Cooperative Issues in Network Robot Systems in Urban Areas

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- Some examples of NRS
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Network Robot Systems

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Network Robot Systems by EU

Definition:

A Network Robot System is a group of artificial autonomous systems that are mobile and that makes important use of wireless communications among them or with the environment and living systems in order to fulfill their tasks.

Elements:

- Autonomous robot
- Communication network
- Environment sensors
- People

Network Robots Systems by Japan

Ubiquitous Network

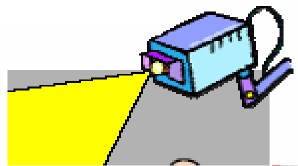
"Visible" type

Apri-alpha Robovie

Network Robots

"Virtual" type

"Unconscious" type



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Some Examples of NRS

URUS: Guiding and Transportation

Cameras and ubiquitous sensors

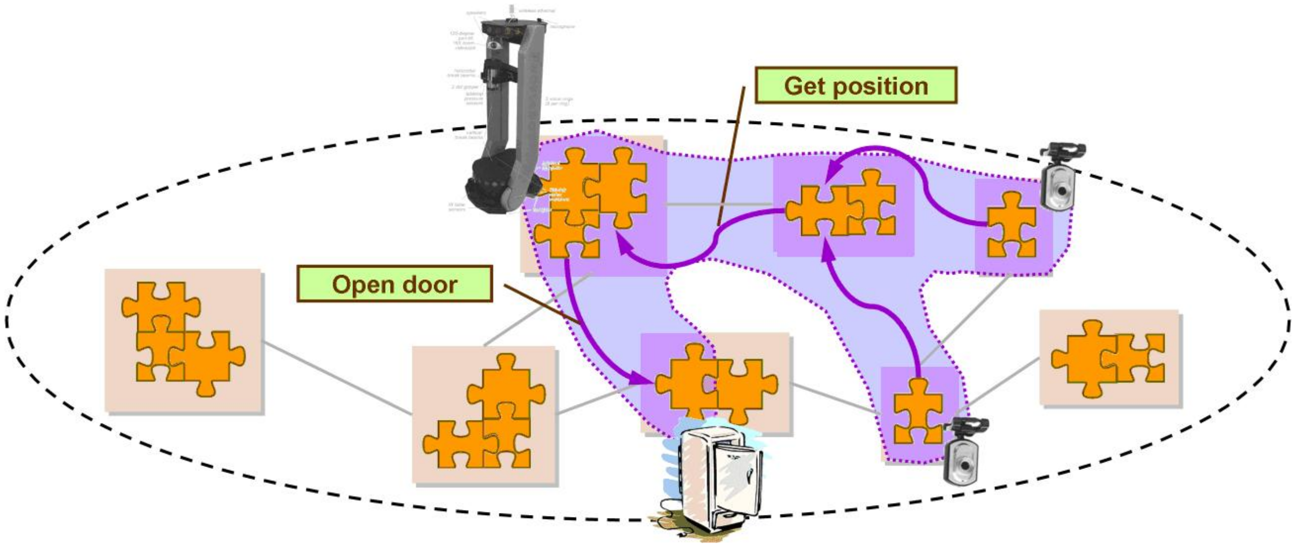
Robots with intelligent head and mobility

People with mobile phones and RDFI

Wireless and network communication

Robots for transportation of people and goods

PEIS Ecology



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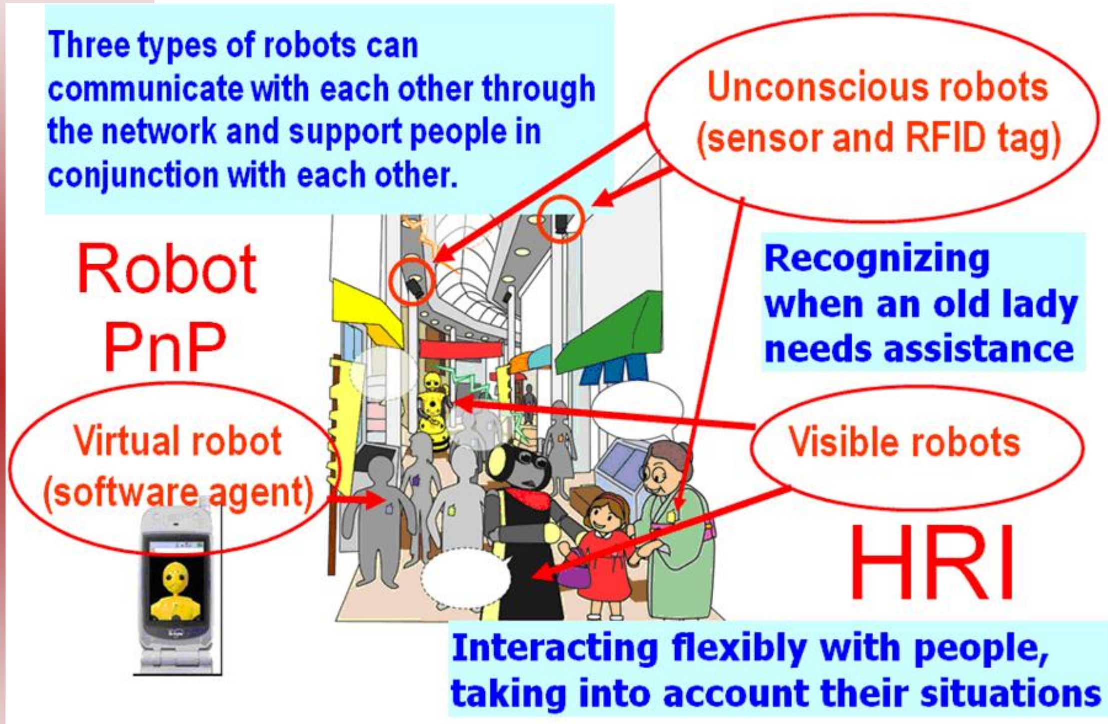
Japan NRS Project



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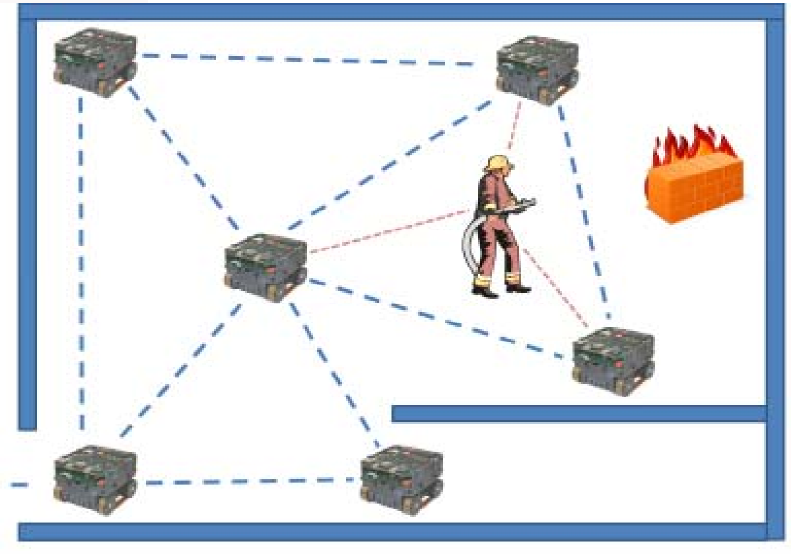
DustBot: Urban Hygiene

DustClean Robot

DustCart Robot

Guardians: Robot Assistant for Firemen



Cooperative Functions in NRS:

Cooperative Localization and Navigation

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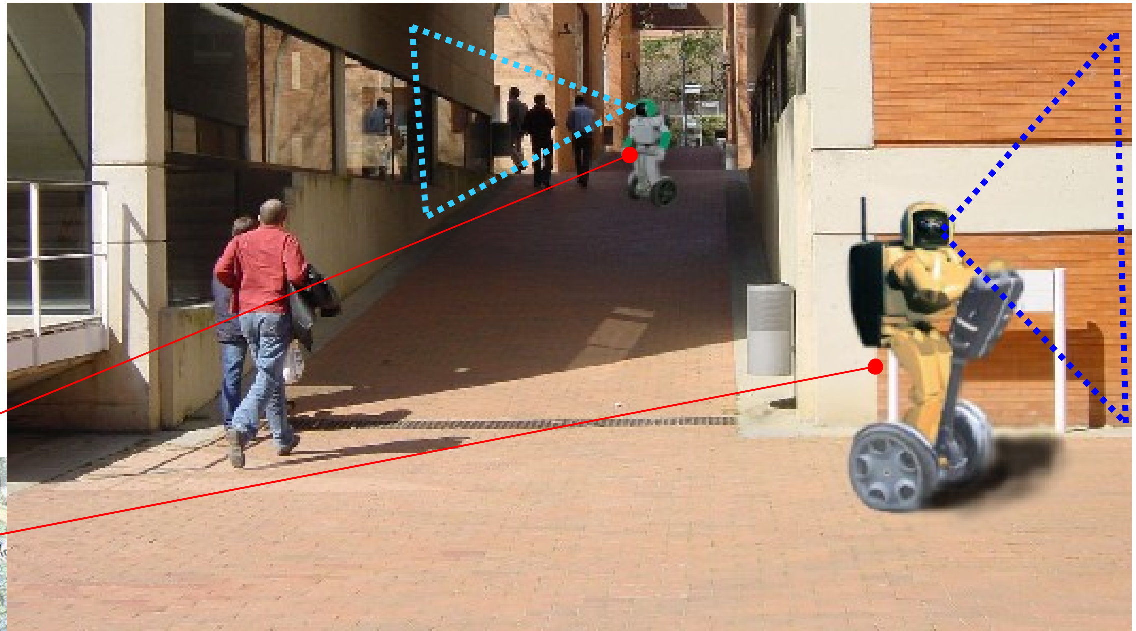
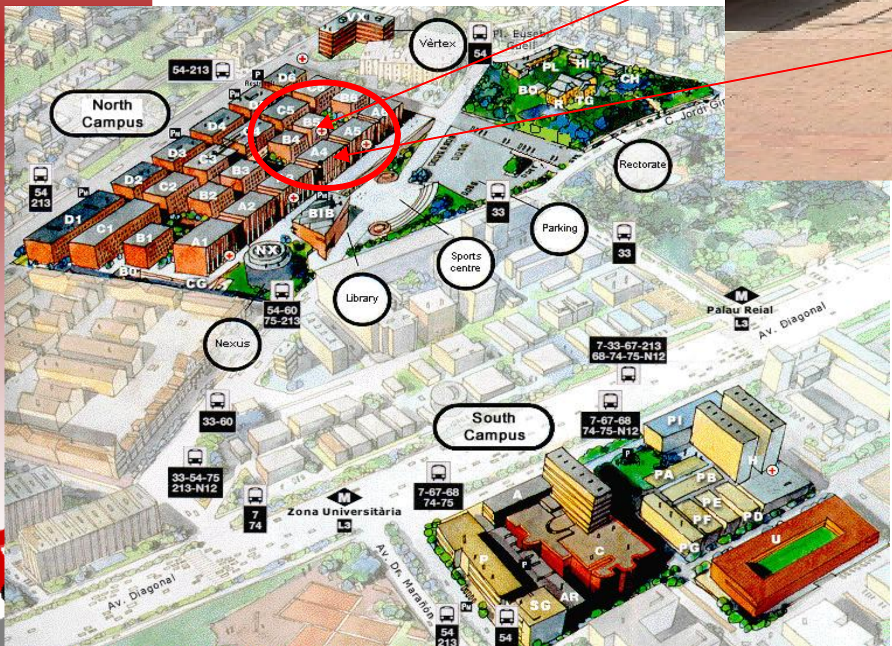
Cooperative Localization and Navigation

