Smart Spaces – Intelligent Transport Systems
A Research Group in the Department of Electronics –University of Alcalá

Universidad de Alcalá

Workshop Ideas de Proyecto para

Próximas Convocatorias de Financiación I+D+i

Transporte Inteligente, Ecológico e Integrado

Capacidades del grupo de investigación Geintra

(Universidad de Alcalá)

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A complete team composed by:

- 3 Full Professors
- 20 Associate Professors
- 1 Administration Staff
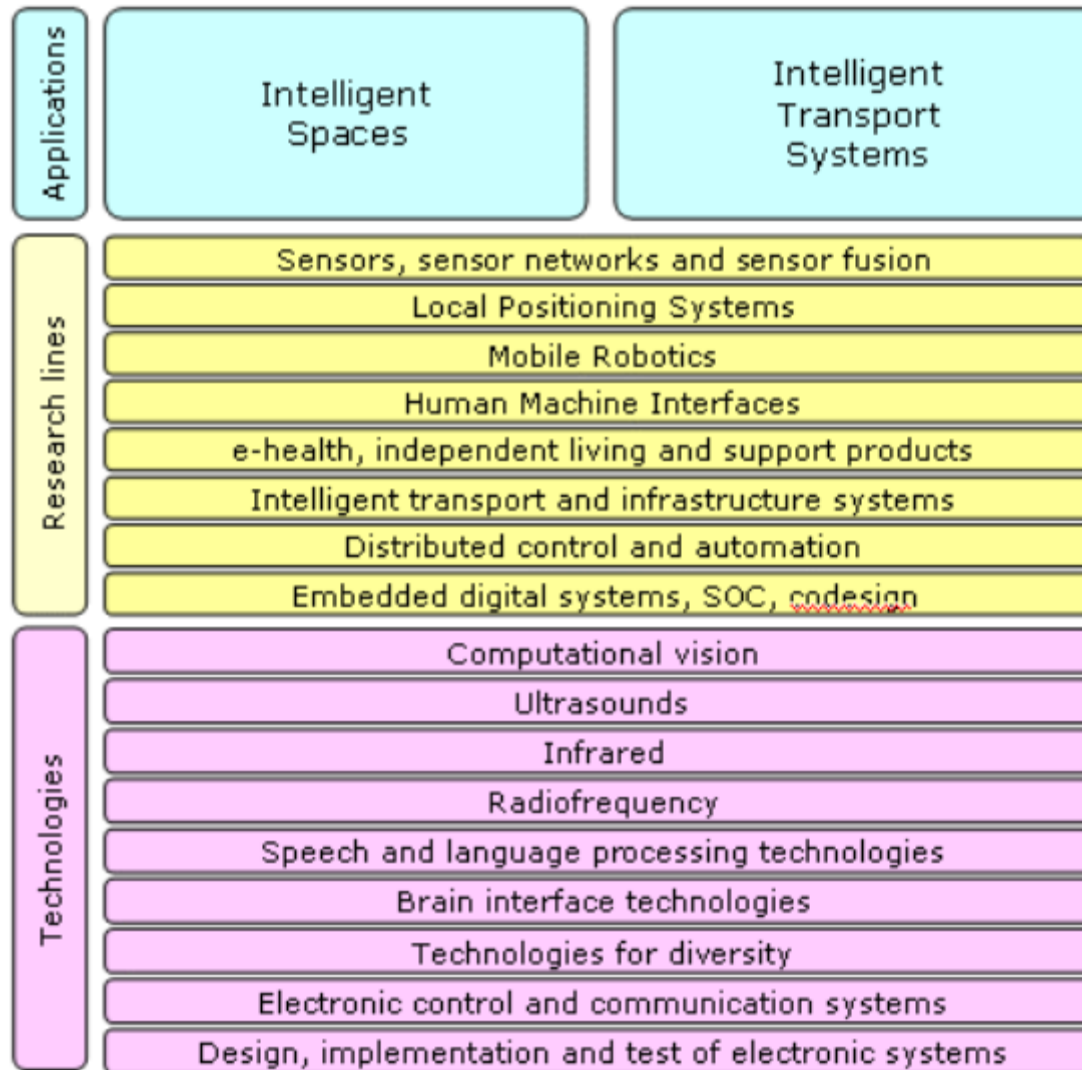- 15 scholarships
- 20 hired engineering

23 Dr.

FPI/FPU: 17
Contratados: 7
Becarios: 12
Admin.: 1

Covering different knowledge areas:

- SMART Sensors
- SMART Environment
- Image processing
- Signal processing
- Electronic Design
- Control Technics

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Activity areas

Applications
- Intelligent Spaces
- Intelligent Transport Systems

Research lines
- Sensors, sensor networks and sensor fusion
- Local Positioning Systems
- Mobile Robotics
- Human Machine Interfaces
- e-health, independent living and support products
- Intelligent transport and infrastructure systems
- Distributed control and automation
- Embedded digital systems, SOC, codesign

