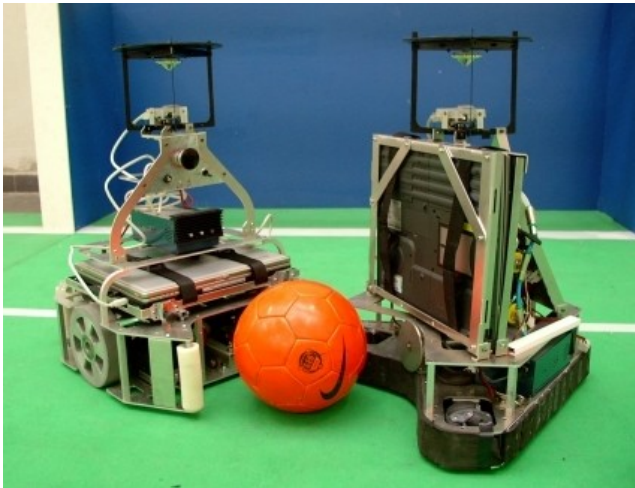   - Lego robots for education

Bio-inspired Robots

- Robots inspired to nature both for movement generation and control
  - Humanoid arm and hand
  - Humanoid legs
  - Haptic glove with force feedback
  - Quadruped
  - …

Control architecture for mobile robots

- Modular architecture to integrate
  - Behavior management
  - Sensor fusion
  - Strategy management
  - Multi-robot coordination
- Module reuse and specialization
- Rapid development

The Modular Robotics Toolkit

Localization – MUREA –

Planning – SPIKE –

Coordination & Sequencing – SCARE –

World Modelling – MAP –

Controlling – MrBRIAN –

Communication with other robots or human users

Sensors Modules

Actuator Modules

Network Interface
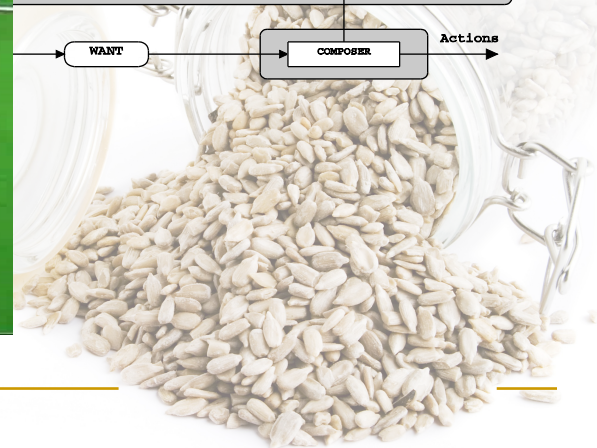
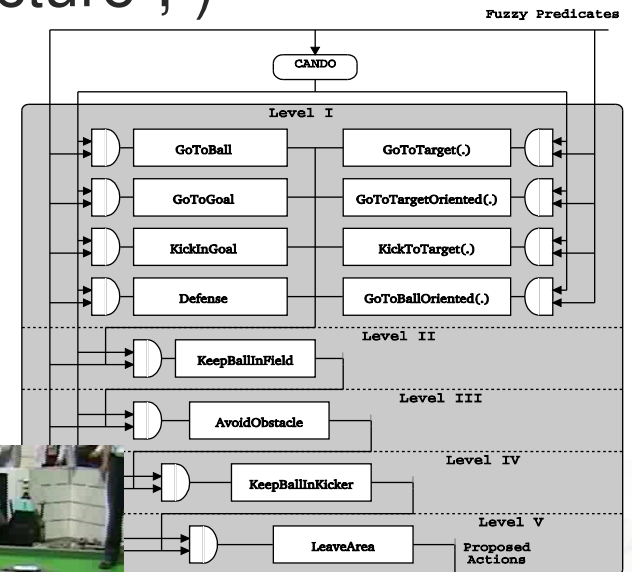Environment, Other Robots and User

Behavior Management System

- **Yes! Another behavior based architecture ;-)**
  - Behaviors as fuzzy rule bases
  - Hierarchical informed composition
  - High level programming of rather complex behaviors …
  - … but winning may require more …

Sensor networks with mobile robots

- In many applications of sensors networks a key point becomes: "**who goes where**"

- Main issues:
  - **Mapping**: acquiring spatial models (maps) of physical environments
  - **Localization**: determining the pose of robots in a map
  - **Target determination**: identifying potentially interesting target poses
  - **Task allocation**: (sub)optimally assigning target poses to robots

- We developed control strategies for single and multiple robots to acquire maps of environments.

