Progress on URUS:
Ubiquitous Networking Robots in Urban Settings

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WebSite

http://www-iri.upc.es/urus

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Project Objectives

- **Objectives:**

  - The main objective is to develop an adaptable network robot architecture which integrates the basic functionalities required for a network robot system to do urban tasks

- *1. Scientific and technological objectives*

  - City rules and requirements due to robots in Urban areas
  - Cooperative localization and navigation
  - Cooperative environment perception
  - Cooperative map building and updating
  - Human robot interaction
  - Multi-task allocation
  - Wireless communication in Network Robots

- *2. Experiment objectives*

  - Guiding and transportation of people
  - Surveillance: Evacuation of people

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URUS Partners

Participant Role*	Country	Participant name	Participant short name
Coordinator Research Partner	Spain	Technical University of Catalonia (Institute of Robotics) Alberto Sanfeliu	UPC
Research Partner	France	Centre National de la Recherche Scientifique Rachid Alami / Raja Chatila	LAAS
Research Partner	Switzerland	Eidgenössische Technische Hochschule Roland Siegward	ETHZ
Research Partner	Spain	Asociación de Investigación y Coop. Indus. de Andalucia Anibal Ollero	AICIA
Research Partner	Italy	Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna Paolo Dario	SSSA
Research Partner	Spain	Universidad de Zaragoza Luis Montano	UniZar
Research Partner	Portugal	Instituto Superior Técnico Joao Sequeira / Jose Santos Victor	IST
Research Partner	UK	University of Surrey John_Illingworth	UniS
Agency Partner	Spain	Urban Ecology Agency of Barcelona Salvador Rueda	UbEc
Industrial Partner	Spain	Telefónica I+D Xavier_Kirchner	TID
Industrial Partner	Italy	RoboTech Nicola Canelli	RT

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Experiment Locations

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Experiment Locations: Scenario 1

Zone Campus Nord, UPC

Zone Campus Sud, UPC

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Zone Campus Nord, UPC

Experiment Locations: Scenario 2

Zone
Gracia District

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Infrastructure for Scenario 1

Central Station

• Potential positions of cameras

Potential positions of access points (Wifi)

Potential positions of Mica2

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Some Videos of Scenario 1

Large video showing the new Segway Robot Platform for URUS developed at UPC during a data acquisition run.
Video: SANYO088.MP4 y   SmartAndSegway.mpg