Technologies
- Computational vision
- Ultrasounds
- Infrared
- Radiofrequency
- Speech and language processing technologies
- Brain interface technologies
- Technologies for diversity
- Electronic control and communication systems
- Design, implementation and test of electronic systems

Current and recent projects

- **With <u>public funding</u>, last 5 years: 4.4 M€**

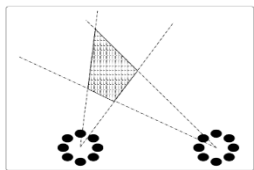 - **LEMUR, THOR, SD-TEAM, VISNU, MANTIS, SIGVE, DETECTREN, ESPIRA, AVIZOR, SIAUCON, ALCOR**
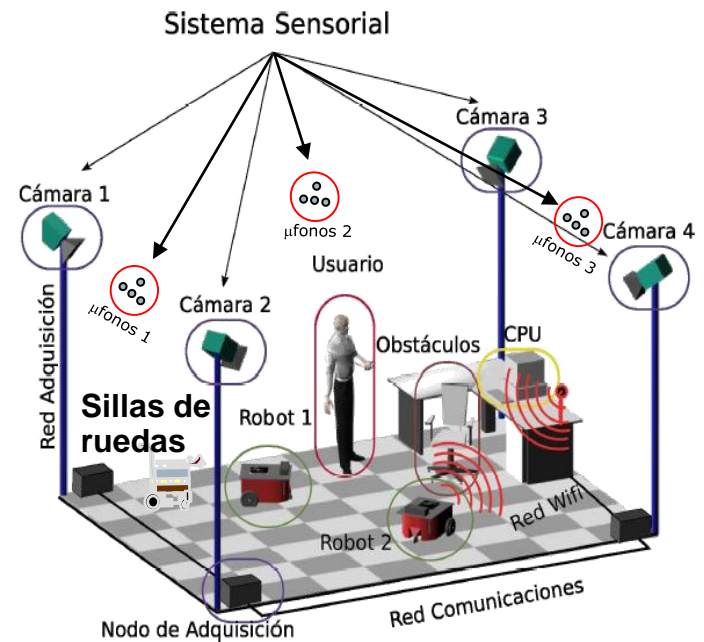
- **With <u>private funding</u>, last 5 years: 6 M€**

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- **AUDIOVISUAL FUSION TECHNOLOGIES FOR MULTI-DOMAIN SPEACH DIALOGUE**

- **Objective**: Robust systems development for detection, localization, tracking and multi-modal pose estimation of multiple speakers in intelligent spaces based on audio-visual sensorial fusion.

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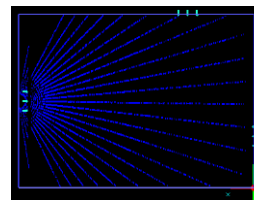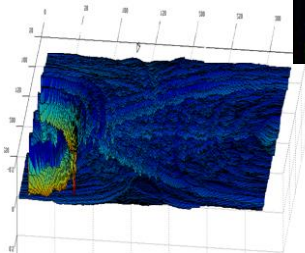
IDENTIFICATION AND INTERACTION OF MULTIPLE AGENTS IN INTELLIGENT SPACES USING CAMERA ARRAYS (VISNU)

- **Objective**: System design for analysis and interaction with agents/users, static as well as in movement, by means of cameras located inside the intelligent space.

  - Identification and localization of robots, humans and obstacles:
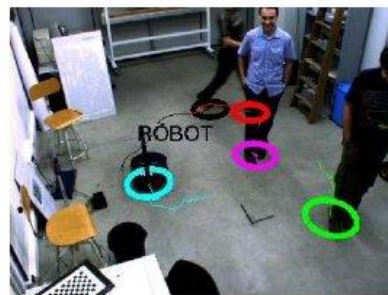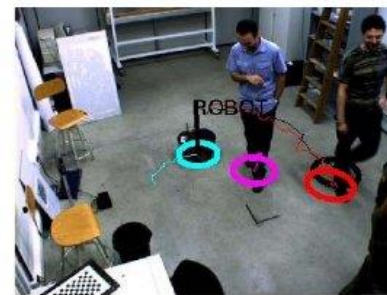
• Real time algorithms
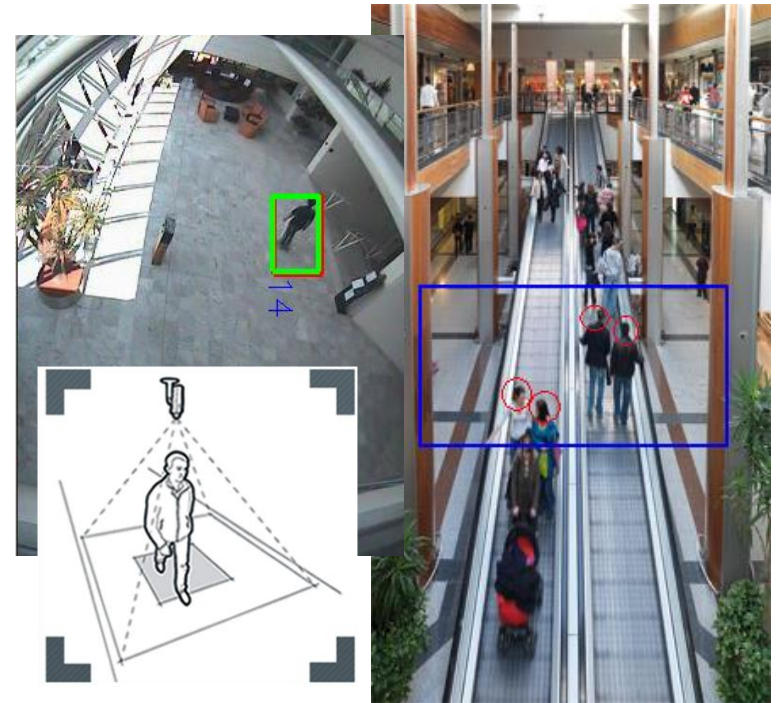
• Robust for cluttered and crowded scenes
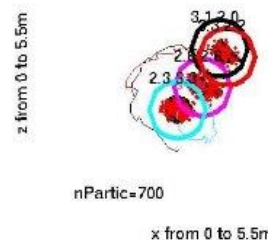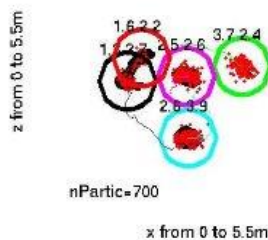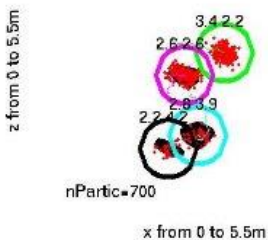
Fig. 6.   Localization in a real environment