- Applications: environmental monitoring, surveillance, ambient intelligence, …
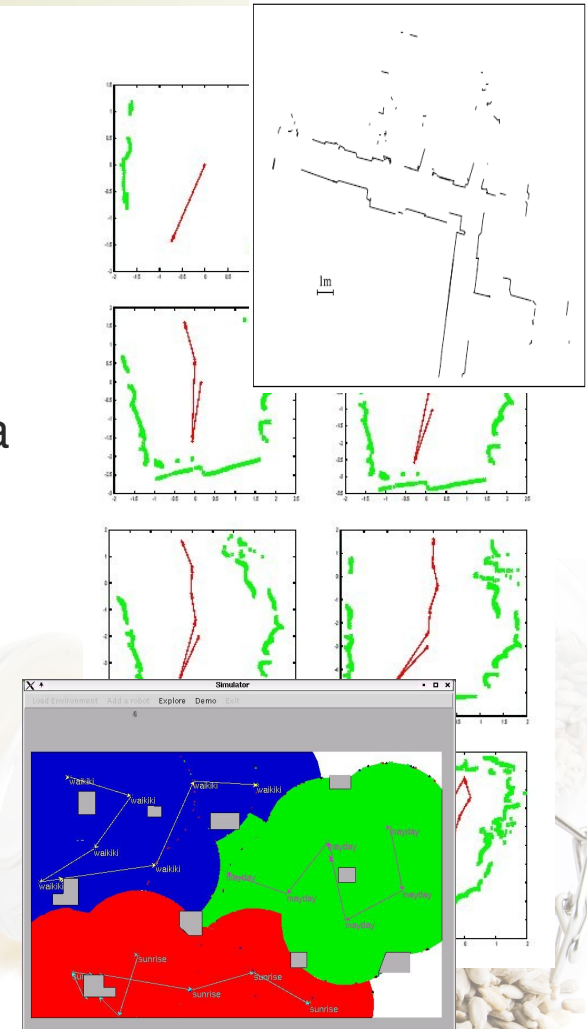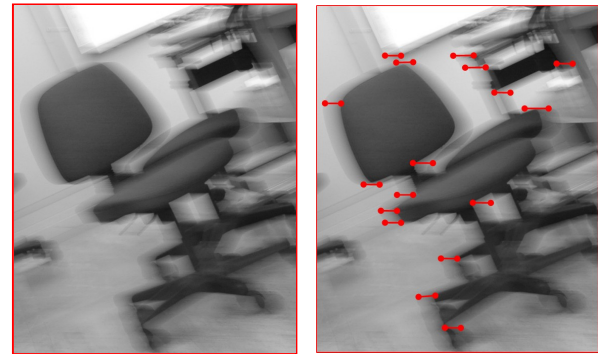
World modeling