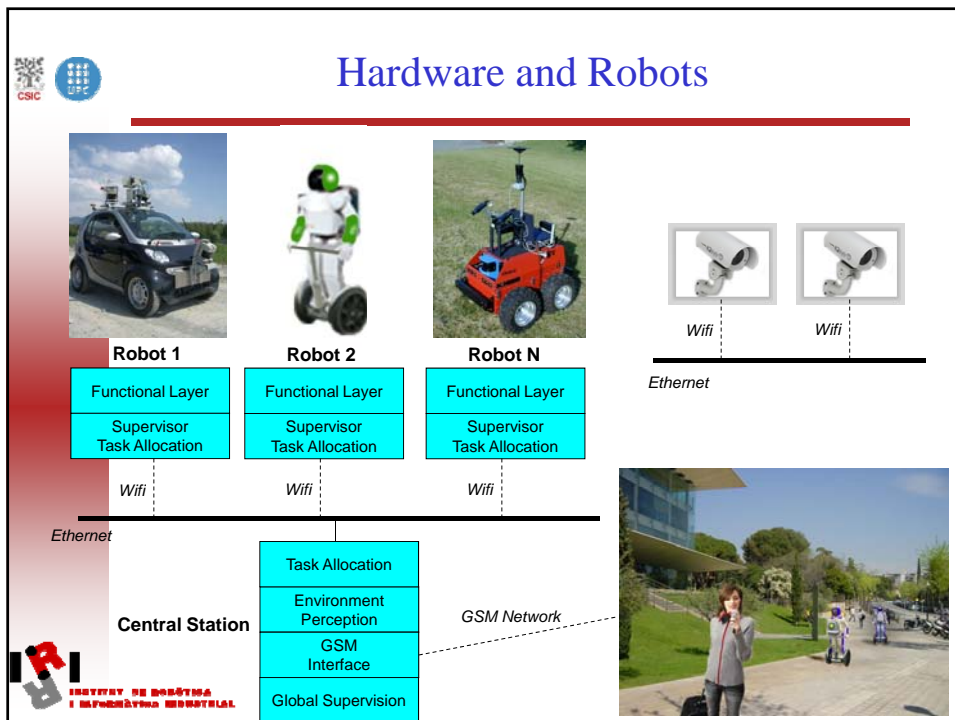IROS_NRS_Workshop_2007

Some Videos of Scenario 1

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Some Videos of Scenario 1

Laser Plot

Image Sequences

007

Hardware and Robots

Robot 1

Functional Layer

Supervisor
Task Allocation

Wifi

Robot 2

Functional Layer

Supervisor
Task Allocation

Wifi

Robot N

Functional Layer

Supervisor
Task Allocation

Wifi

Wifi

Wifi

Ethernet

Ethernet

Central Station

Task Allocation

Environment
Perception

GSM
Interface

Global Supervision

GSM Network

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Scientific and Technological Objectives

City rules and requirements due to robots in Urban areas

- **Objectives:**

  - To analyze the city requirements to use robots in urban areas, for example, easy mobility, reserve areas for robot loading and unloading, etc.

  - To study and modify, if necessary, city rules with respect to placement of sensors, robot security issues, etc.

  - To analyze and modify, if necessary, city rules with respect to people security and privacy.

  - To study city zones for pedestrians (superblocks) where the services can be given by robots.

  - To study sensor deployment in robots for measuring environment conditions

Cooperative Localization and Navigation

- **Objective:**

- To extend the navigation capabilities of the robots by:

  - Combining techniques of absolute localization
  - Using embedded and wearable sensors to localize robots and people
  - Developing centralized and distributed methods to collaboratively, move in a given area and localize robots or people
  - Integrating planning, reactive techniques and safety considerations
  - Keeping intelligent formations

in dynamic environments, in particular for urban settings.

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Cooperative Localization and Navigation

Localization using:
- GIS
- multiple robots
- ubiquitous sensors

Navigation:
- Using GIS
- Own and embedded sensors
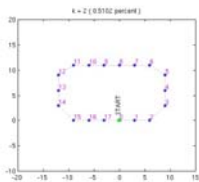
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Cooperative Localization and Navigation

Fusion of odometry and visual odometry with an information filter. [Andrade, et al. IAV2007]

Video: SLAM_29Janallfast.avi
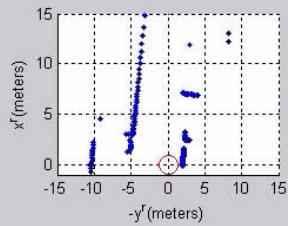

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Cooperative Localization and Navigation
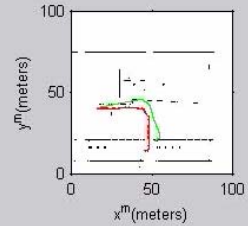
Localization of robots using GIS and laser information