Detection and Counting People. Access Control.

- Goal: Design of an ad-hoc system based on Image Processing oriented to the detection and counting people in an indoor area with high accuracy (≈ 95%)

- Target: Access control to areas, supervision of reserved areas, energy efficiency, market analysis, etc.

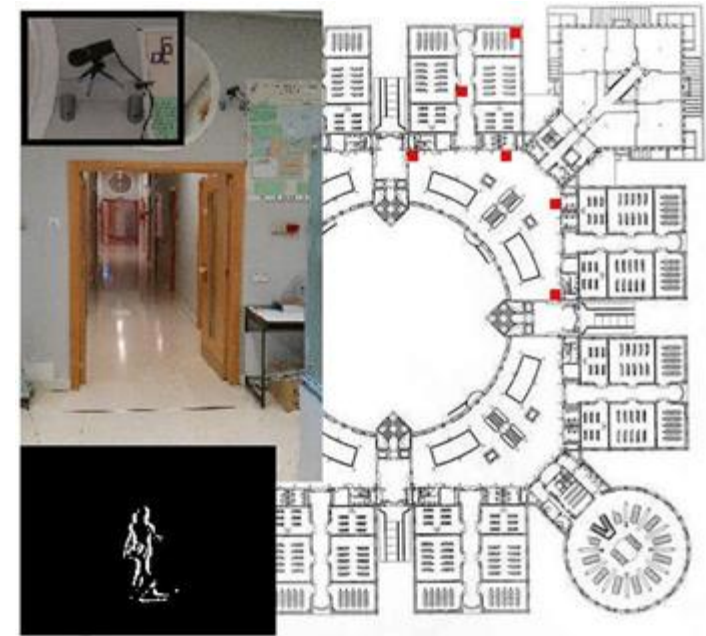**Smart Spaces – Intelligent Transport Systems**
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System based on SMART Cameras Array

Implementation of SMART cameras oriented to the tracking of moving objects .

Development of 2 demonstrators:

A) For people tracking (indoor)

B) For vehicle tracking (outdoor)

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IR-LPS. Differential Phase-Shift Digital Measurement of IR-Signal.

- Goal: Design of an accurate and highly reproducible LPS based on a IR emitter board.

- Target: Mobile robotics in Intelligent Spaces, assistance robotics, industrial automation, object tracking.