Localization using:
- GIS, Compass, laser, estereo
- multiple robots
- ubiquitous sensors

Navigation:
- Using GIS, laser, compass
- Own and embedded sensors

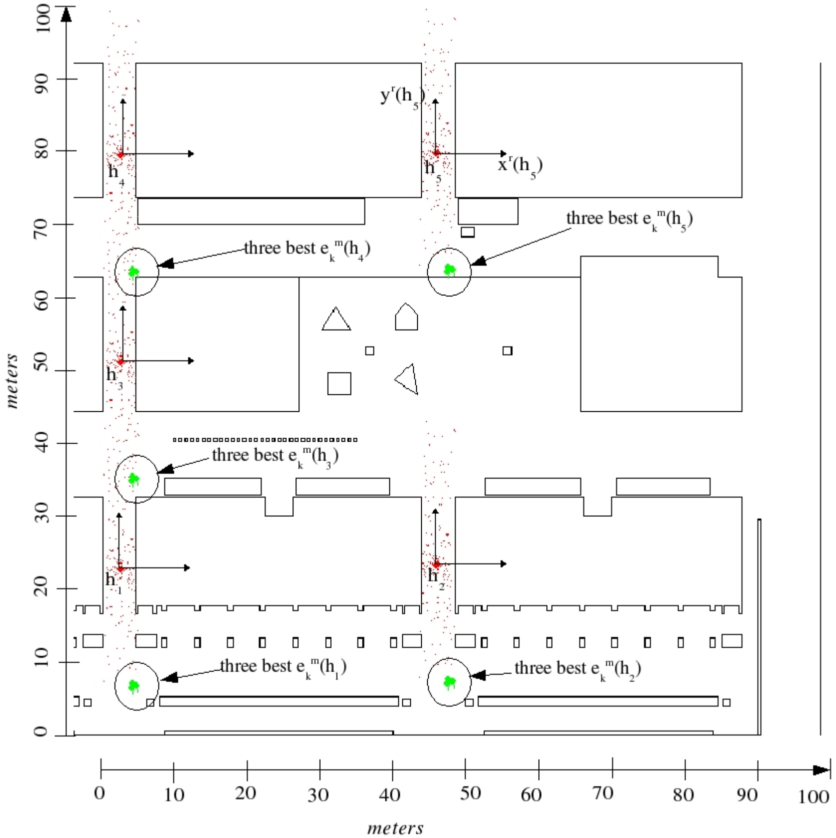




Cooperative Localization and Navigation

Robot localization using active global localisation

Video: **20080508posTrackingShort.mp4**



[Corominas et al ICRA08]

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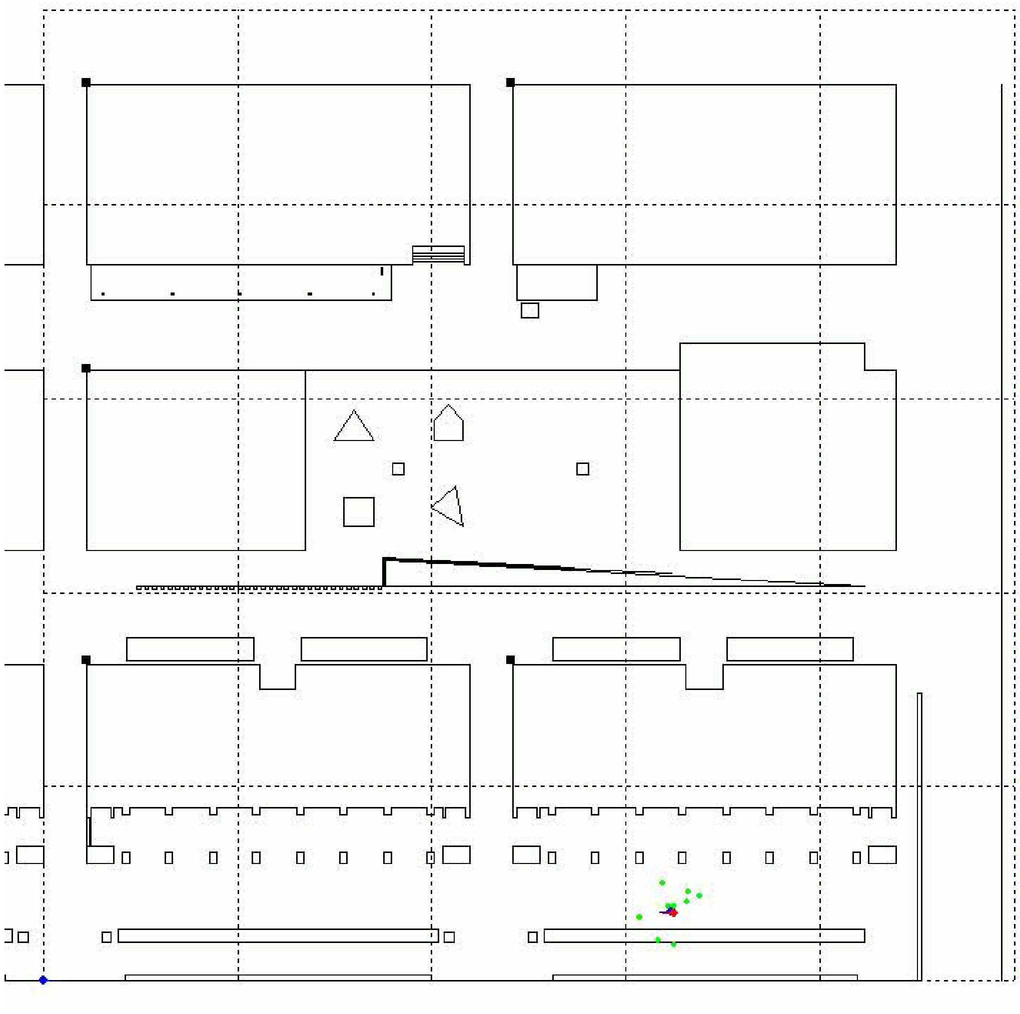
Cooperative Localization and Navigation

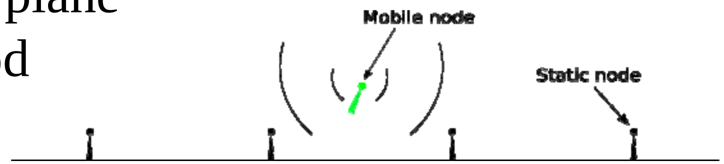
Robot localization using cooperative localization



Cooperative Localization and Navigation

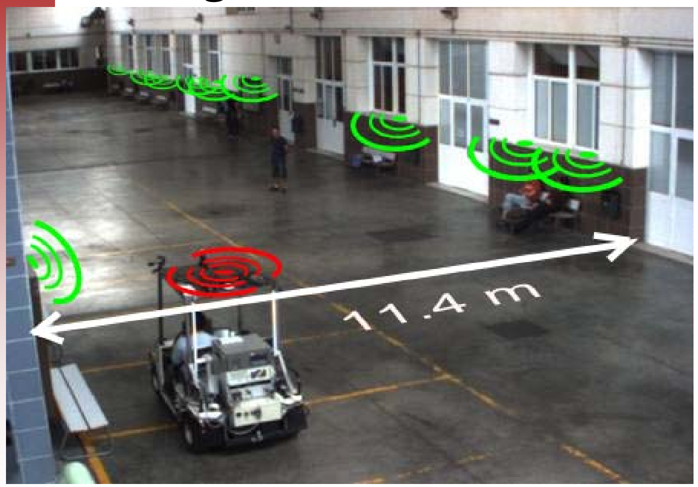
Relative Ranging method

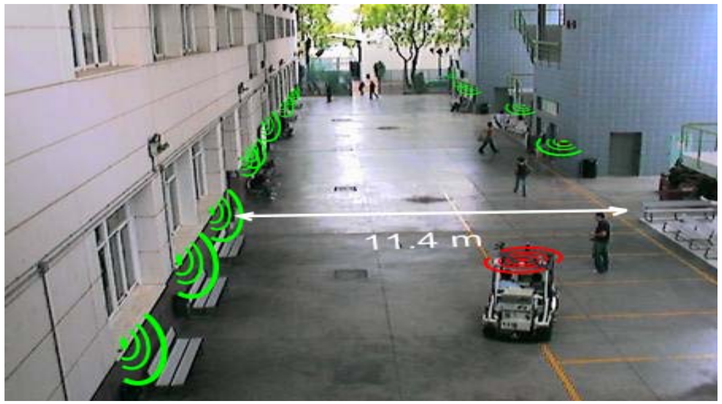
Try to eliminate effect of antenna orientation
Suitable for static nodes approximately in the same plane
Triangulation using a non-linear least-square method



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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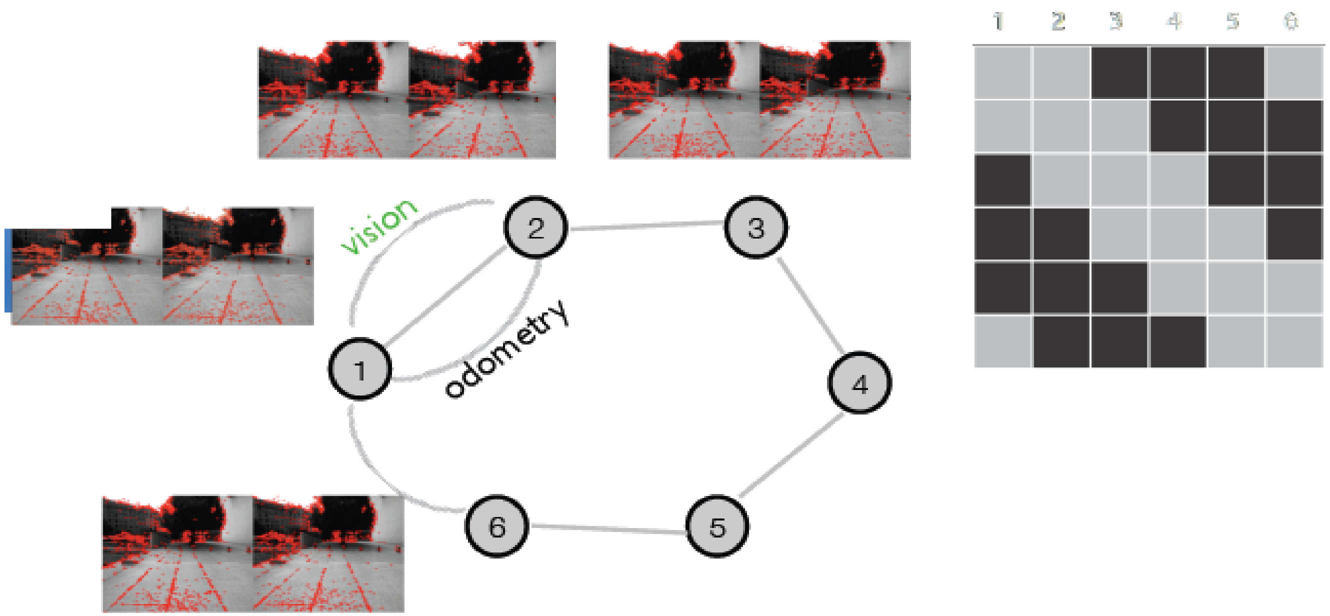
Cooperative Localization and Navigation