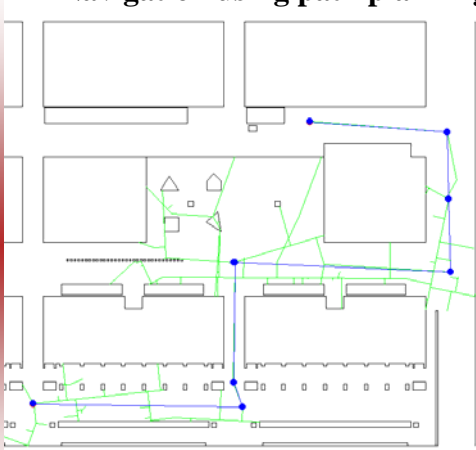IROS_NRS_Workshop_2007
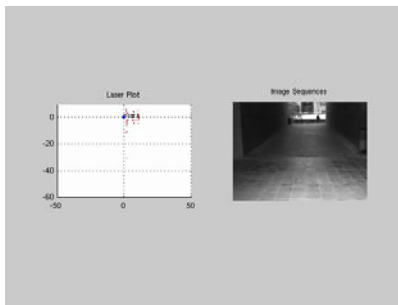
Cooperative Localization and Navigation
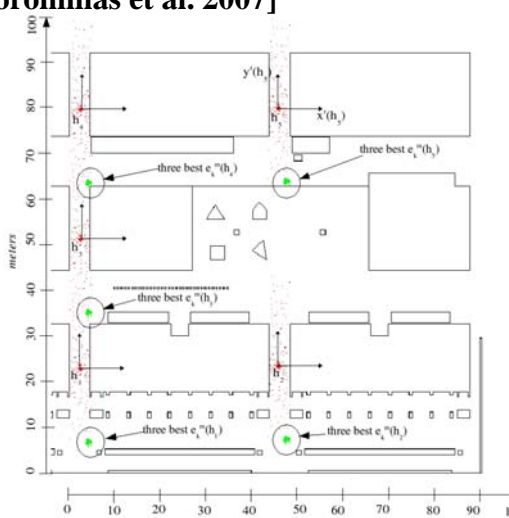
Navigation using path planning and sensor information

Navigation with laser

Path planning

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Cooperative Localization and Navigation

Auto-localization using probabilistic model [Corominas et al. 2007]

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Cooperative Localization and Navigation

Robot formation

Network connectivity

leader

Path planning
Obstacle avoidance

Slave robots
Specific motion control

Executes allocated task
Obstacle avoidance

leader

MANET

Acces
point

3 robots collaborate to maintain connectivity
Specific motion control

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Cooperative Environment Perception

- **Objective:**

  - To create and maintain a consistent view of the urban world by means of the information provided by the robot sensors and the sensors embedded in the urban environment.

    - Identification of Objects (humans and robots) in multiple cameras
    - Identification of humans in multiple cameras
    - Object Handover - Tracking humans and robots across cameras
    - Identification of events, scenario and situations

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Cooperative Environment Perception

Cooperative perception using:
- embedded and own sensors
- fusion techniques and technologies

Cooperative
environment
perception

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Cooperative Environment Perception
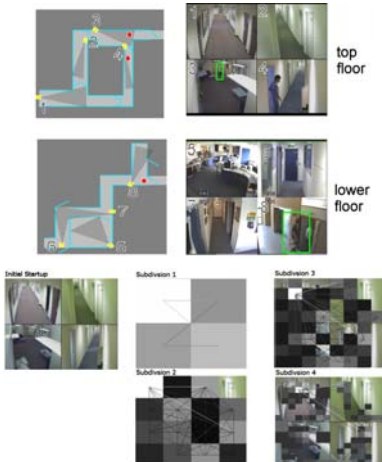
Following a person with environment cameras

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Cooperative Environment Perception

Following several persons with environment cameras

- Inter Camera – uncalibrated, non overlapping
- Learns relationships
  - Weak Cues
    - Colour, Shape, Temporal
    - Learns consistent patterns
  - Learns Entry/Exit regions
- Real Time (25fps)
- Incremental design
  - work immediately
  - improves in accuracy over time