- Sensors (Sonars, artificial nose, infrared, laser, …)
- Computer vision:
    - Frontal view
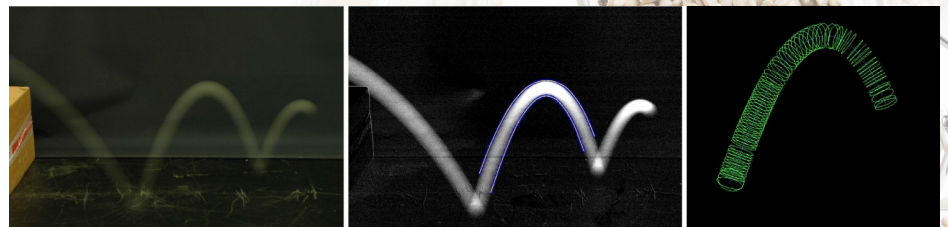   - Stereovision
    - Omnidirectional vision
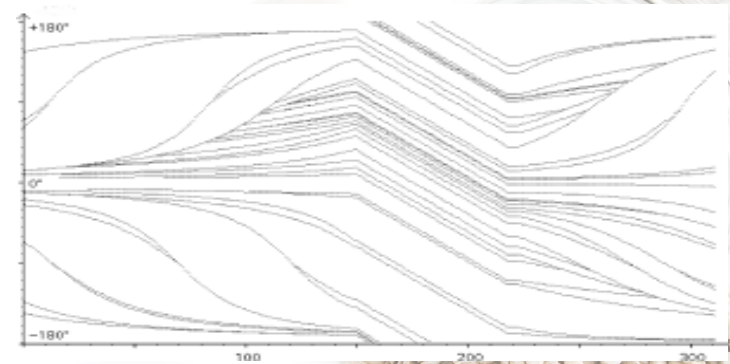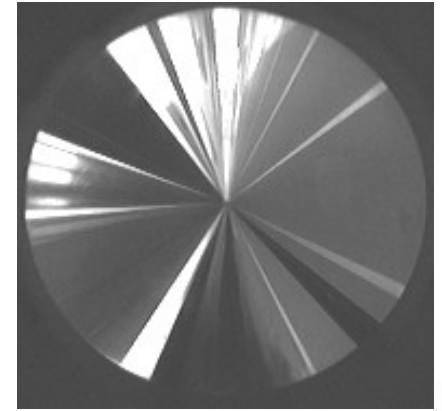
Computer vision

- Motion blur analysis
- Tracking of objects
- Object detection and visual measurement

3D camera motion understanding from blurred image

Trajectory reconstruction from blurred images

RAWSEEDS: Robotics Advancement through Web-publishing of Sensorial and Elaborated Extensive Data Sets

Politecnico di Milano – Matteo Matteucci
University of Freiburg – Wolfram Burgard
Università di Milano-Bicocca – Domenico G. Sorrenti
Universidad de Zaragoza – Juan Domingo Tardos

What is RAWSEEDS ?

- EU Funded Project in the VI Frame Program from the 1st of November 2006 to April 2009

- A Specific Support Action to collect and publish a benchmarking toolkit for (S)LAM research

- Involved Institutions:
  - Politecnico di Milano (Italy – Coordinator)
  - Università di Milano-Bicocca (Italy – Partner)
  - University of Freiburg (Germany – Partner)
  - Universidad de Zaragoza (Spain – Partner)

Benchmarking Beyond Radish

Nowadays we feel the lack of tools and methods to *compare* and *evaluate* market strength products. To aim at this we foster publishing of:

- Extended multi-sensor data sets for the testing of systems on real-world scenarios
- Benchmarks and methodologies for quantitative evaluation and comparison of algorithms/sensors
- Off-the-shelf algorithms, with demonstrated performances, to be used for research bootstrap and comparison.

The RAWSEEDS Activities

- Definition and collection of benchmarks and methodologies for the assessment/comparison of algorithms for (S)LAM

- Creation of a website from which researchers and companies will be able to download these benchmarks, contribute new material and communicate with each other.

- Dissemination of knowledge about the RAWSEEDS benchmarks and the website

www.rawseeds.org
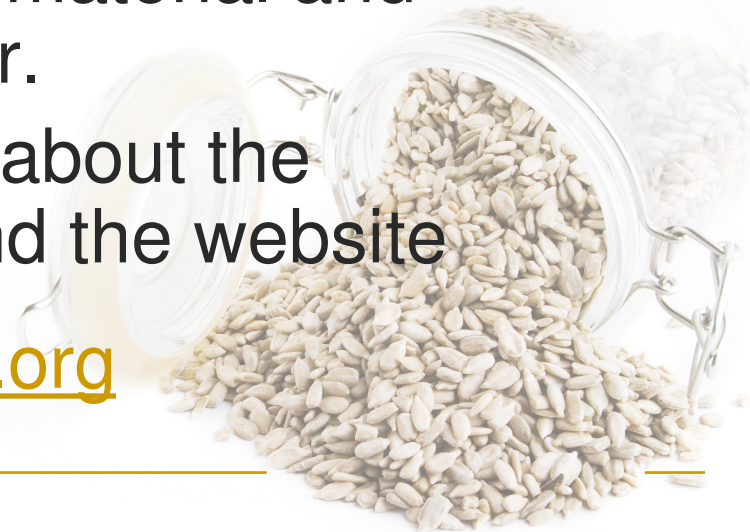
Benchmarks Problems & Solutions

The RAWSEEDS Toolkit is obtained by the combination of Benchmark Problems (BP) and Benchmark Solutions (BS).