Signal digitization

PC d_{ij} , d_{ik} ... d_{in} → Pose
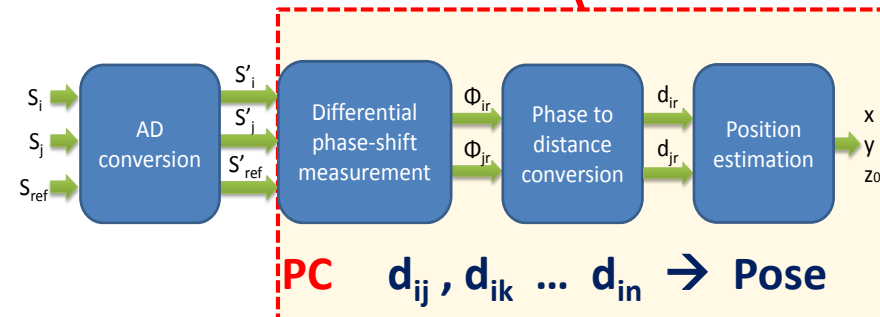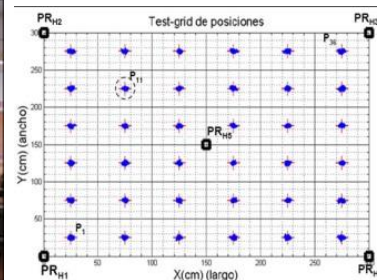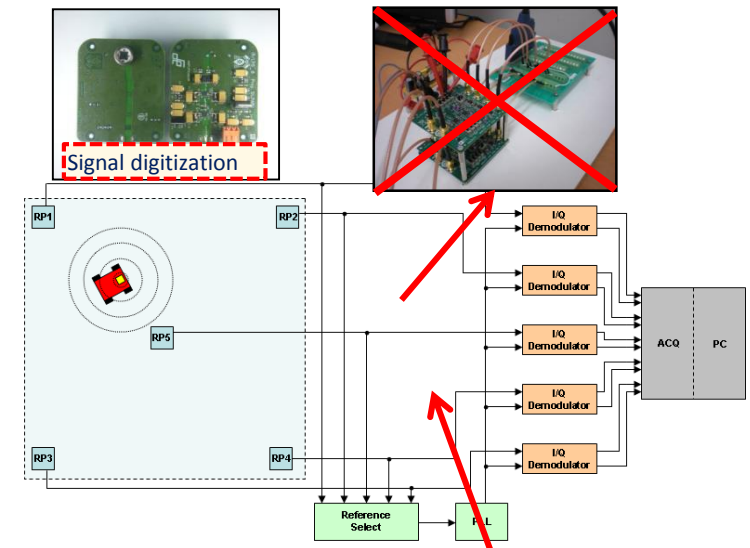
ARTEMIS (CAM-DPI)
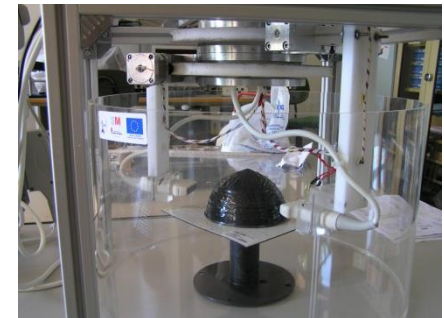
Advanced Real-TimE Multimodality medical Imaging

- Ultrasound tomography
- Nuclear imaging
- Real time multimodality image tracking and registration
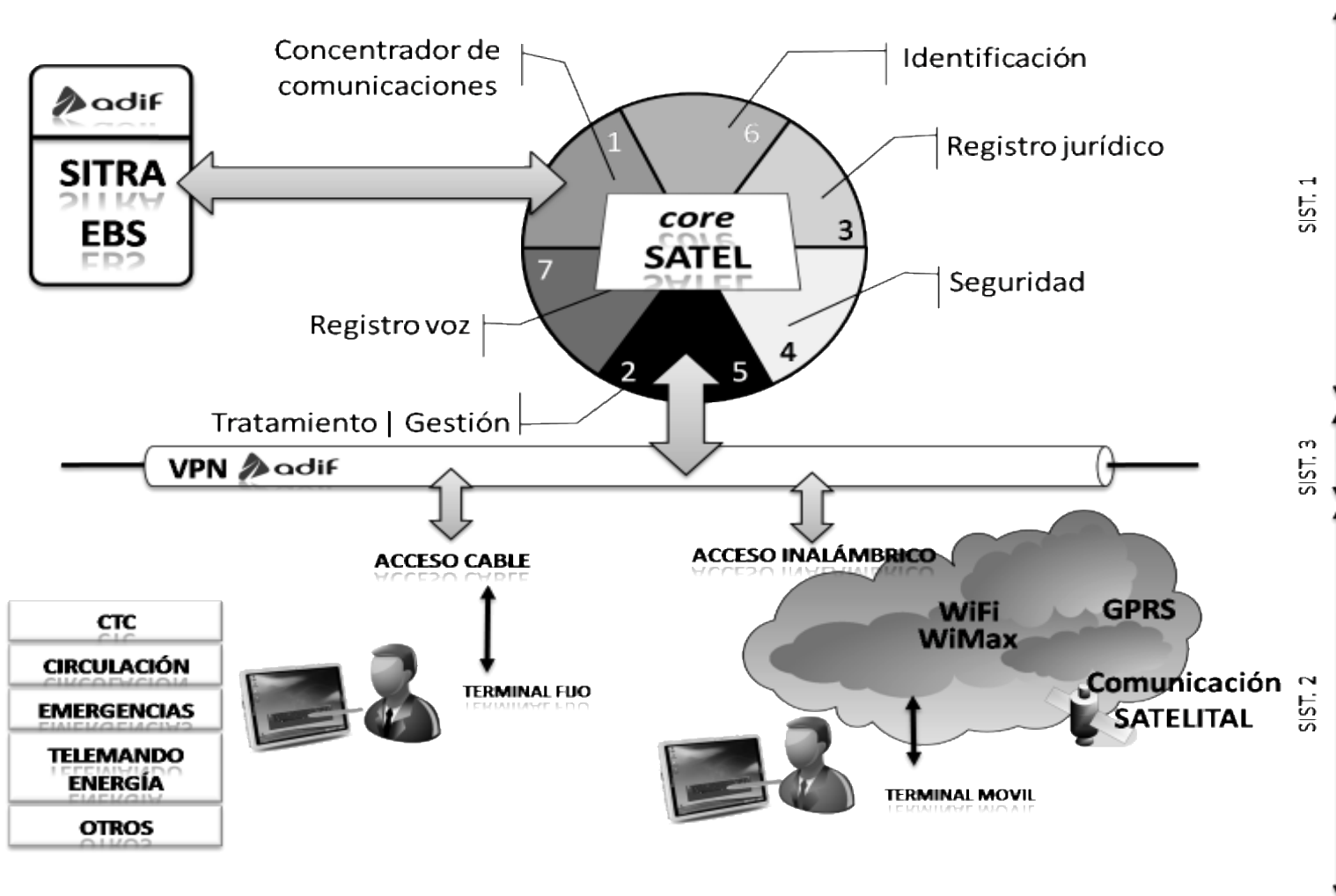
Partners-research groups:

- GM Hospital, CSIC, UAH, UPM, UCM

GOAL: Development of a technique to generate an ultrasonic image for ultrafast and high resolution tomography (HiRUT).

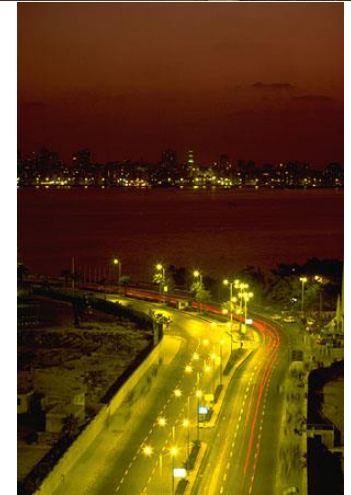Our group is responsible for developing a high performance FPGA based architecture for this technique.

eBook Railway (eBR)

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Smart Infrastructures

- Goal: Distributed Intelligent based on "*a neuron for each street-LED lighting*" oriented to provide RT information to the driver and the Supervision Center. Mesh inter-communication of nodes.

- Targets:

  - Light level adapted to the vehicles/people detection.

  - Building street-lighting networks sharing information with an ad-hoc Wireless Network to report information to other drivers and/or Central Node.

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SMART THINGS LAB (ADVANTICSYS)

- R&D laboratory for a Spanish SME.
- Development of different Industrial applications based on WSN (Wireless Sensor Networks).
- Deployment of WSN in different scenarios (environment, SMART Cities, SMART Labs, ….)
- Study, assessment and implementation of different R&D prototypes based on motes.

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Demo: RM´s pose based on landmarks recognition

- Objetivo:

  - A partir de un mapa "a priori" (geométrico-topológico) del entorno, y de la identificación del entorno (matching de marcas naturales), se estima la posición del RM (localización probabilística)
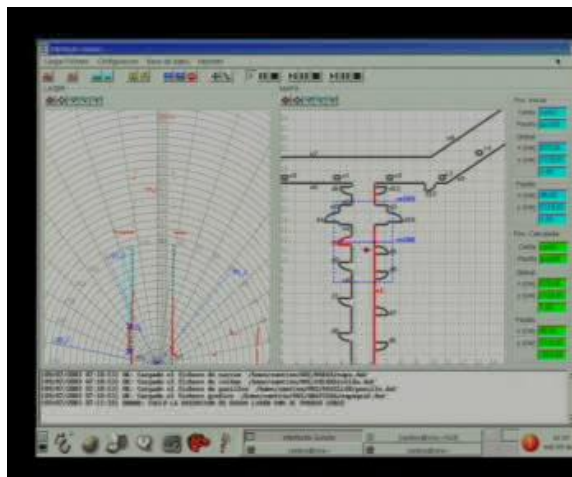
  Modelo del entorno

 - BDML
    - *Coordenadas globales y orientación*
    - *Dimensiones*
    - *Enlaces*
    - *Celdas*
  - BDCM
    - *Paredes*
    - *Puertas*
    - *Esquinas*
    - *Columnas*