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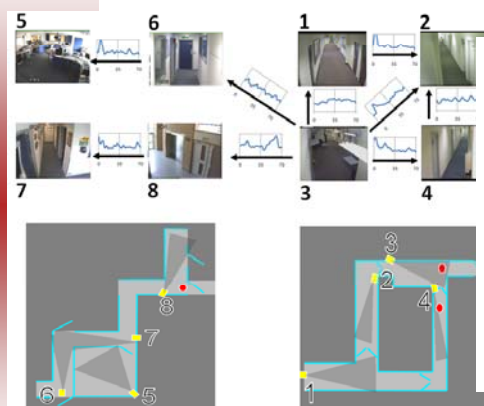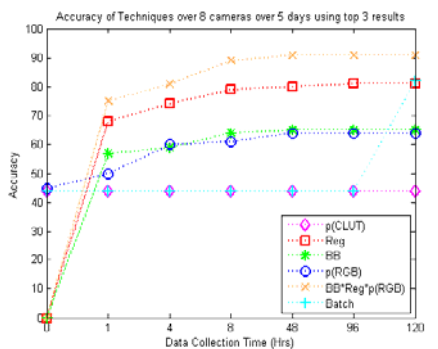
Cooperative Environment Perception

Following several persons with environment cameras

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Cooperative Environment Perception

**Eliminating shadows in a sequence of images
[Scandaliaris et al., 2007]**

Original image   **Gradient image**   **Without shadows image**

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Cooperative Environment Perception

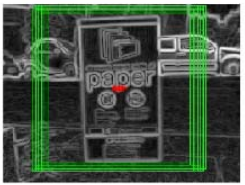**Eliminating shadows in a sequence of images
[Scandaliaris et al., 2007]**

Original image   **Gradient image**   **Detection image**

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Cooperative Environment Perception

- Homogeneus regions in scale-space: Color-blob based approach: Each blob is described by a 3d-normal distribution in RGB color space
- Without any predefined model of a person
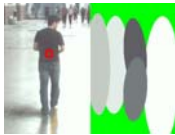- Initial startup: blob to track

Image i   Image i+1

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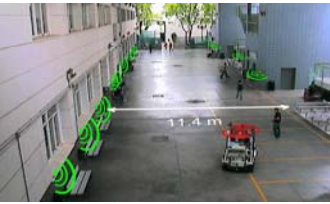
Cooperative Environment Perceptio

Relative Ranging method
- Try to eliminate effect of antenna orientation
- Suitable for static nodes approximately in the same plane
- Triangulation using a non-linear least-square method
– Experiments
– ROMEO 4R autonomous robot with onboard WSN node
– Static WSN nodes deployed on campus
  • Average distance between consecutive nodes: 7.18 m

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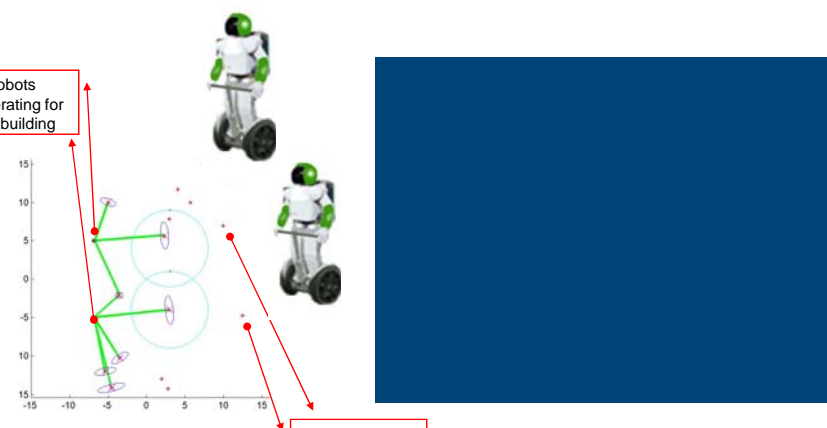
Cooperative Map Building and Updating

- **Objective:**

  - To augment the classical static Simultaneous Localization and Map Building (SLAM) problem to deal with dynamic environments, and to be cooperative using not only a troupe of robots, but all the different elements of the NRS.

    - Various map layers to be exploited during operational phases for localization and navigation purposes.
    - Incidentally, some map-based localization algorithms that can be of use in the project. At least for the set of robots used to build the map layers.
    - The positions and calibration of the camera sensor network.