Segway-robot navigation based on fusing odometry and visual odometry

Video: SANYO088.MP4 and video_SLAM_21Aug_new.avi

$$p(\mathbf{x}) \sim \mathcal{N}(\mathbf{x} : \boldsymbol{\mu}, \boldsymbol{\Sigma}) \sim \mathcal{N}^{-1}(\mathbf{x} : \boldsymbol{\eta}, \boldsymbol{\Lambda})$$

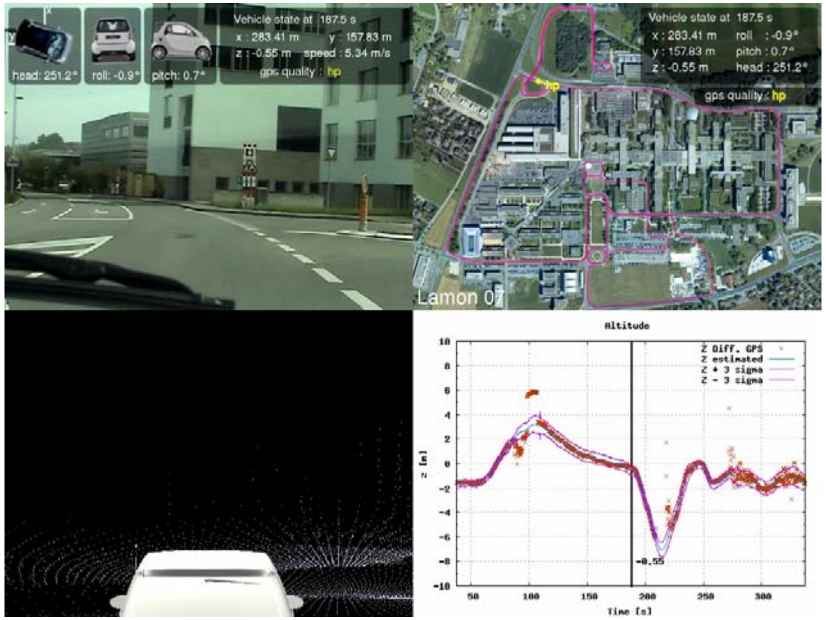


[Ila et al, IROS07]

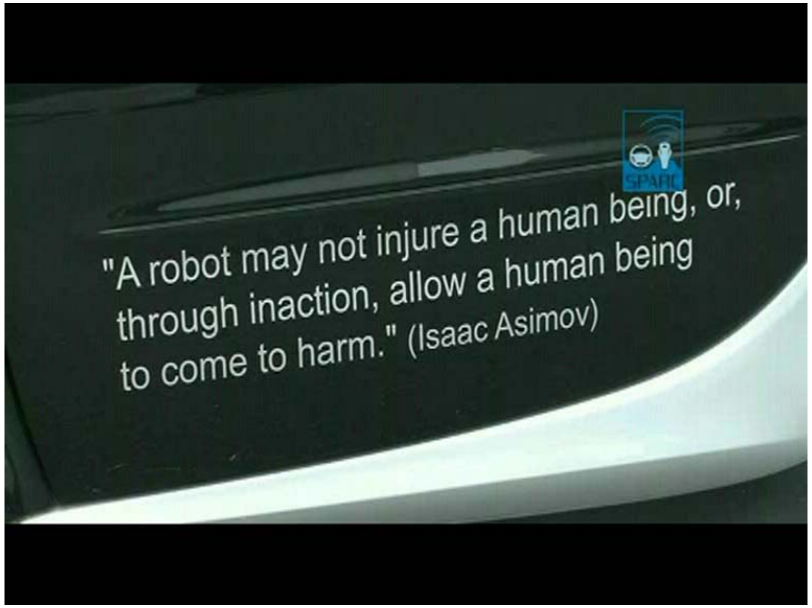
Cooperative Localization and Navigation

Smart navigation based on fusion of sensor information

Video showing Smart Ter at UPC siteVideo: SmartAndSegway.mpg



SmartTer: GPS/IMU/Odometry fusion **[Lamon et al 06].**



Safe RRT-based local planning and obstacle avoidance **[Macek et al 08]**.

Cooperative Functions in NRS:

Cooperative Environment Perception

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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

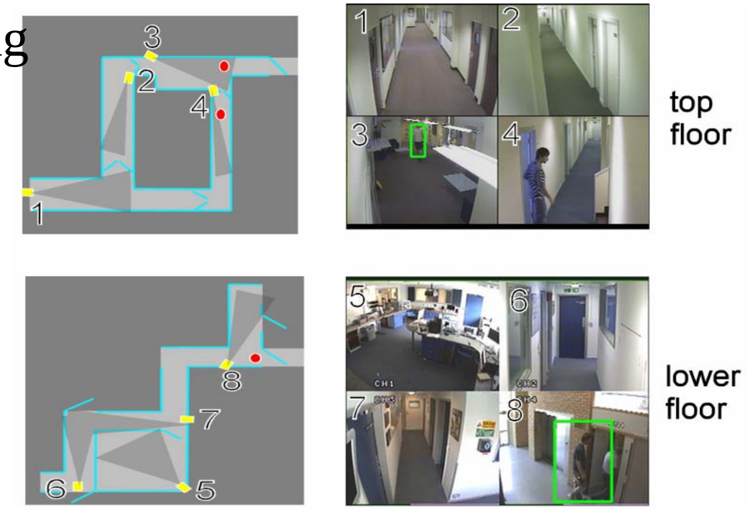
Following a person with environment cameras

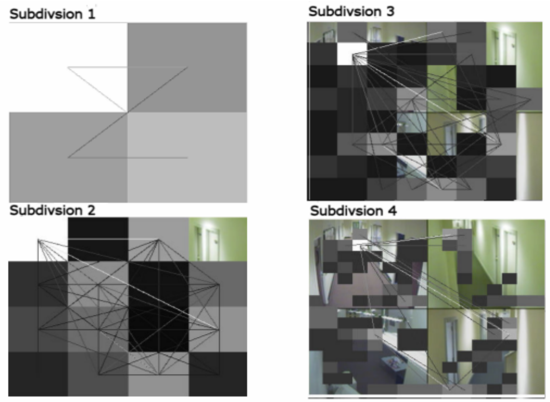
video **videoUrus1.avi**

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

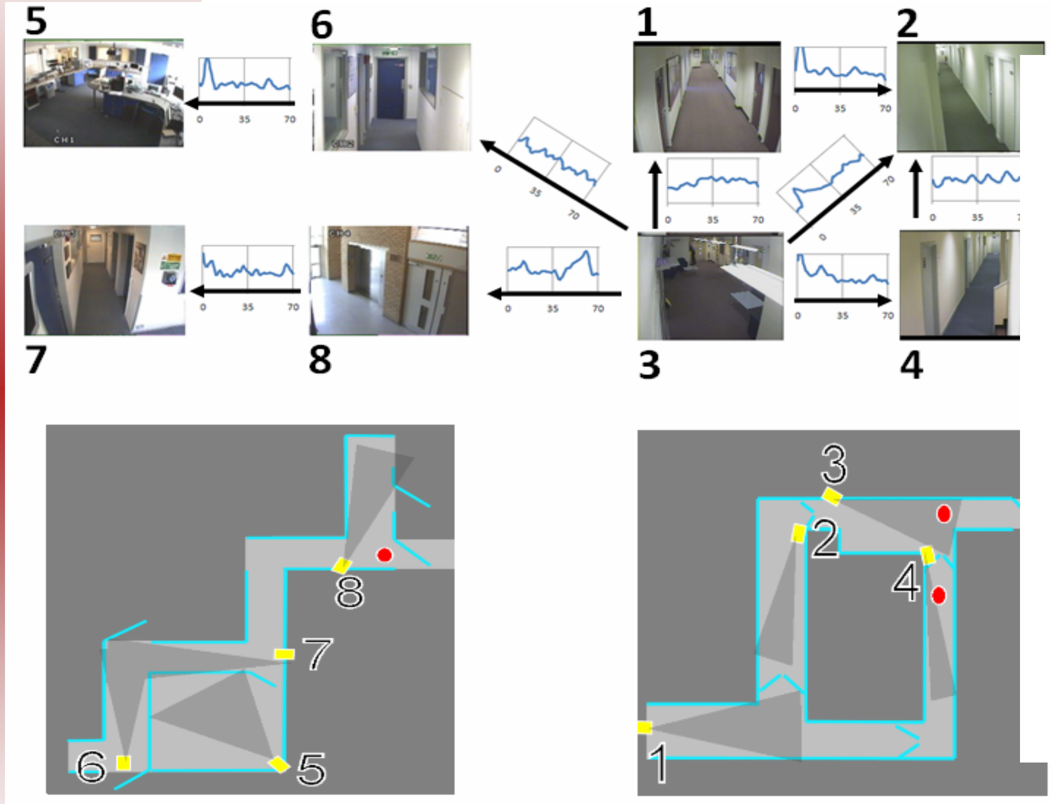


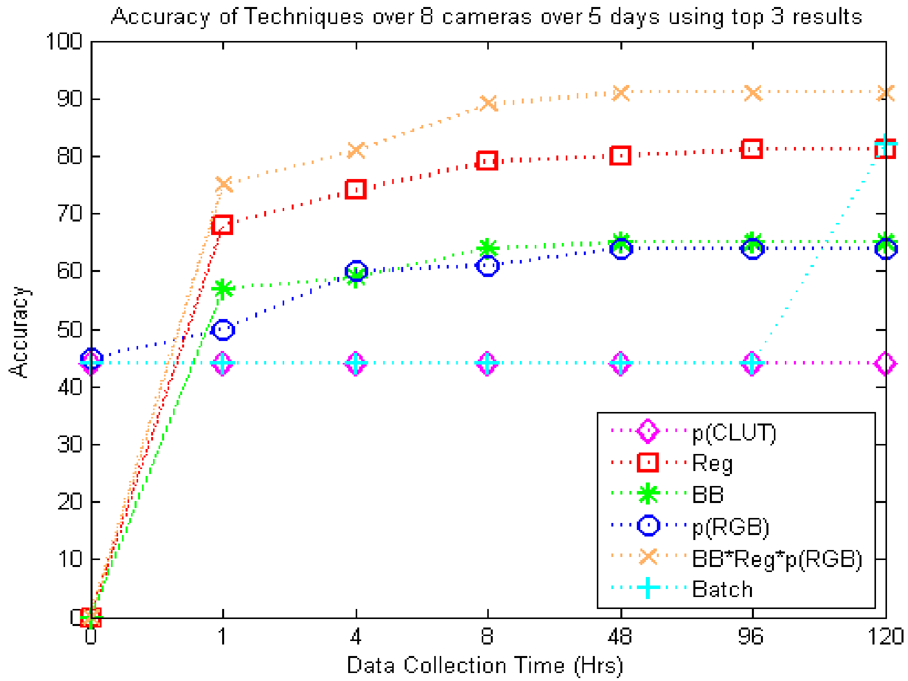


[Gilbert et al., HRI ICCV07]