Leyenda

- Wi: Pared
- Ci: Columna
- Ei: Esquina
- Di: Puerta
- Ri: Habitación
- X, Y: Eje de coordenadas absolutas
- (Xpi,Ypi): Coordenadas absolutas de el origen de coordenadas local
- ϕ_{Pi}: Inclinación de los ejes de coordenadas locales
- X'pi,Y'pi: Ejes de coordenadas locales
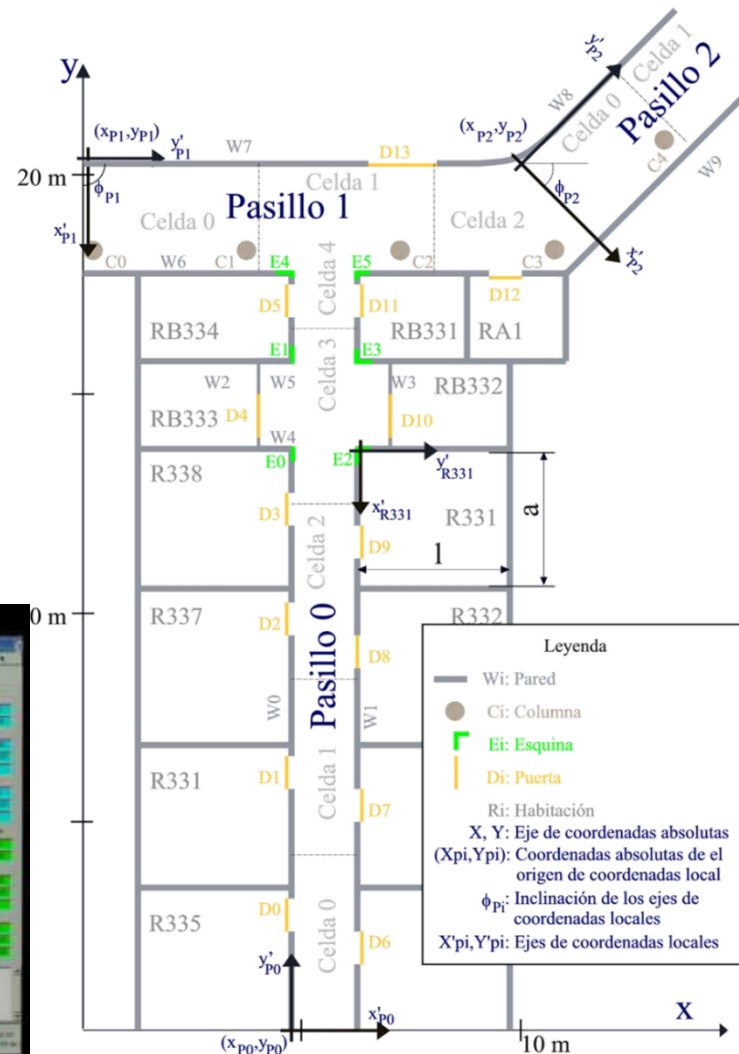
Demo: Objects tracking

- Objetivos: Seguimiento de múltiples objetos utilizando visión artificial en entornos interiores muy poblados basado en la combinación de métodos probabilísticos y determinísticos.
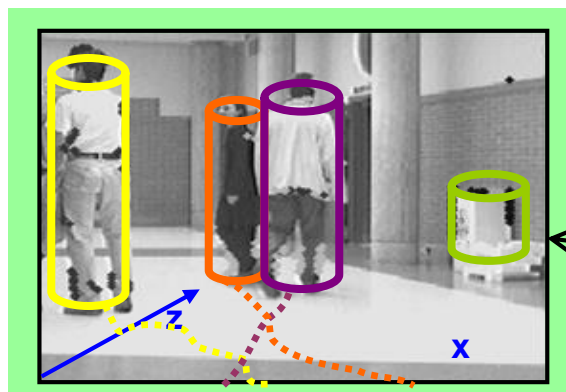

Estimation with a PF: Re-initialization.

Estimation with PF: Prediction.
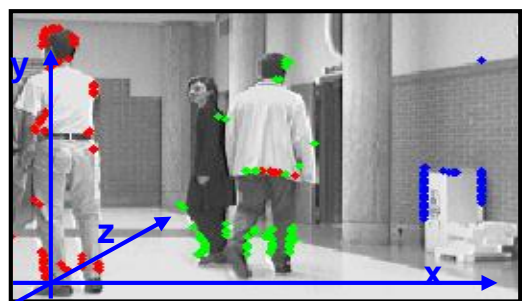
Clustering Measurement

Estimation with PF: Association + Correction.

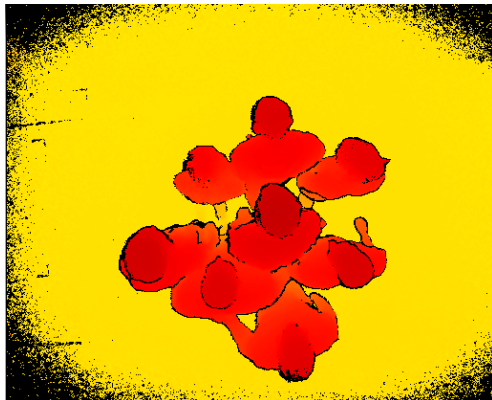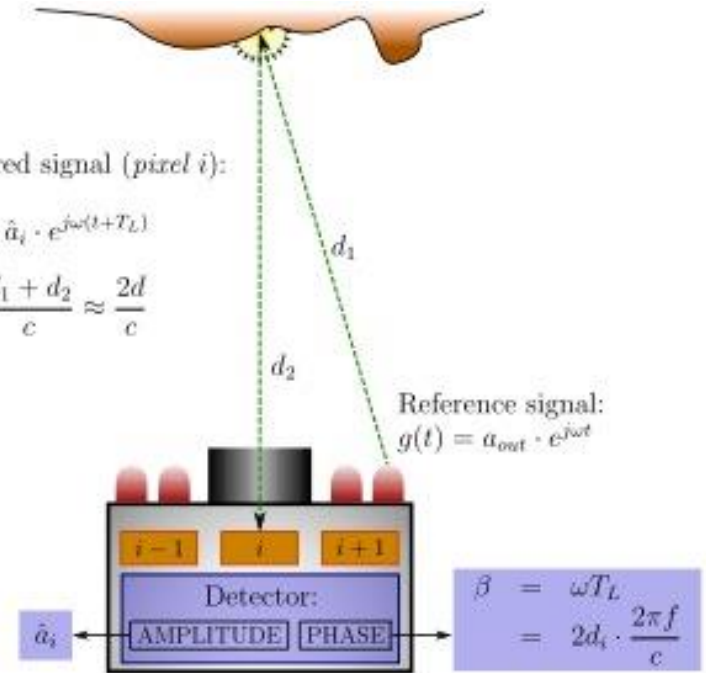Estimation with PF: Selection.