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Cooperative Map Building and Updating

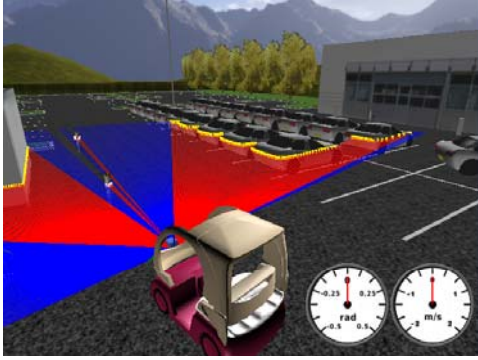Robots cooperating for map building

Land marks

Cooperative SLAM:
• Using multiple robots and sensors
• Using control techniques

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Cooperative Map Building and Updating
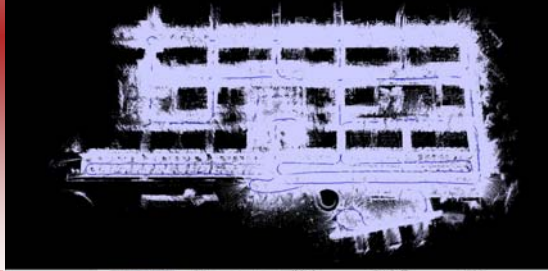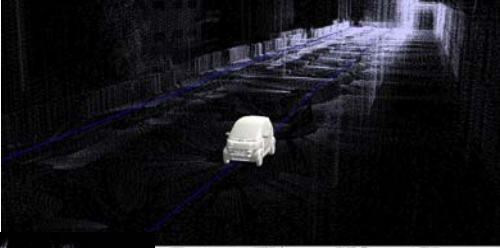
3D Map construction using laser beams

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Cooperative Map Building and Updating

3D Map construction using laser beams

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Human Robot Interaction

● **Objective:**

  ● To develop a series of tools to have a robust communication interface between robots and persons

    ● Develop a user friendly and robust communication scheme

    ● Develop a robot head able to generate neck and head motion and facial expressions

    ● Develop expressive motions that the robots will use to convey meanings to people

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Human Robot Interaction

Human robot interaction:
• Combining mobile phones, voice, touch screen

Communication by voice and touch screen

Communication by voice

Communication between robots and humans trough the mobile phone

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Human Robot Interaction

Fig.2: Interaction between the user and the robot across different distances

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Human Robot Interaction

Design and features of the head

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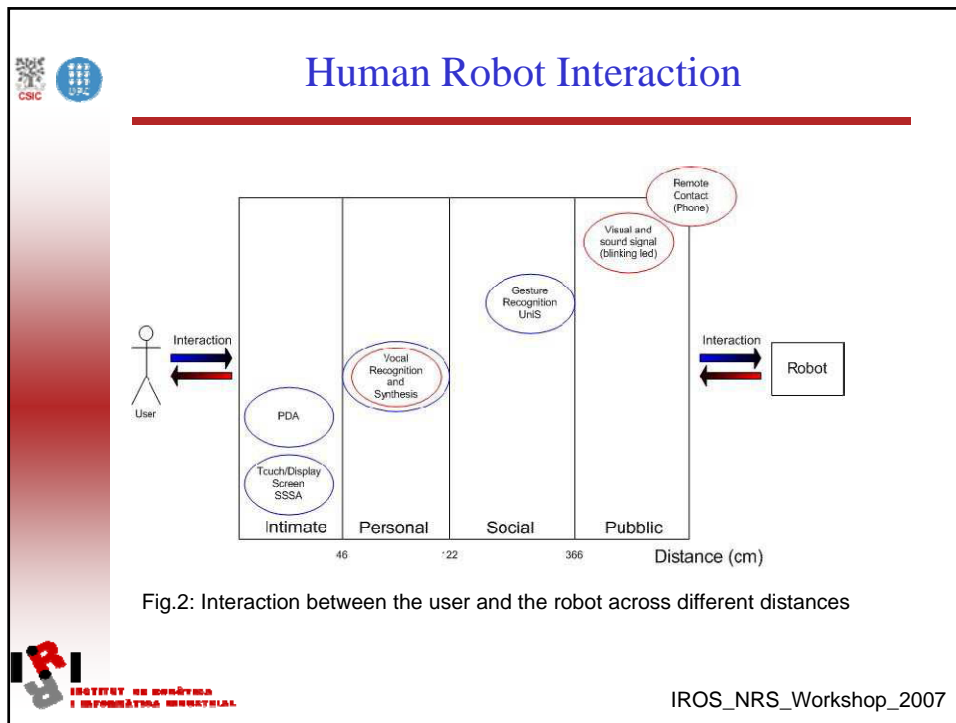
Multi-task Allocation

