

# **INSTITUTE for SYSTEMS and ROBOTICS**

(v2015.V9. May1st 2015)



# Outline

- Mission and vision
- Facts and figures
- Research
  - Computer and Robot Vision (VisLab)
  - Dynamical Systems and Ocean Robotics (DSOR)
  - Evolutionary Systems and Biomedical Engineering (LASEEB)
  - Intelligent Robotics Systems (IRSg)
  - Signal and Image Processing (SIPg)
- Advanced training
- Tech transfer
- Conclusions





# Mission and Goals

**ISR-Lisbon** is an RD&I institution, affiliated to the Instituto Superior Técnico (IST), where multidisciplinary advanced research activities are developed in the areas of Robotic Systems and Information Processing,

## **Research domains:**

Systems and Control Theory, Robotics, Signal Processing, Computer Vision, Optimization, AI and Intelligent Systems, Biomedical Engineering.

## **Three-fold activities:**

Research, advanced training and outreach



# Facts and figures

Foundation: 1992

# Faculty: 31

# Post docs: 12

# PhD students: 82

# PhD theses awarded (2014): 9

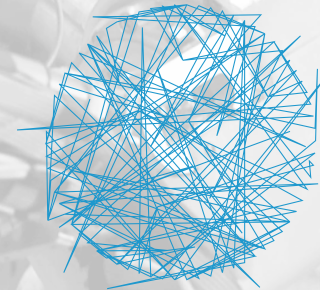
Funding (2008-12):

FCT: 7,4M€

EU: 4.8M€

Other: 0.7M€

Member of



**LARSyS**

Laboratory of Robotics  
and Engineering Systems



# Outline

- Mission and vision
- Facts and figures
- **Research**
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  - Dynamical Systems and Ocean Robotics (DSOR)
  - Evolutionary Systems and Biomedical Engineering (LASEEB)
  - Intelligent Robotics Systems (IRSg)
  - Signal and Image Processing (SIPg)
- Advanced training
- Tech transfer
- Conclusions

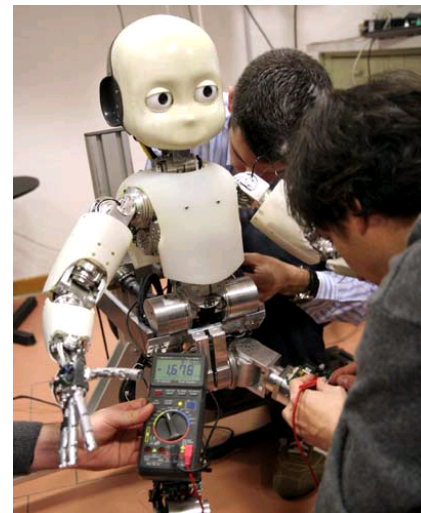
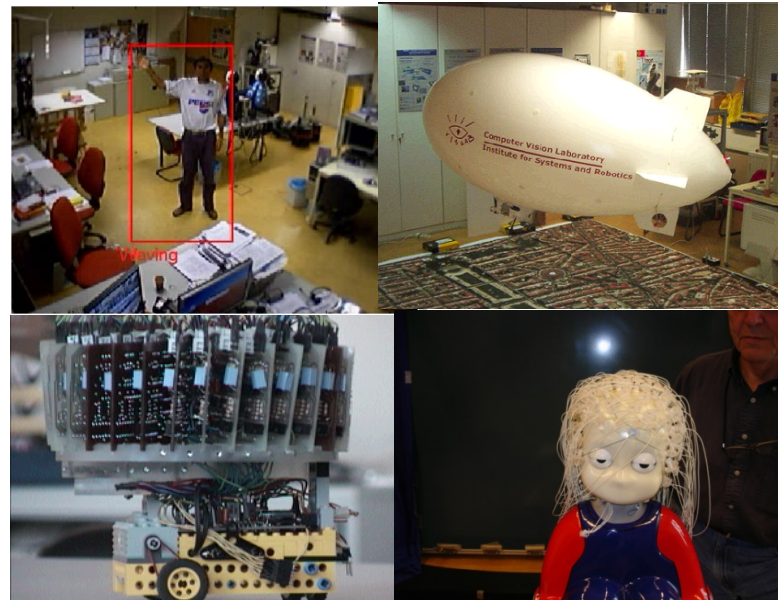


# Computer and Robot Vision Lab (VisLab)

## Research Areas

- Image Analysis & Surveillance
- Visual Navigation & Calibration
- Bioinspired Vision and Learning
- Cognitive Robots

- 9 Phds (4 Faculty + 5 PostDocs)
- 16 PhD students
- 8 PhDs awarded (2013/2015)
- Hosts of the iCub