Clustering the Particle Set

XPFCP

Demo: 2.5D Vision based on ToF camera: Fundamentals
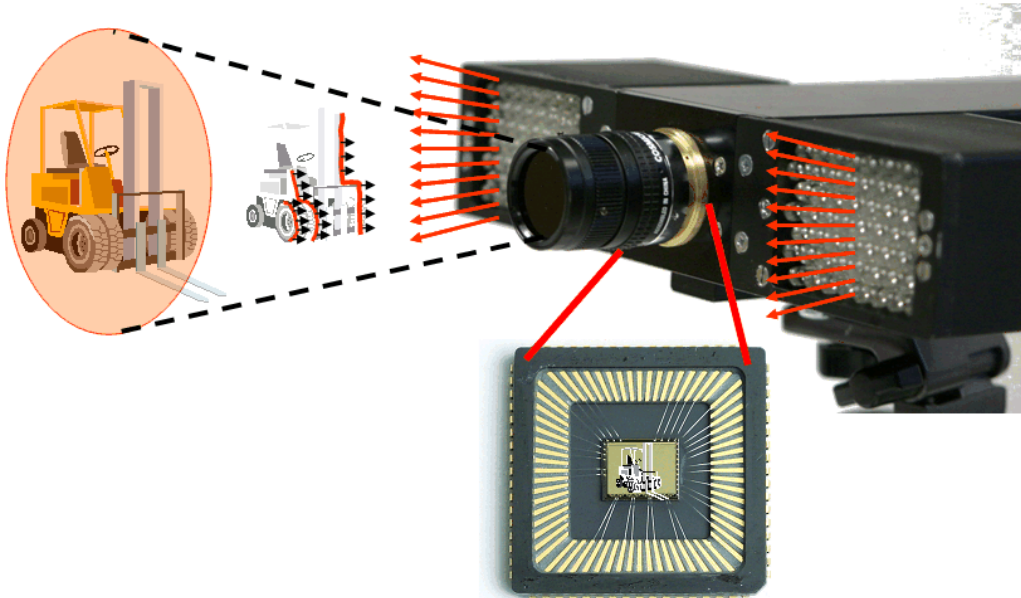
Measured signal (*pixel i*):

$$s_i(t) = \hat{a}_i \cdot e^{j\omega(t + T_L)}$$

$$T_L = \frac{d_1 + d_2}{c} \approx \frac{2d}{c}$$

Reference signal:

$$g(t) = a_{out} \cdot e^{j\omega t}$$

$$\beta = \omega T_L$$
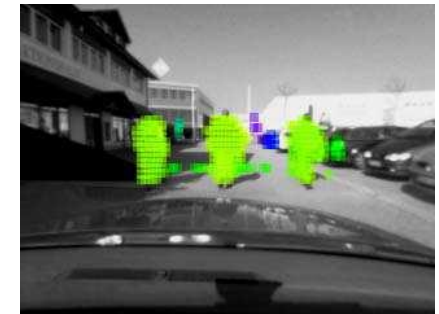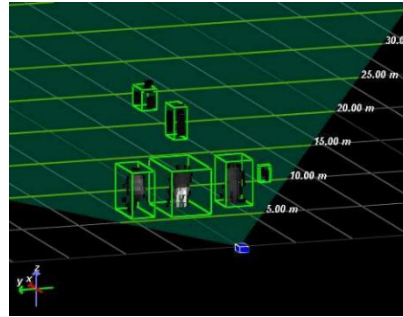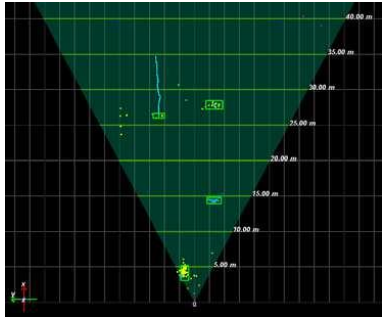$$= 2d_i \cdot \frac{2\pi f}{c}$$