- **Objective:**

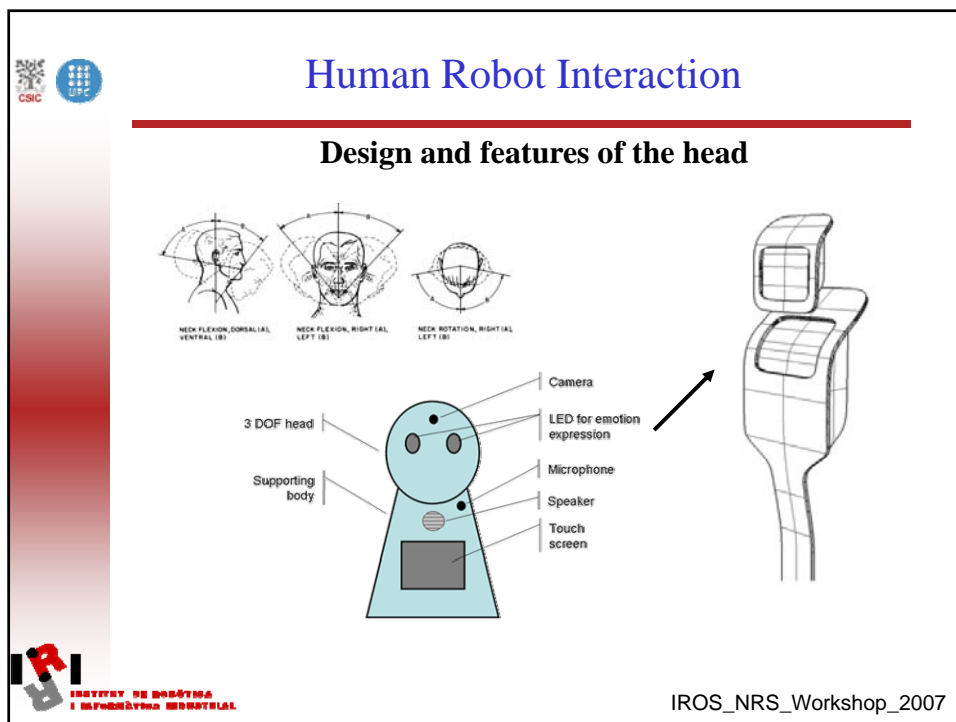 - The objectives are oriented to the Experiments that will be done in the project.