Cooperative Environment Perception

Following several persons with environment cameras





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

Image i

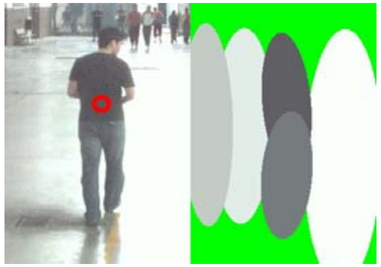


Image i+1

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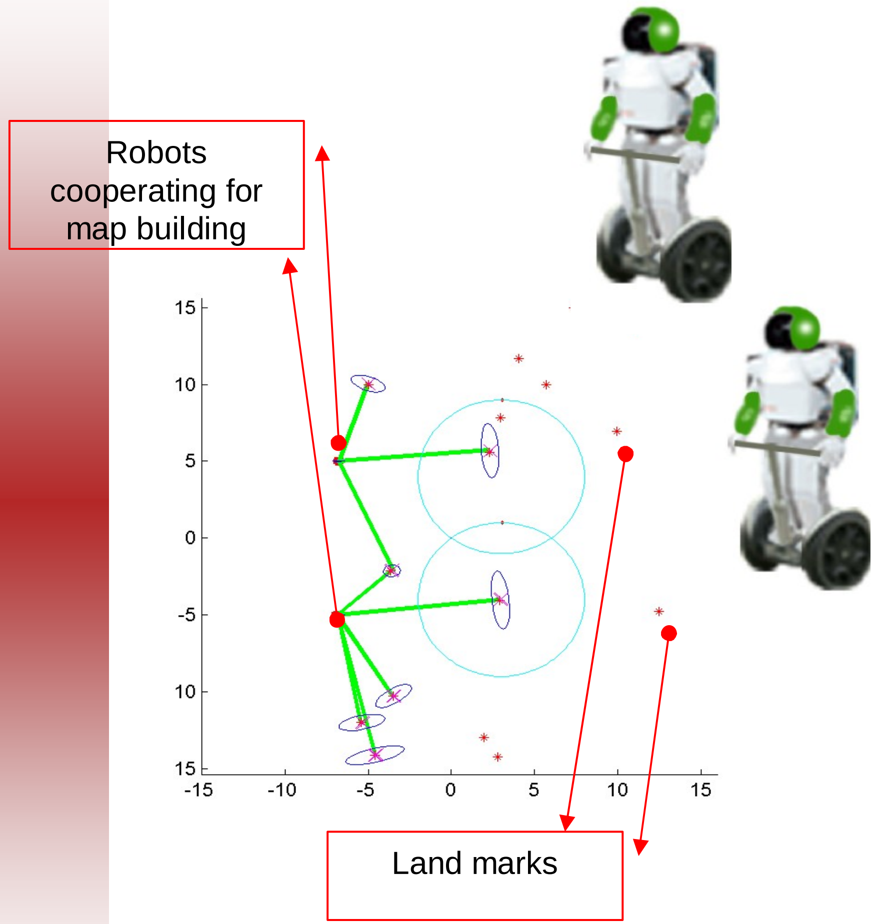
Cooperative Functions in NRS:

Cooperative Map Building and Updating

Cooperative Map Building and Updating



Cooperative Map Building:

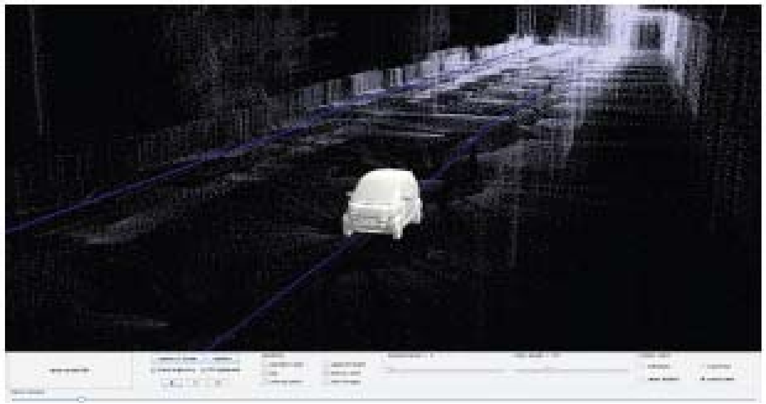
- Using multiple robots and sensors
- Using control techniques

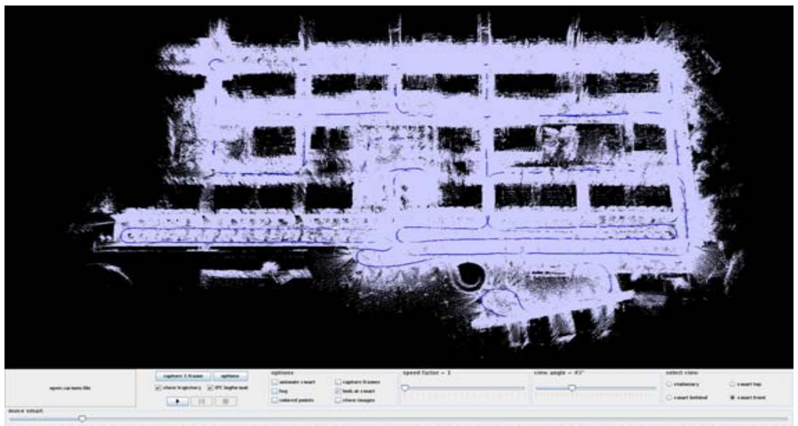
Cooperative Map Building and Updating

3D Map construction doing by Smart Ter robot

Video SmartData.mpg

(a) Localization sensors (b) Environment sensors



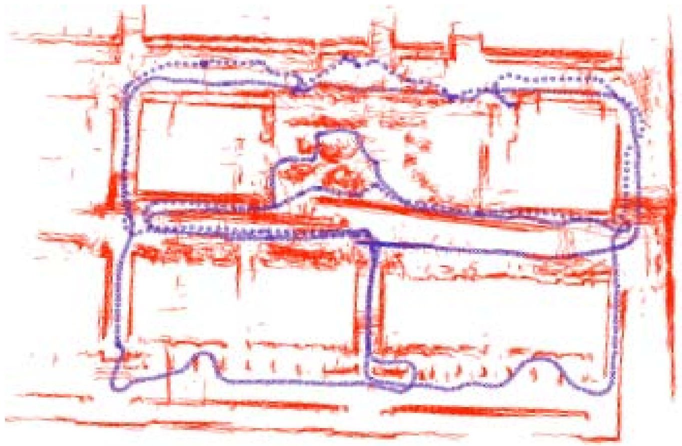


Cooperative Map Building and Updating

Video showing trasversability map building based on 3D odometry and stereovision Data robot

Video: serie04-1000-3000-dtm.mov

Video: serie04-1000-2260-classif.mov



Reprojection of raw laser data on
the basis of 2D odometry estimates
Final position error < 1m

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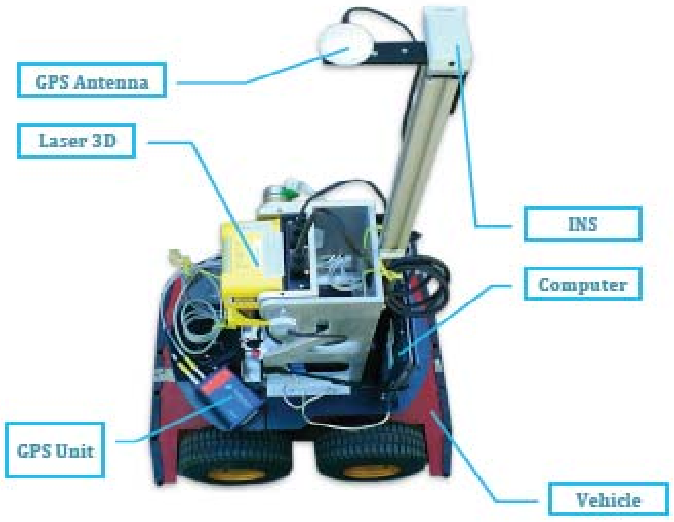
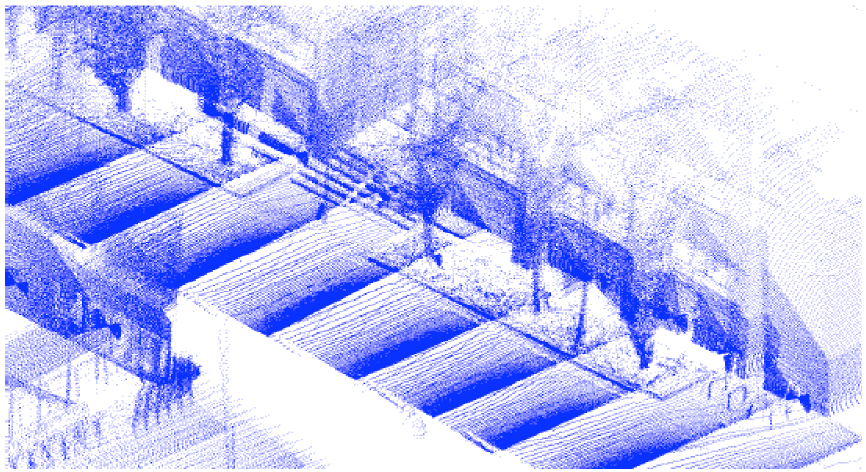
Cooperative Map Building and Updating

UPC 3D ranger scan





Cooperative Task in NRS:

Cooperative People Evacuation

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Cooperative People Evacuation

