Progress on URUS: Ubiquitous Networking Robots in Urban Settings

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WebSite

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

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
## URUS Partners

<table>
<thead>
<tr>
<th>Participant Role*</th>
<th>Country</th>
<th>Participant name</th>
<th>Participant short name</th>
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<tr>
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<td>Centre National de la Recherche Scientifique</td>
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<td>Industrial Partner</td>
<td>Italy</td>
<td>RoboTech</td>
<td>RT</td>
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## Experiment Locations

- **UPC Campus Nord**
- **Gràcia Superblock**
- **22@ Campus**
- **Fibbers Guellbloc” (1st block-entrance)
Experiment Locations: Scenario 1

Zone Campus Nord, UPC

Zone Campus Sud, UPC
Experiment Locations: Scenario 2

Zone
Gracia District

Infrastructure for Scenario 1

- Potential positions of cameras
- Potential positions of access points (Wifi)
- Potential positions of Mica2
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
Some Videos of Scenario 1

Hardware and Robots
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.

Localization using:
- GIS
- multiple robots
- ubiquitous sensors

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

Navigation using path planning and sensor information

Navigation with laser

Path planning

Cooperative Localization and Navigation

Auto-localization using probabilistic model
[Corominas et al. 2007]
Cooperative Localization and Navigation

Robot formation

Network connectivity

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
Cooperative Environment Perception

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

Following a person with environment cameras
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
Cooperative Environment Perception

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

Original image | Gradient image | Without shadows image

Cooperative Environment Perception

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

Original image | Gradient image | Detection image
Cooperative Environment Perception

- Homogeneous 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

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
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.

Cooperative SLAM:
- Using multiple robots and sensors
- Using control techniques
Cooperative Map Building and Updating

3D Map construction using laser beams
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

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

Communication by voice and touch screen
Communication by voice
Communication between robots and humans through the mobile phone
Human Robot Interaction

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

Design and features of the head
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

Multi-task negotiation:

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

- Combining wireless techniques for robust 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

Guiding and Transportation

- Cameras and ubiquitous sensors
- Robots with intelligent head and mobility
- People with mobile phones and RFID
- Wireless and network communication
- Robots for transportation of people and goods
Surveillance

Cameras and ubiquitous sensors and network communication

Robots with intelligent heads, mobility and network communication

Central information system

Robots for surveillance

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
Some References