URUS Project

Prof. Alberto Sanfeliu
Instituto de Robótica (IRI) (CSIC-UPC)
Technical University of Catalonia
January 7-8th, 2008
http://www.iri-upc.es/groups/lrobots

Index

- Objectives
- Partners
- Experiment locations
- Hardware and robots
- Scientific and technological issues
- Experiments
- Conclusions
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>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinator</td>
<td>Spain</td>
<td>Technical University of Catalonia (Institute of Robotics) Alberto Santonja</td>
<td>UPC</td>
</tr>
<tr>
<td>Research Partner</td>
<td>France</td>
<td>Conservatoire de la Recherche Scientifique Rachid Alami / Raja Chariya</td>
<td>LAAS</td>
</tr>
<tr>
<td>Research Partner</td>
<td>Switzerland</td>
<td>Technische Universität München Roland Siegwart</td>
<td>ETHZ</td>
</tr>
<tr>
<td>Research Partner</td>
<td>Spain</td>
<td>Asociación de Investigación y Cooperación Andaluza AbelOlmo</td>
<td>AKIA</td>
</tr>
<tr>
<td>Research Partner</td>
<td>Italy</td>
<td>Scuola Superiore di Studi Universitari e di Perfezionamento Sant’Alessandro Paolo Dario</td>
<td>SSSA</td>
</tr>
<tr>
<td>Research Partner</td>
<td>Spain</td>
<td>Universidad de Zaragoza Luis Montano</td>
<td>UozZ</td>
</tr>
<tr>
<td>Research Partner</td>
<td>Portugal</td>
<td>Instituto Superior de Tecnologia Jean Sagreras / Jose Santos Vicente</td>
<td>IST</td>
</tr>
<tr>
<td>Research Partner</td>
<td>UK</td>
<td>University of Surrey John Burgeson</td>
<td>UozS</td>
</tr>
<tr>
<td>Agency Partner</td>
<td>Spain</td>
<td>Urban Ecology Agency of Barcelona Salvador Rodas</td>
<td>UMC</td>
</tr>
<tr>
<td>Industrial Partner</td>
<td>Spain</td>
<td>Teléfonica FDI Xavier Kirchner</td>
<td>TBD</td>
</tr>
<tr>
<td>Industrial Partner</td>
<td>Italy</td>
<td>RTRoboTech Nicola Canelli</td>
<td>RT</td>
</tr>
</tbody>
</table>

Experiment Locations
Experiment Locations: Scenario 1

Zone Campus Nord, UPC

RISE 2008 Workshop
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
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.
Cooperative Localization and Navigation

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

Video: SLAM_29Janallfast.avi

Cooperative Localization and Navigation

Localization of robots using GIS and laser information

RISE 2008 Workshop
Cooperative Localization and Navigation

Navigation using path planning and sensor information

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

Robot formation

- Leader
- Path planning
- Obstacle avoidance
- Slave robots
- Specific motion control
- 3 robots collaborate to maintain connectivity
- Specific motion control

Network connectivity

- Leader
- Executes allocated task
- Obstacle avoidance
- MANET
- Access point
- 3 robots collaborate to maintain connectivity
- Specific motion control

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
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

Following several persons with environment cameras

Accuracy of Techniques over 5 cameras over 6 days using top 3 results

RISE 2008 Workshop
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

Video SmartData.mpg
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

Communication by touch-screen

Communication between robots and humans through the mobile phone
Human Robot Interaction

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

Human Robot Interaction

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 reached.

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
- Robots for transportation of people and goods
- Wireless and network communication
Conclusions

- The project has just started and we have analyzed the specifications.
- Between 2007 and 2008 we will develop the techniques and in 2009 we will do the experiments.
- The project faces 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