Evacuating people with robots

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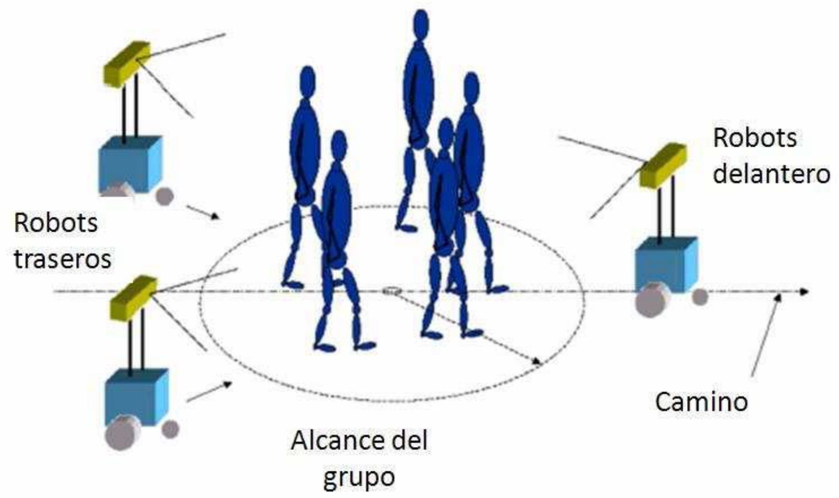
Cooperative People Evacuation

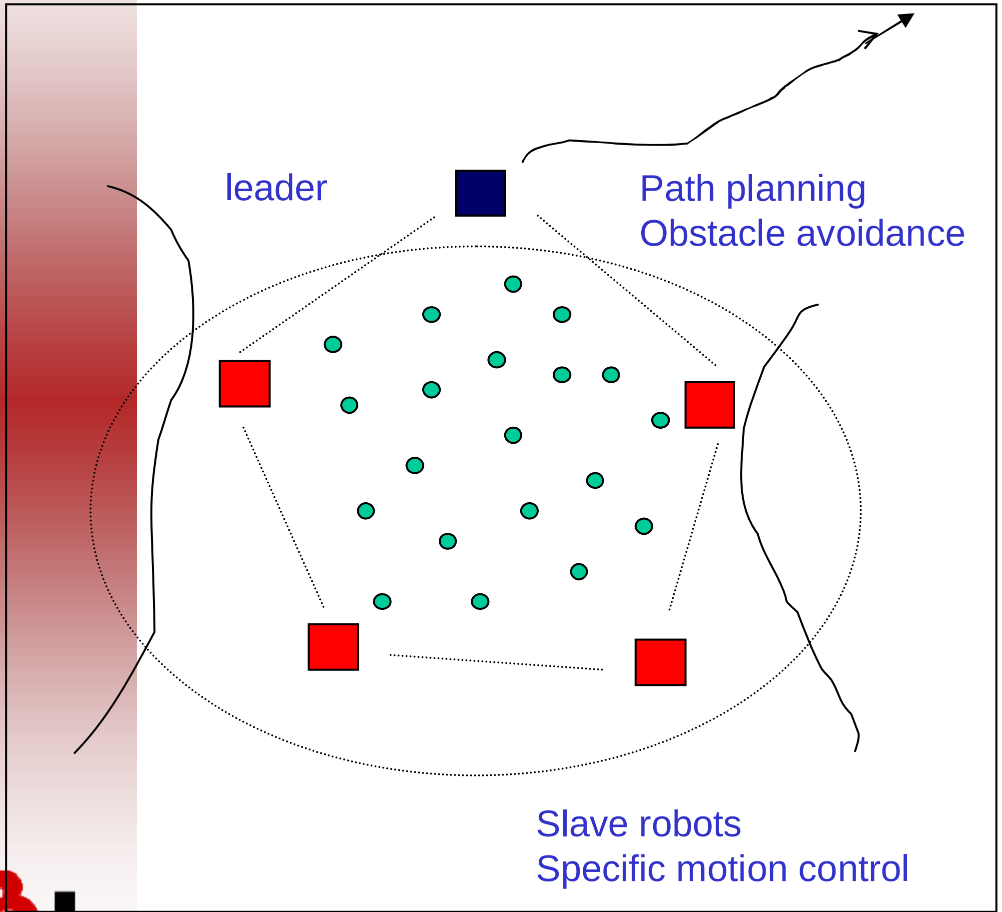


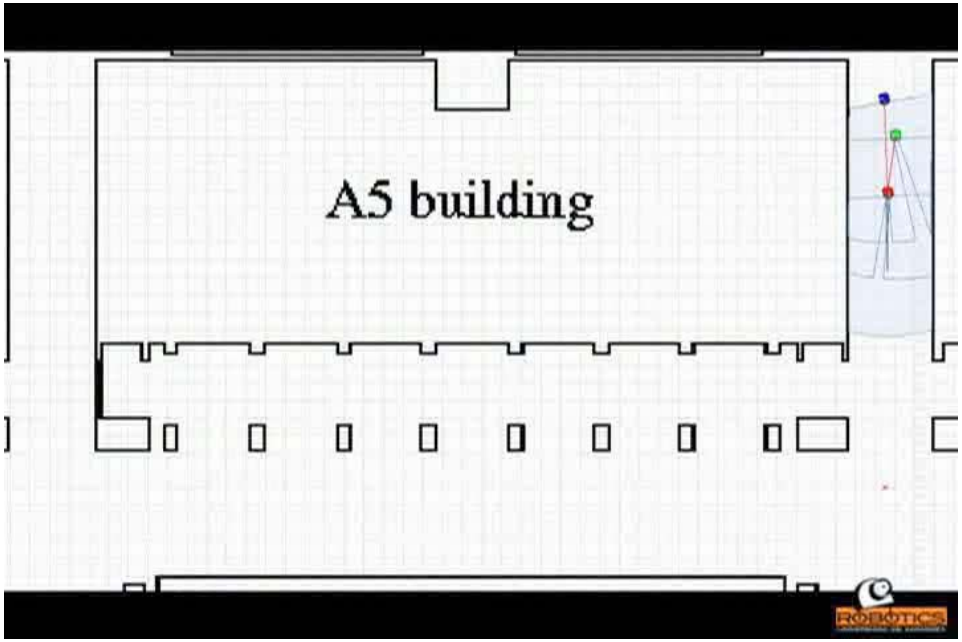
Guiding people by robot formation

Dog shepherding

Cooperative People Evacuation

Robot formation

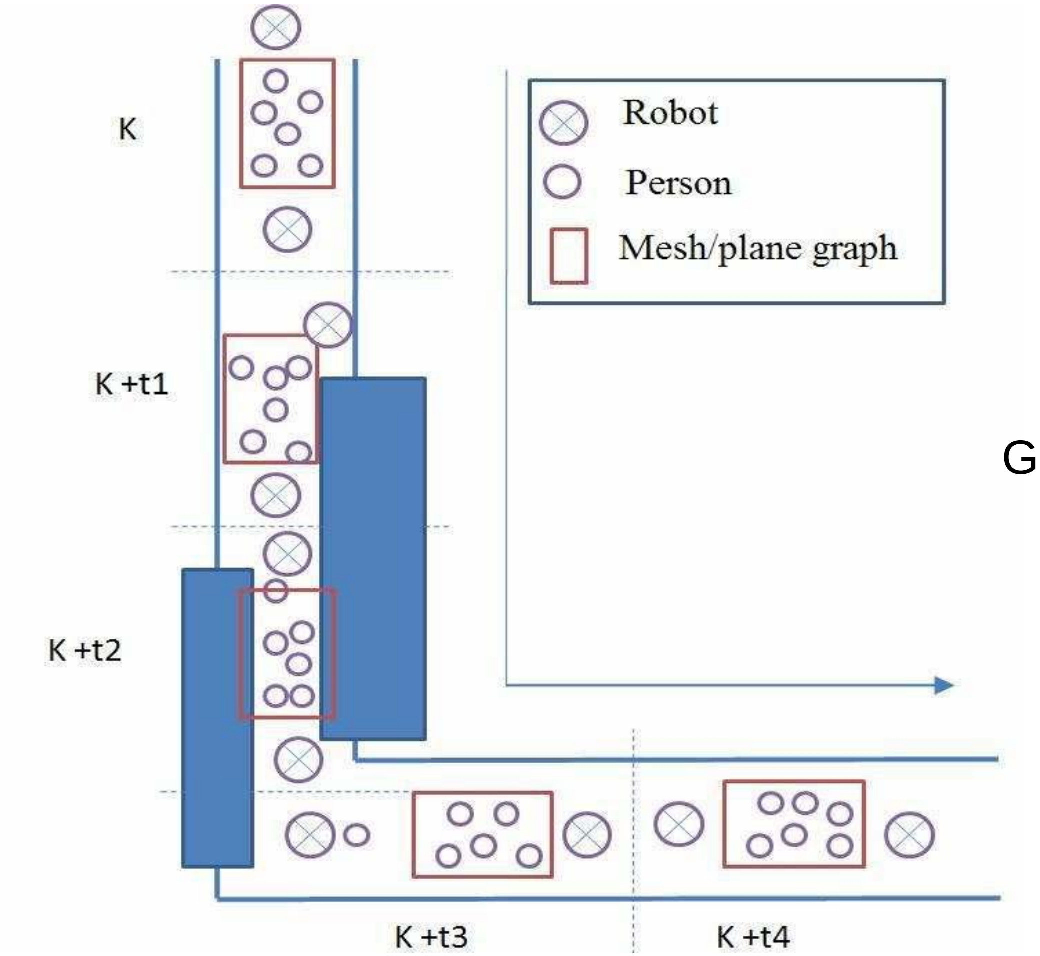




[Mosteo et al. ICRA08]