Benchmark Problems aim at testing algorithms and include detailed:

- Description of the task
- Multi-sensor Data Set related to the task
- Evaluation Methodology and Tools agreed by the community

Benchmarks Problems & Solutions

Benchmark Solutions (BS) extend BPs with:

- Description of the algorithm for solving the BP and possible implementation (src or binary)
- Algorithm output on the BP dataset
- Evaluation (using the BP methodology)

You can contribute with:

- Discussion on the RAWSEEDS forum
- The definition of evaluation methodology
- A solution (BS) for a Benchmark Problem
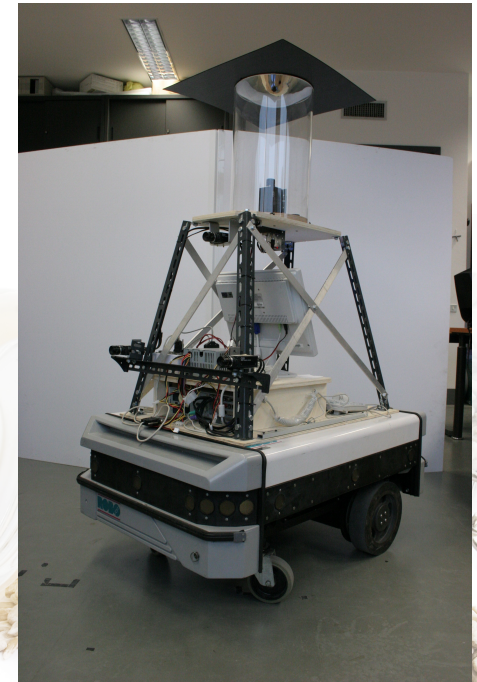
RAWSEEDS Sensor Suite

- **Use of an extensive sensing suite**
  - B/W + Color cameras (mono/stereo)
  - 3D cameras
  - LRFs (2D)
  - Omnidirectional camera
  - Sonars
  - GPS and D-GPS
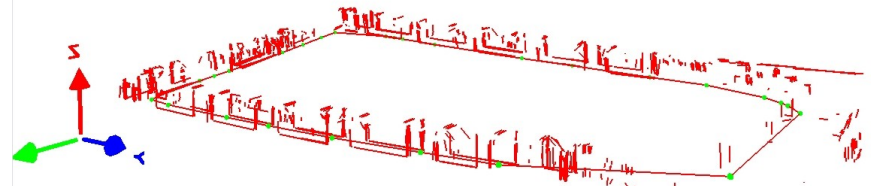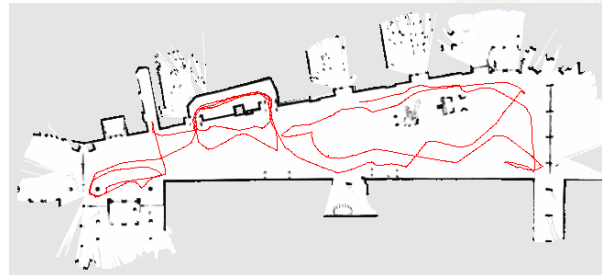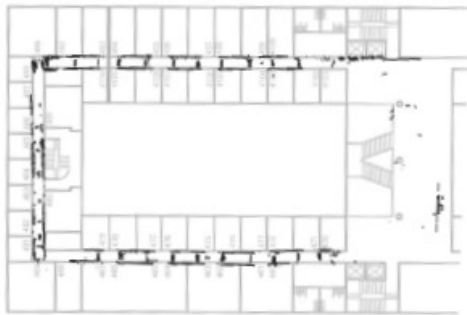 - Other proprioceptives (odometry, gyros)