Detector: AMPLITUDE PHASE

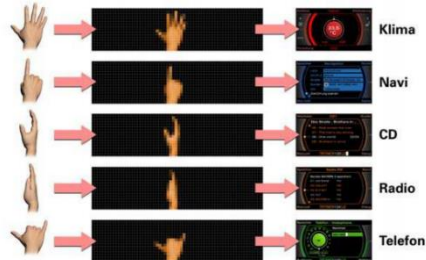Time of Flight Imaging based on PMD principle [Moller et al., 2005]

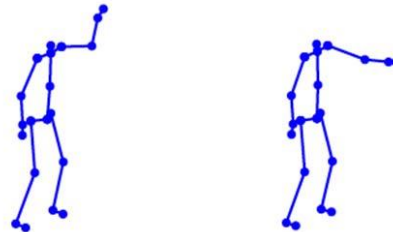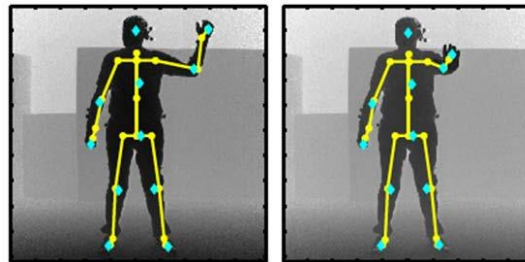## Demo: 2.5D Vision based on ToF camera: Applications

Automotive (Pedestrian detection)

User interaction (Gesture recognition)

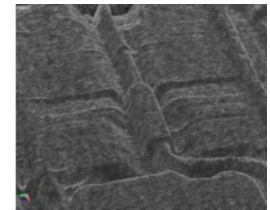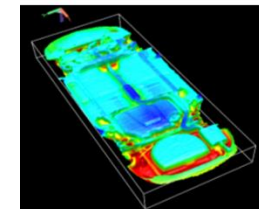

3D Point Cloud Processing (Skeleton detection)

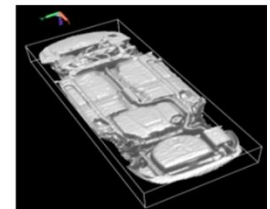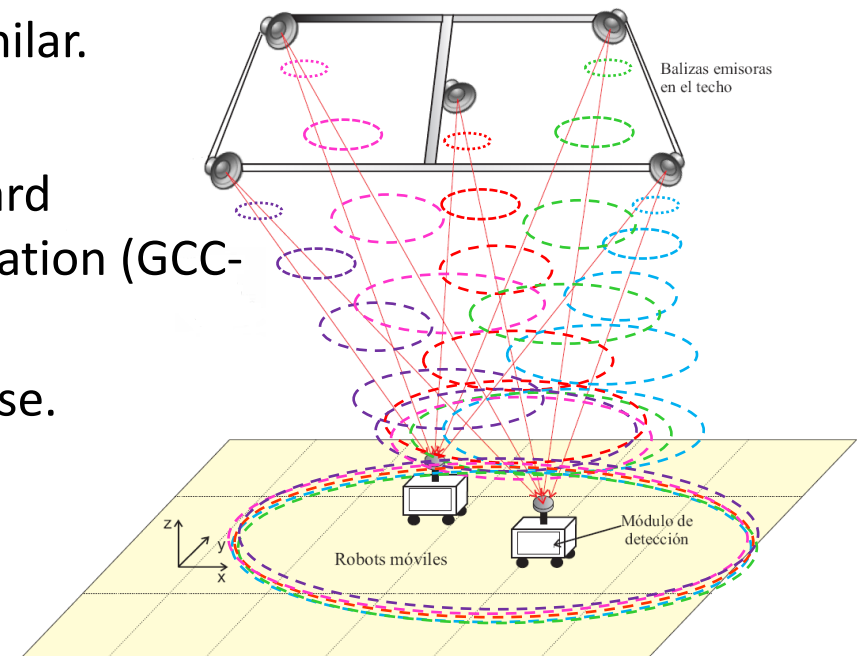

Industrial (Vehicle inspection)

Design of an U-LPS with wide coverage using coding techniques

- ☐ Decentralized ULPS without emitter-receiver synchronism.

- ☐ Coverage improvement.

- ☐ Beacons' emissions based on multiaccess techniques
  - ▪ CDMA using *Kasami* sequences or similar.
  - ▪ Combined CDMA with TDMA

- ☐ Detection at the receiver based on Standard Correlation or in Generalized Cross-Correlation (GCC-PHAT).

- ☐ Improvement of immunity to ISI, MAI, noise.

Balizas emisoras
en el techo

Módulo de
detección

Robots móviles

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ALCOR (MINECO 2014-2016)

- Main challenge

  Optimization of local and shared resources in environments with multiple sensorial modules -**SM**- which service multiple robotic mobile units -**MU**-, using a wireless communication network –**WN**- as link.

- Main research activities

  - UAH (ALCOR/IRME): DPI2013-47347-C2-1-R
    - Sensory decision strategies and
    - Control sampling adapted to the system needs,

  - UCO (RESI): DPI2013-47347-C2-2-R
    - Efficient use of the communication channel guaranteeing a safe interaction between nodes.