Cooperative People Evacuation

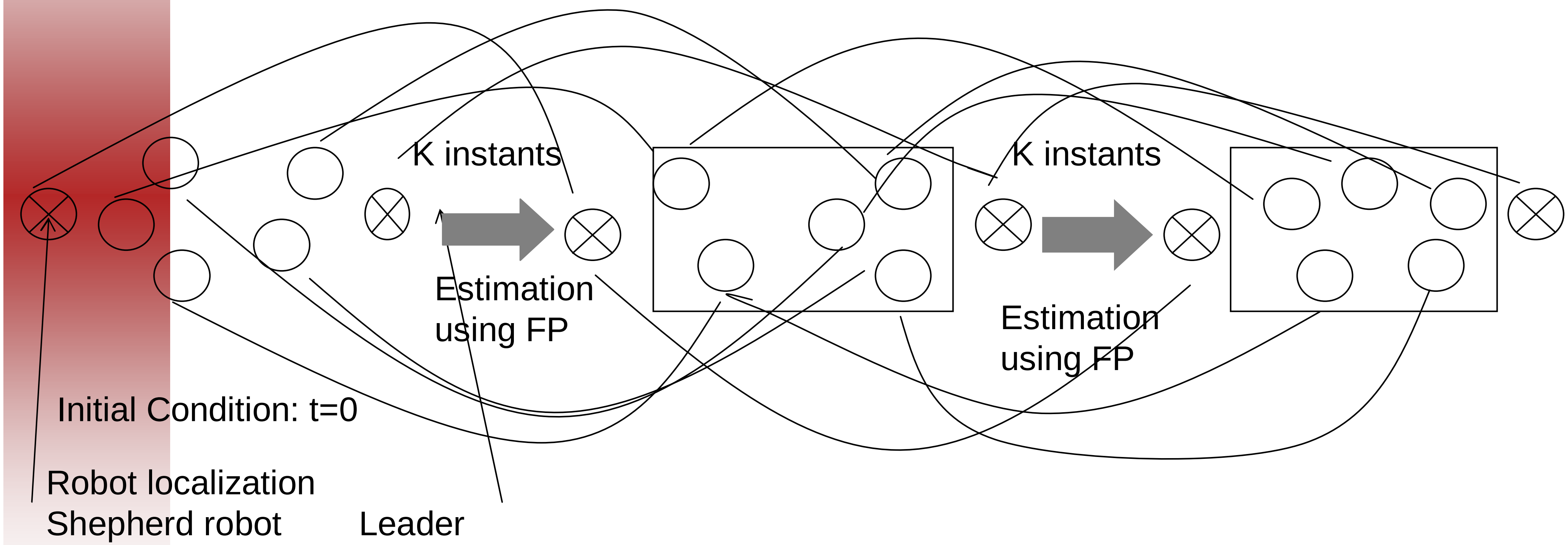
Dynamic model of Local Environment



Garrell and Sanfeliu, 2008

Cooperative People Evacuation

- The DLE model has a dynamic and static component
  - **Dynamic Component**



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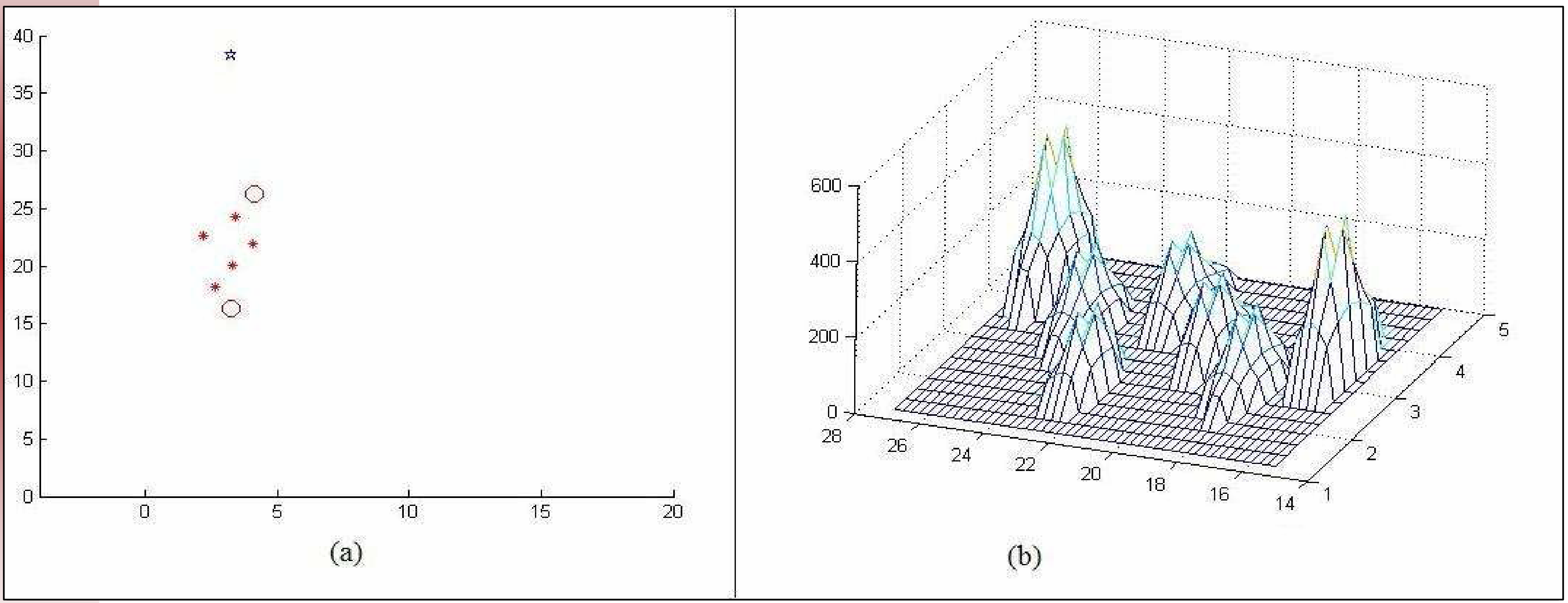
Cooperative People Evacuation

Preliminary results



(a) (b)

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URUS project

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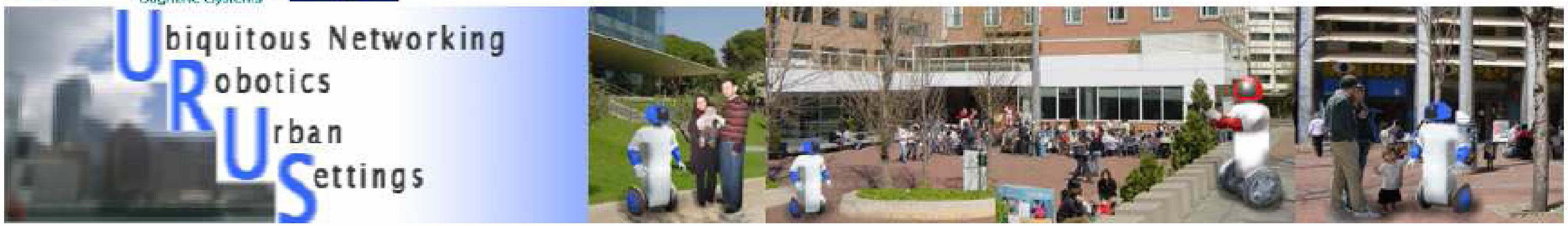
CSIC UPC

URUS project
Ubiquitous Networking Robotics in Urban Settings

CogSys
Cognitive Systems



http://urus.upc.es

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SIG_Workshop_Lisbon_2008

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***
  - Specifications 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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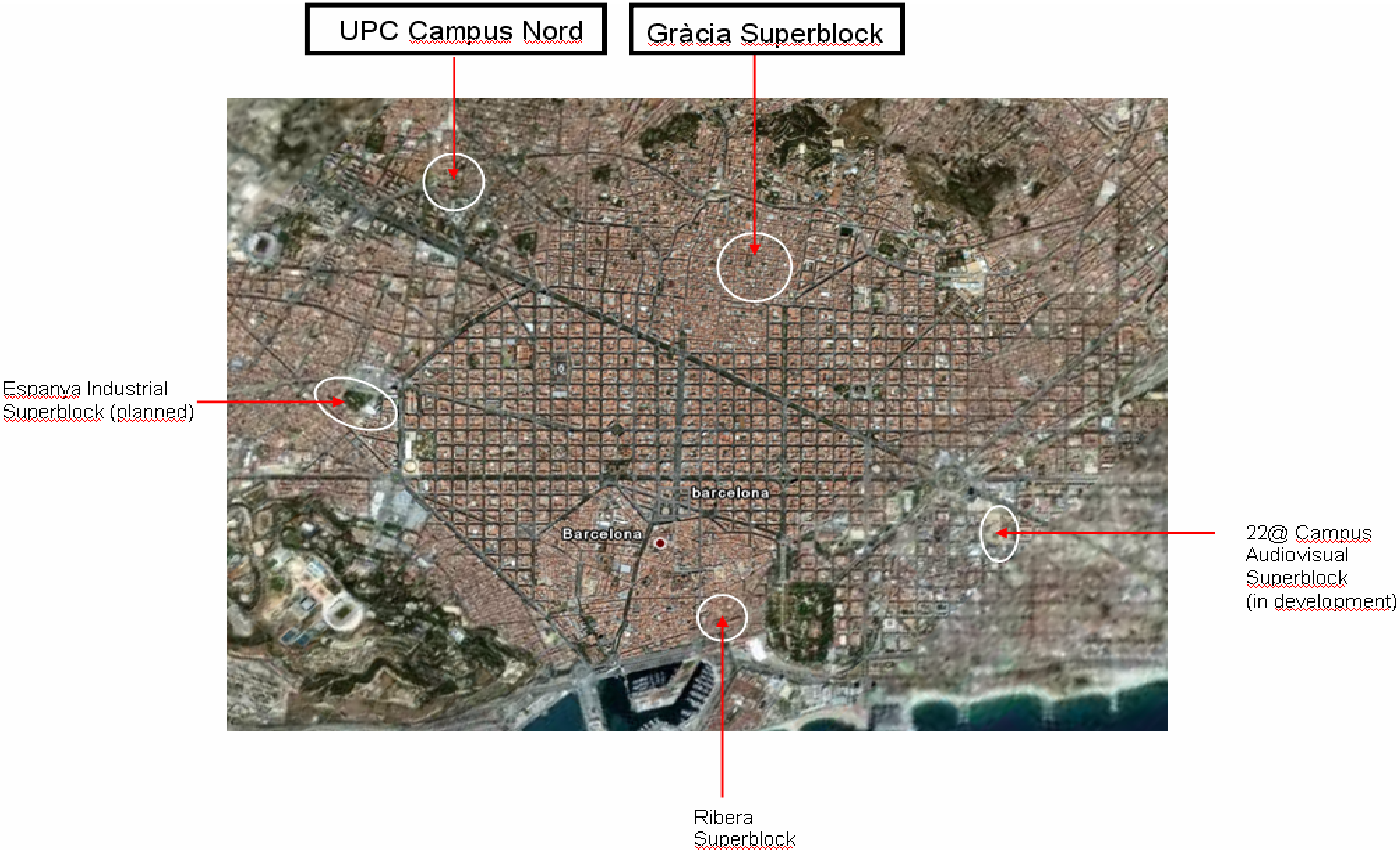
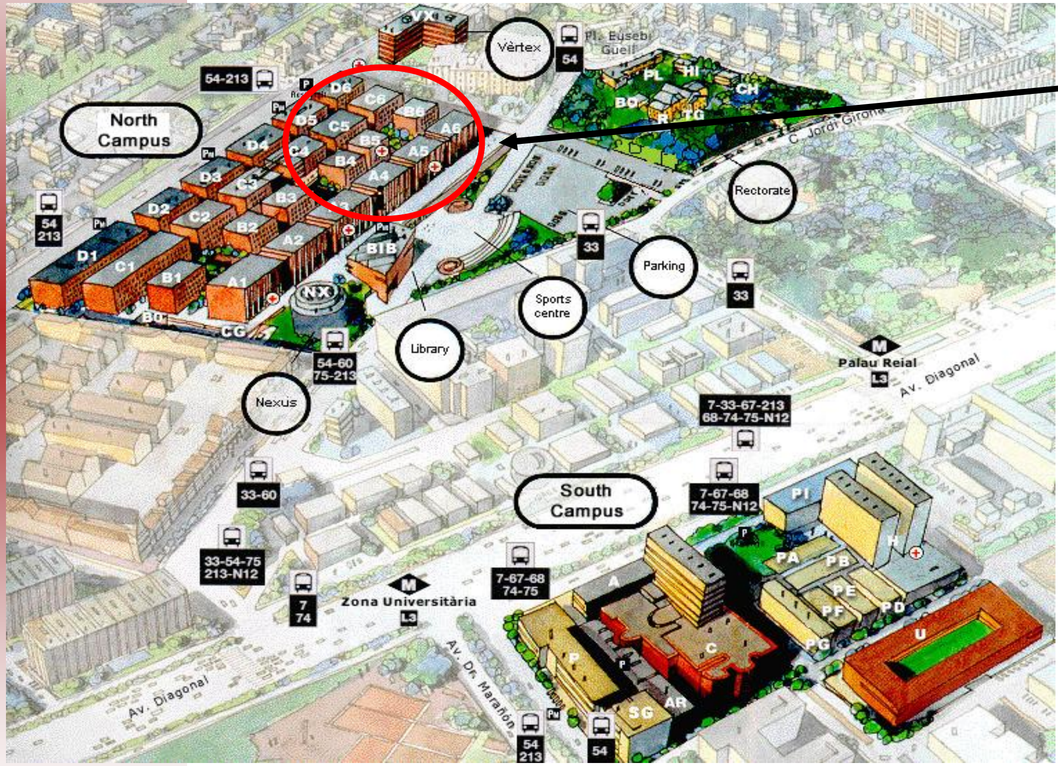
Experiment Locations