# Research @ VisLab: Image Analysis & Surveillance

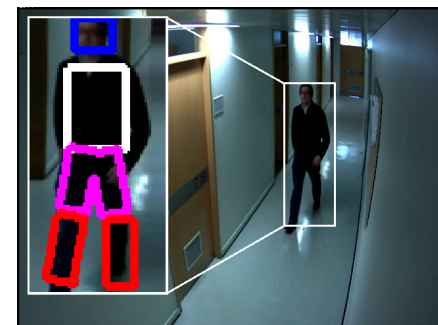
## Projects:

- CAVIAR (EU-FP6)
- URUS (EU-FP7)
- DICORE2S (EU-FP7)
- HDA (QREN)
- SEAGULL (QREN)
- MAIS-S (CMU-PT)
- ARGUS (FCT)

Gesture and activity recognition



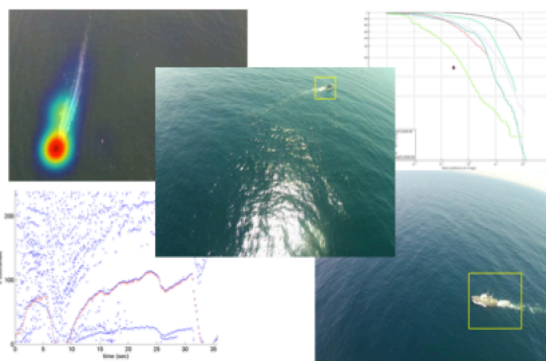
People detection, identification and tracking



Behaviour Modeling



Airborne Surveillance



Camera/Robot Networks





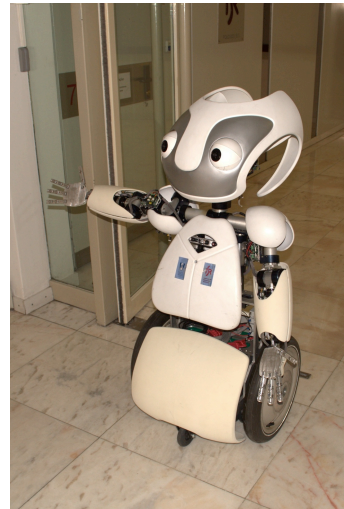


# Research @ VisLab: Visual Navigation & Calibration

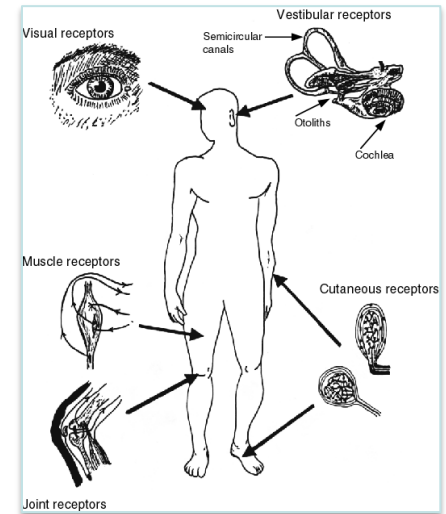
## Projects:

- NARVAL (EU-FP5)
- FIRST-MM (EU-FP7)
- ROBOSOM (EU-FP7)
- DCCAL (FCT)

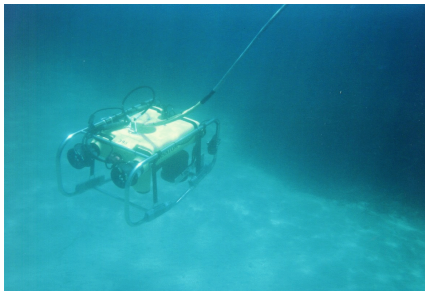
Visual Navigation



Robotic sense of motion



Underwater Vision



Aerial Vision



Mobile Manipulation



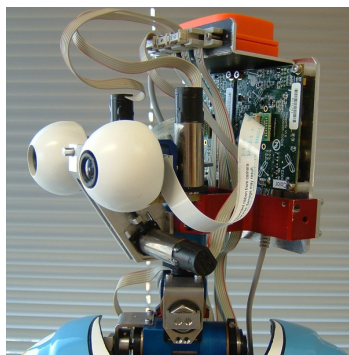


# Research @ VisLab: Bioinspired Vision & Learning

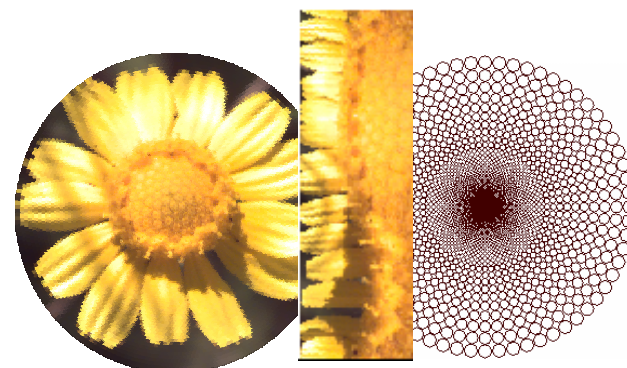
## Projects:

- ROBOTCUB (EU-FP7)
- OMNIVIEWS (EU-FP5)
- BIOLOOK (FCT)
- BIOMORPH (FCT)

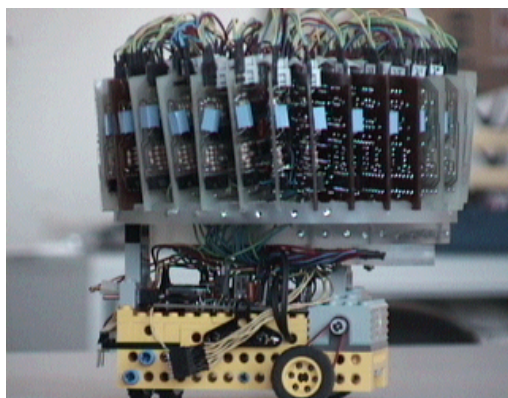
## Visual Attention



## Foveal Vision



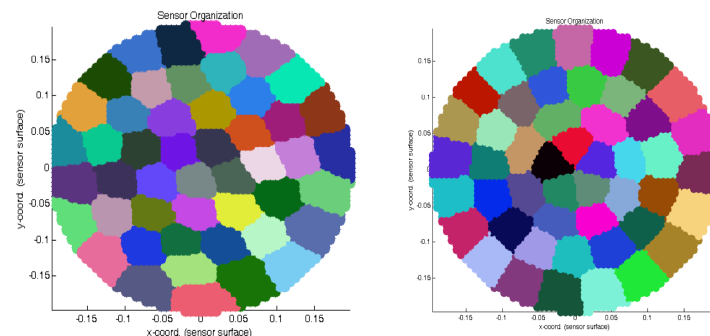
## Insect-like vision



## Omnidirectional sensors



## Self-developing retina



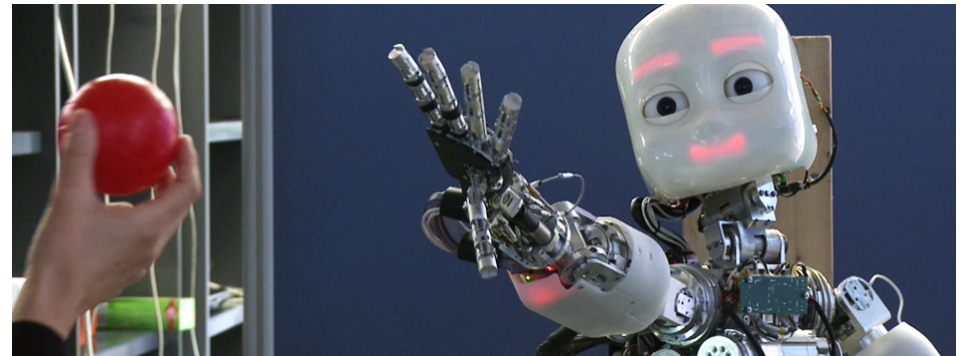


# Research @ VisLab: Cognitive Robots

## Projects:

- POETICON++ (EU-FP7)
- HANDLE (EU-FP7)
- CONTACT (EU-FP6)
- MIRROR (EU-FP5)
- AHA (CMU-PT)

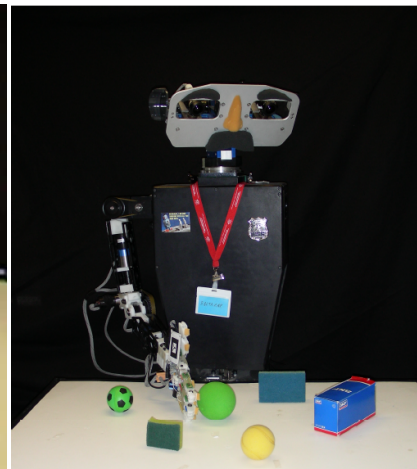
## Human Robot Interaction



## Grasping & Manipulation



## Object Affordances



## Tool learning



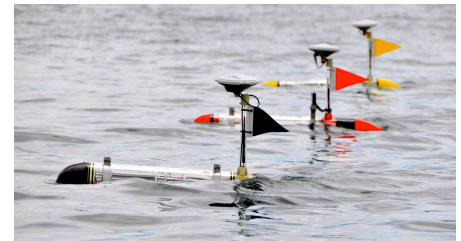
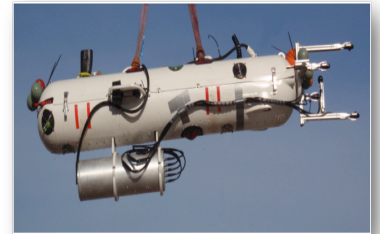