    - Surveillance:
      - Detecting abnormal situations: possibility of camera detection of crowds, fires or people in the ground.
      - Coordinating and evacuation of a group of people
    - Transportation and guiding of people
      - Transporting: People or cargo is loaded at a meeting point, and transported to a requested unload location.
      - Guiding: A person is lead by a robot to a desired location or transferred to another robot that will continue the guiding, until the final destination is reaches
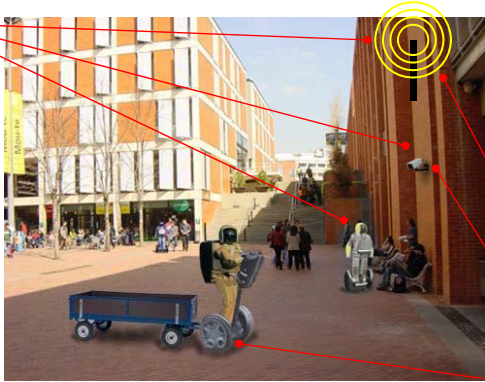
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Multi-task Allocation

Multi-task negotiation:
- Using sub-optimal techniques
  for multi-system task allocation

Multi task
negotiation for
assistance

Multi task
negotiation for
transportation

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Wireless communication in Network Robots

● **Objective:**

- To establish a robust wireless communication between robots, humans, sensors and other systems.

- To improve the communication recovery for robots and humans.

- To establish a common wireless interactive language and protocol for the communication between humans (by means of mobile phone), robots and ubiquitous sensors.

Wireless communication in Network Robots

Wireless communication:
- Combining wireless techniques for robust communication

Wireless communication

Blue tooth communication

Experiments

- **Urban experiments:**

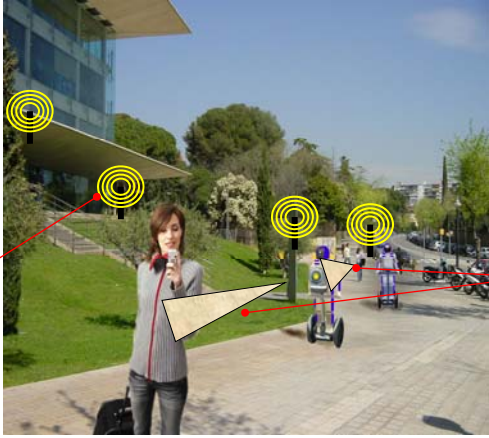 - 1.- Transportation of people and goods

    - Transporting people
      - Taxi service requested via the phone
      - User request the service directly
    - Transport object

  - 2.- Guiding people
    - Guiding a person with one robot
    - Guiding a person with two robots

  - 3.- Surveillance
    - Coordinate evacuation of a group of people

  - 4.- Map building

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Guiding and Transportation

Wireless and network communication

Cameras and ubiquitous sensors

Robots with intelligent head and mobility

People with mobile phones and RDFI

Robots for transportation of people and goods
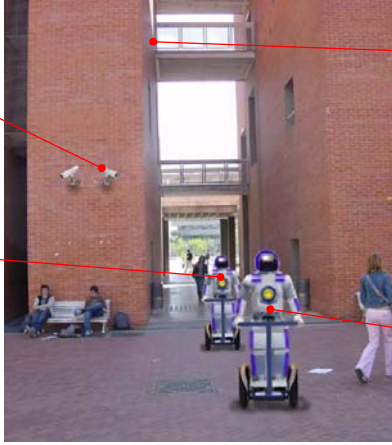
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Surveillance

Central information
system

Cameras and
ubiquitous sensors
and network
communication

Robots with
intelligent heads,
mobility and
network
communication

Robots for
surveillance

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Conclusions

- The project has just started and we have analyzed the specifications

- Between 2007 and 2008 we will develop the techniques and between 2008 and 2009 we will do the experiments

- The project face several problems, for example
  - The development of cooperative techniques among heterogeneous robots
  - Working with technologies that still do not allow to solve problems in dynamic and outdoors scenarios (communication, dynamic range of the cameras, etc.)
  - Robot-human interaction in outdoors scenarios

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Some References

Sanfeliu and J. Andrade-Cetto, *Ubiquitous networking robotics in urban settings*. Workshop on Network Robot Systems. Toward Intelligent Robotic Systems Integrated with Environment. Proc. of 2006 IEEE/RSJ International Conference on Intelligence Robots and Systems (IROS2006), Beijing, China, Oct. 10-13, 2006.

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