Experiment Locations: Scenario 1
UPC

Zone Campus Nord, UPC



Barcelona Tech Robot Lab

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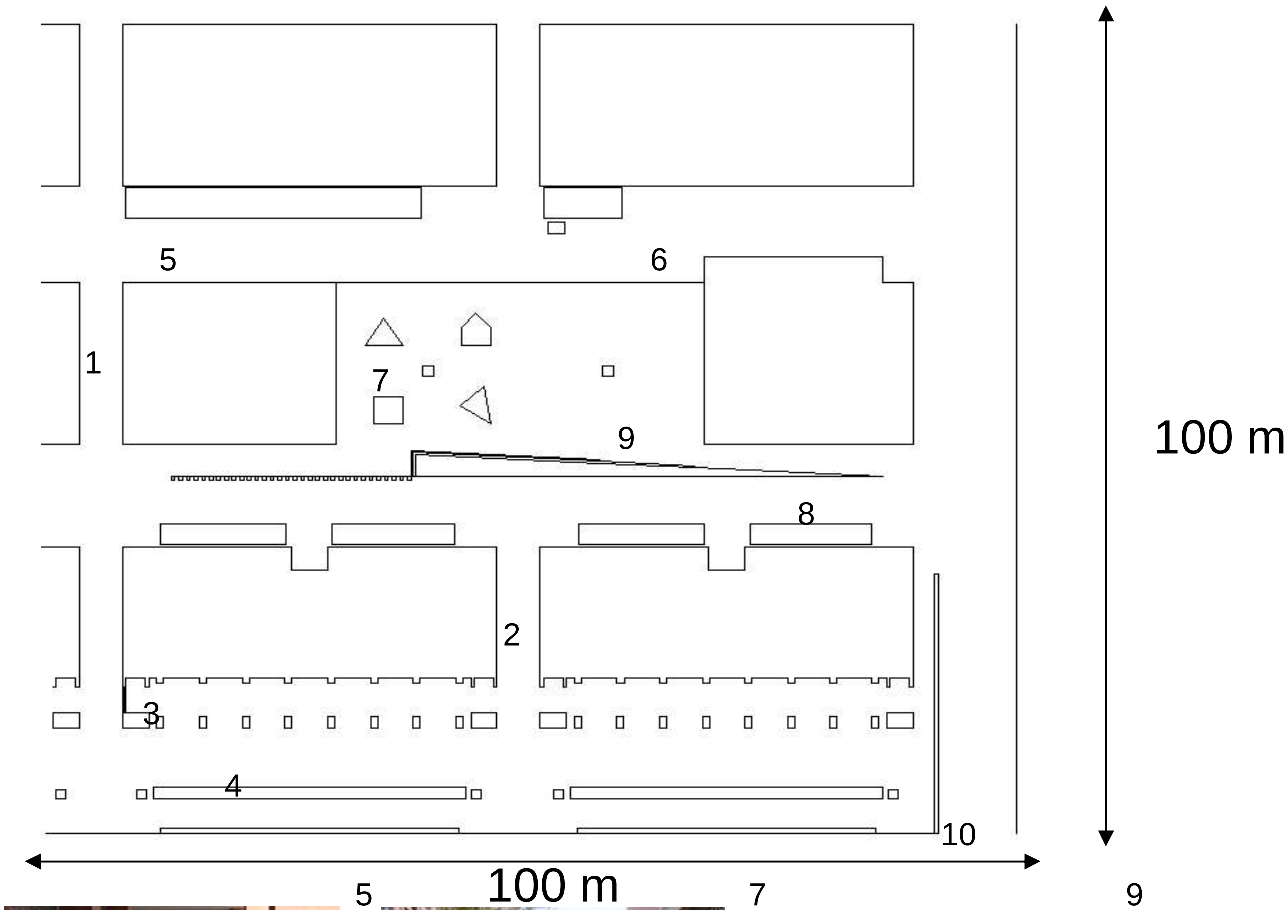
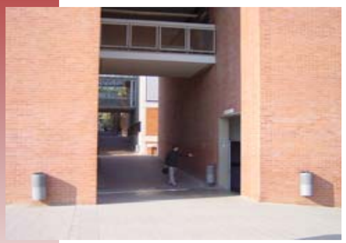
Zone
Campus Nord, UPC



1


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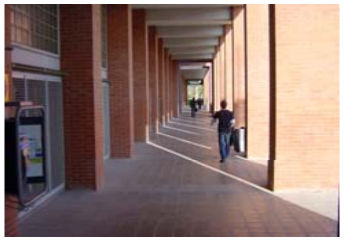