RAWSEEDS Scenarios

- Different scenarios and robot platforms
  - Indoor (e.g., office building, house, etc.)
  - Outdoor publics roads
 - Outdoor moderately rough terrain & parks

RAWSEEDS Solutions

- State of the art solutions for the tasks will be provided such as:
  - Ground truth and planimetry
  - Occupancy grids and 2D maps
  - Full 3D maps

RAWSEEDS Today

- **Done with the platform setup**
  - Indoor
  - Outdoor
- **Location Selected**
  - Indoor
  - Campus
  - Outdoor
- **Definition of Ground truth**
  - Ubisense for indoor position
 - RTK-GPS for outdoor position
  - Executive design of environments
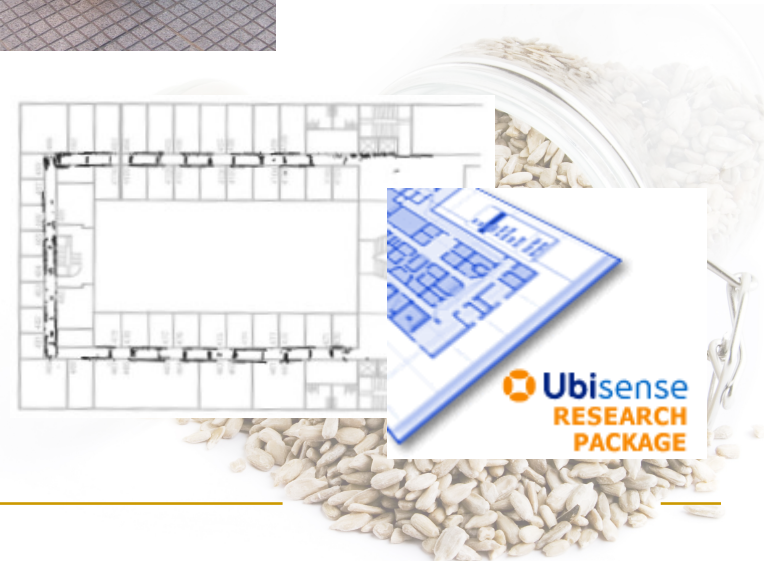
RAWSEEDS Measures

- Localization performance
  - Positioning with respect to executive plant
- Mapping performance
  - Accuracy measured with respect to laser measures of predefined landmark
- SLAM performance
  - Error in positioning before loop closure
  - Map accuracy after loop closure
  - Localization error in your map for new trajectory
- What about real-time?
  - "I got this real time algorithm that gives you a random map in zero time. Its quality to time ratio is infinite!" J.D. Tardos
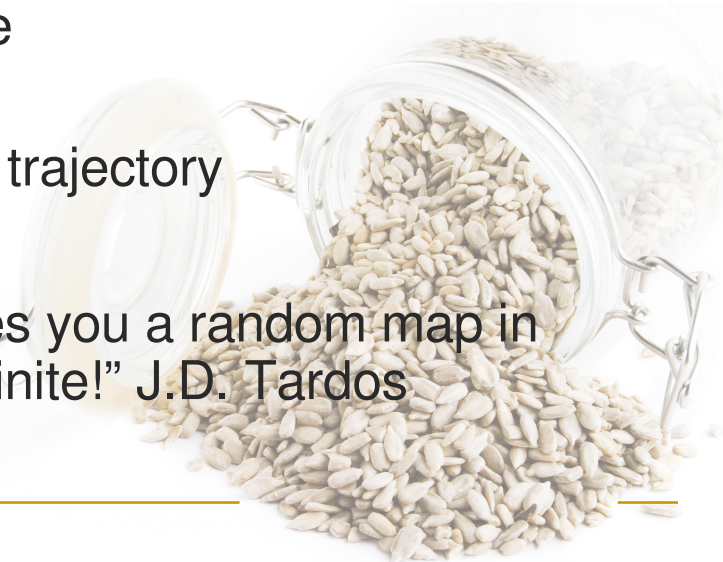
Contact RAWSEEDS

Please get in touch with us!
We need also YOUR contribution.

- info@rawseeds.org
- www.rawseeds.org