5


7


9

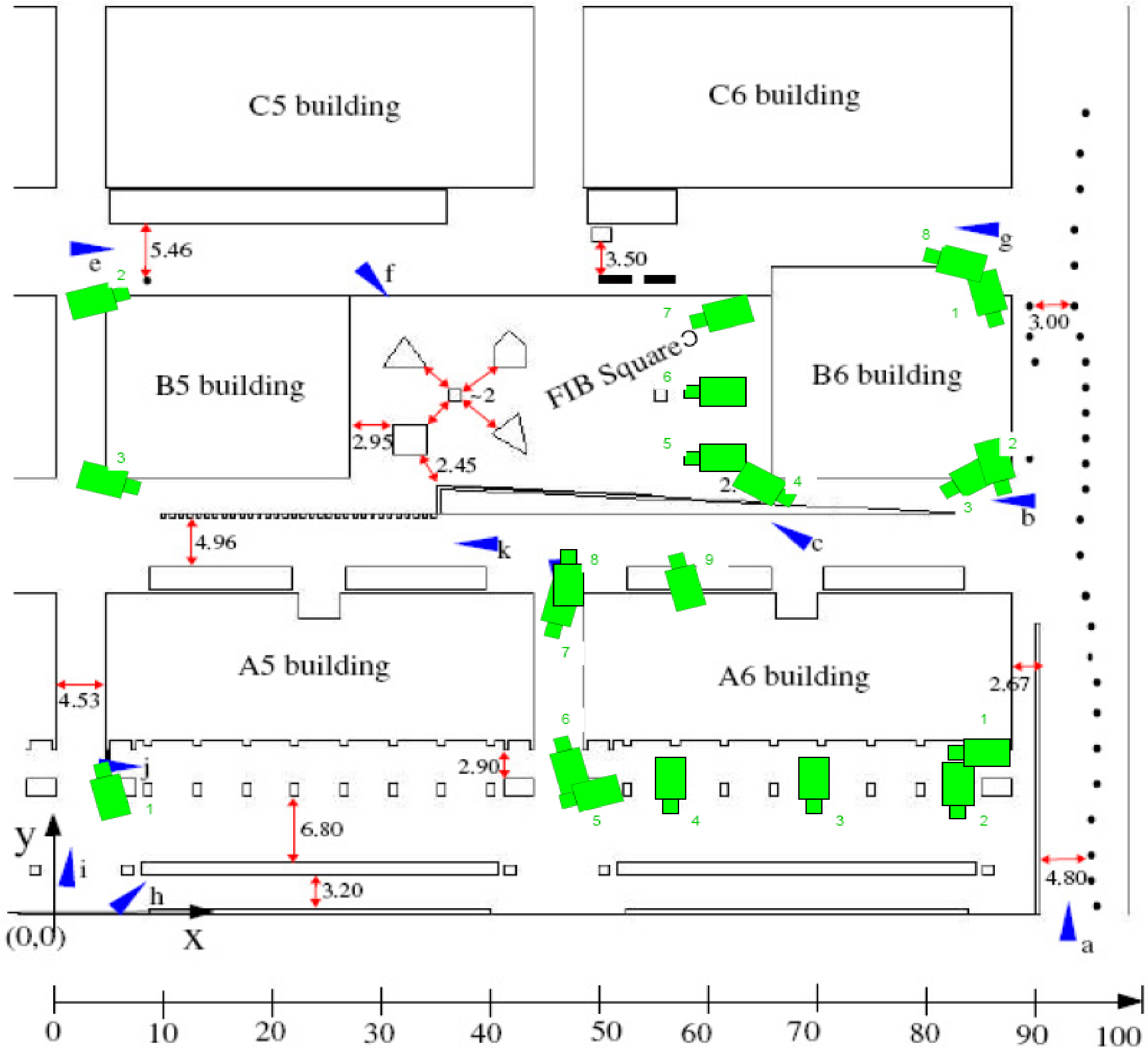

2


4


6


8


10



C5 building
C6 building
B5 building
B6 building
A5 building
A6 building
FIB Square
5.46
3.50
3.00
2.95
2.45
~2
4.96
4.53
2.67
2.90
6.80
3.20
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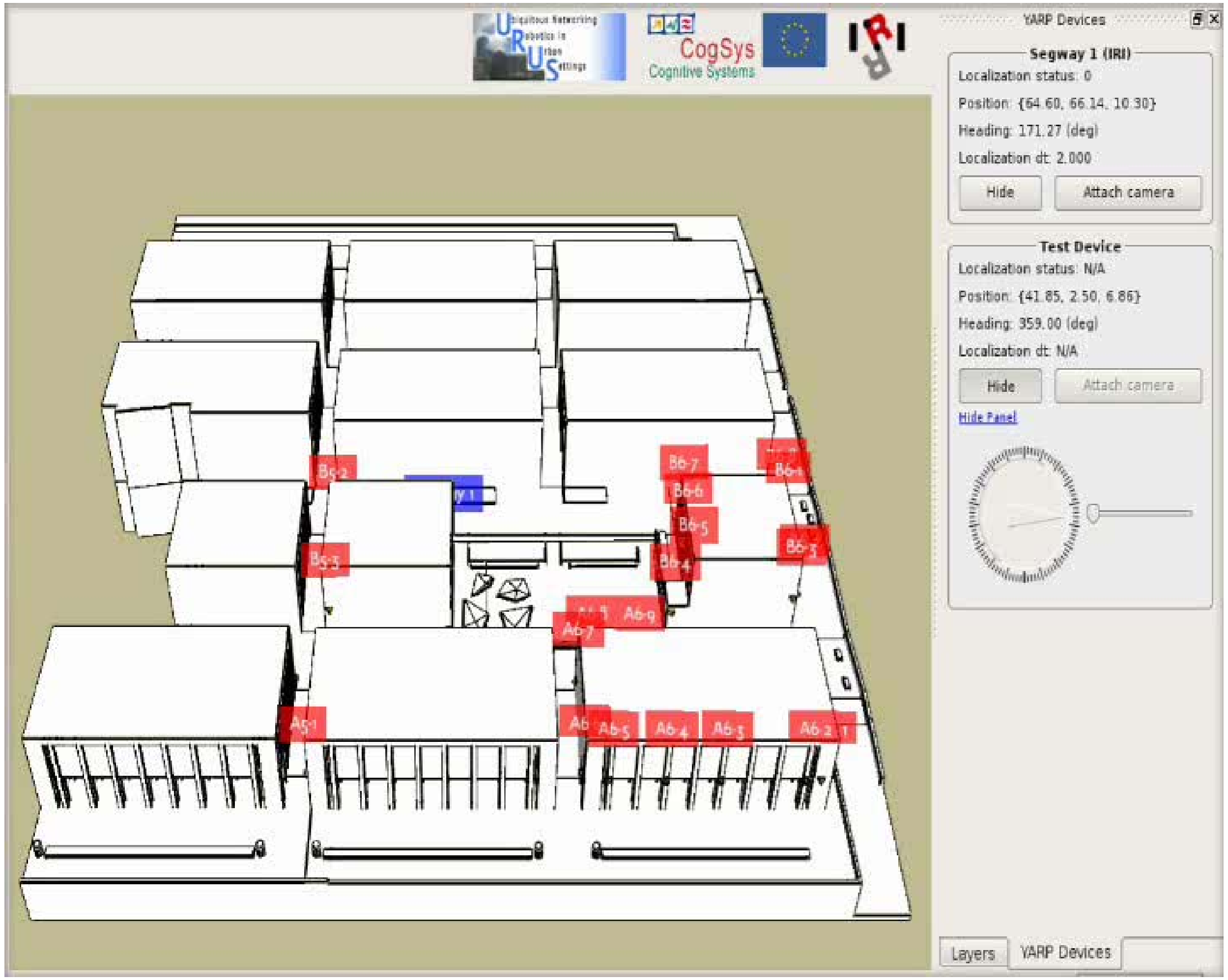
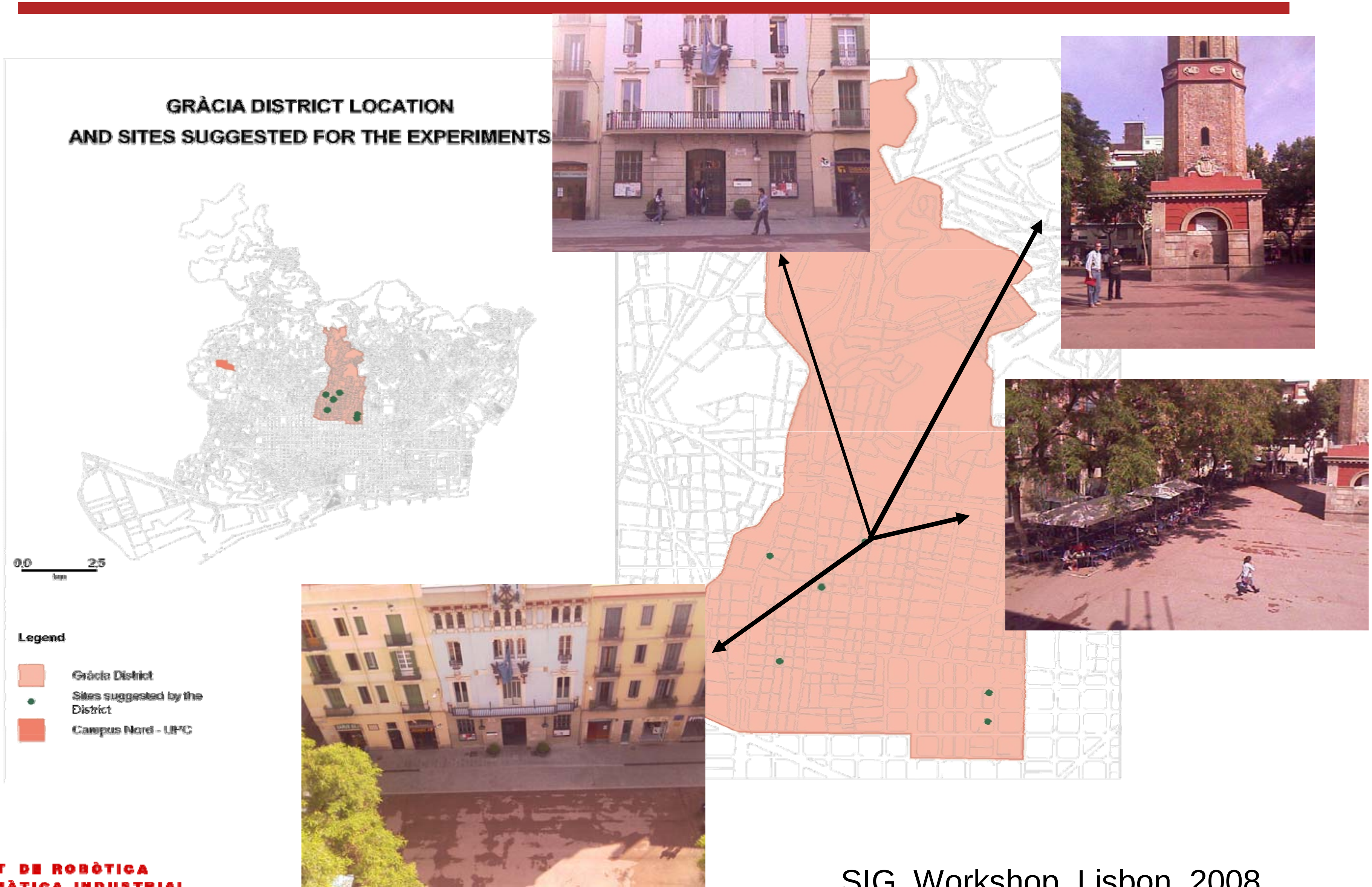
100

Experiment Location: Scenario 1
UPC



Experiment Location: Scenario 2
Gracia District



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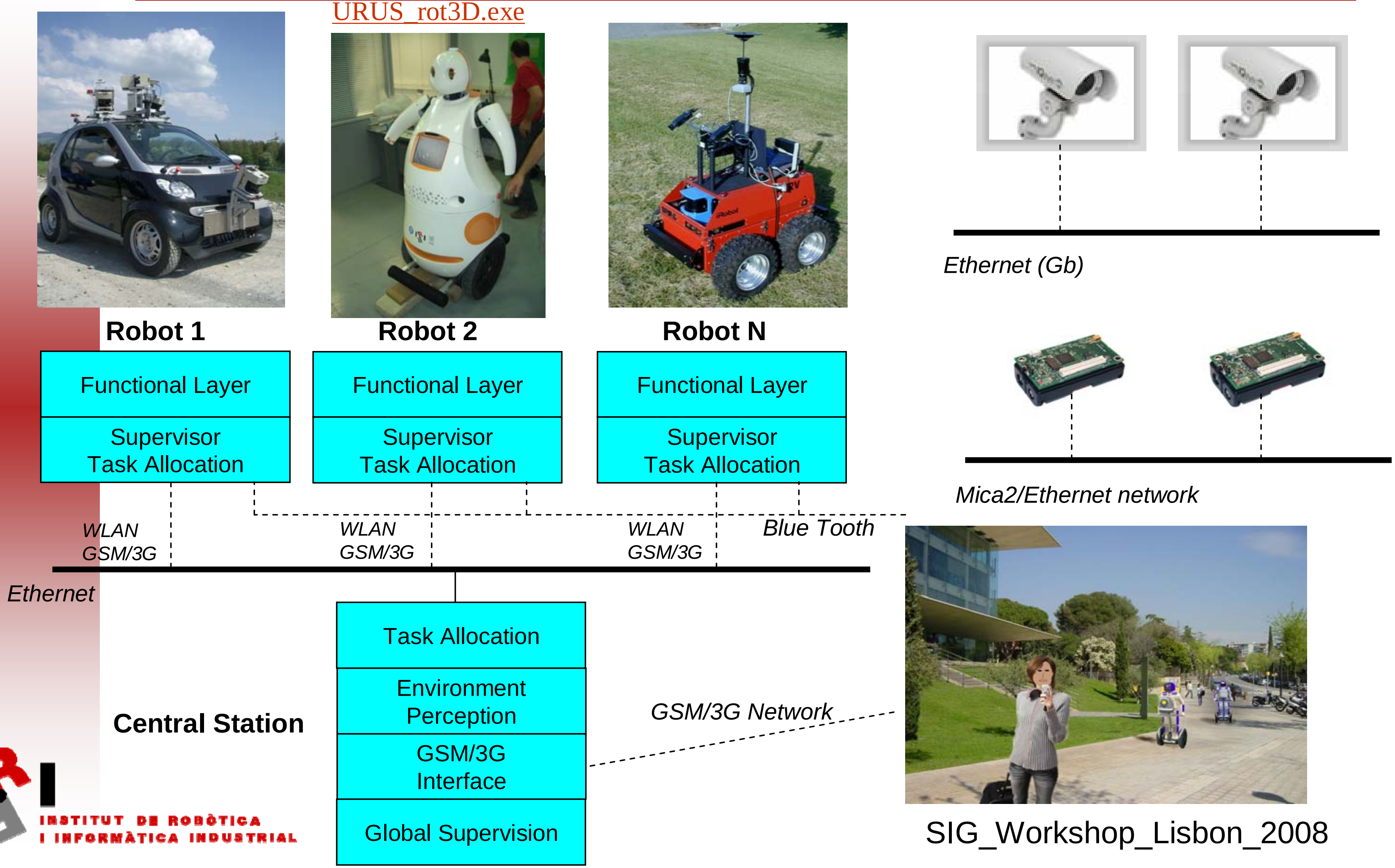
Global Architecture

URUS_rot3D.exe



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Experiments

- **Urban experiments:**
  - 1.- Transportation of people and goods
    - Transporting people and goods
      - Taxi service requested via the phone
      - User request the service directly
  - 2.- Guiding people
    - Guiding a person with one robot
  - 3.- Surveillance
    - Coordinate evacuation of a group of people
  - 4.- Map building