# Dynamical Systems and Ocean Robotics group (DSOR<sub>G</sub>)

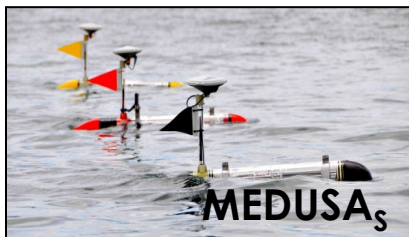
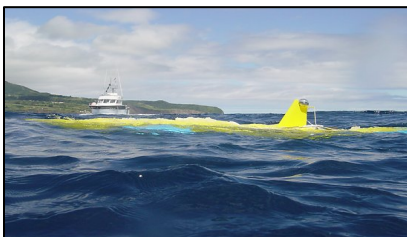
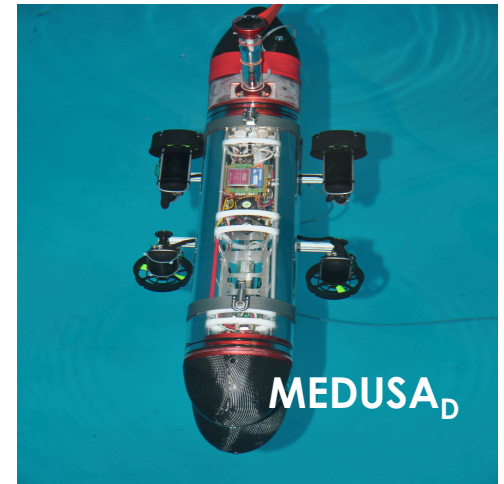
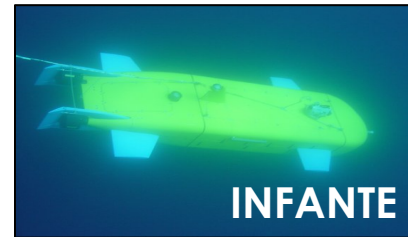
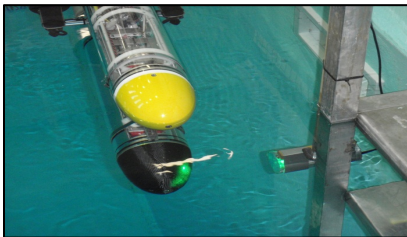
## Areas of intervention:

- Technologies for ocean exploration including networked air and marine robots
- Robotic systems for the inspection of critical marine infrastructures





# R&D capabilities / major achievements

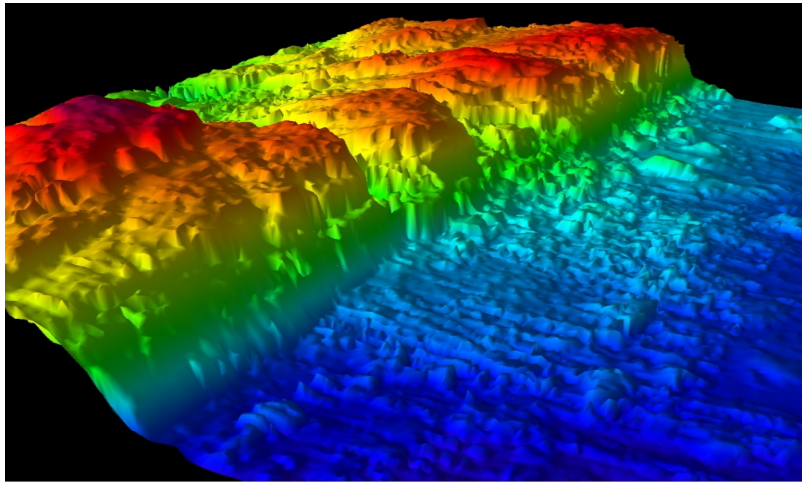


**Fleet of 4 autonomous Surface and  
2 underwater robots  
Underwater optical communications  
system**



# R&D capabilities / major achievements

- Joint operations involving systems / tool providers and commercial / scientific end-users in harsh environments (e.g. the Azores seas, with the Univ. Azores)

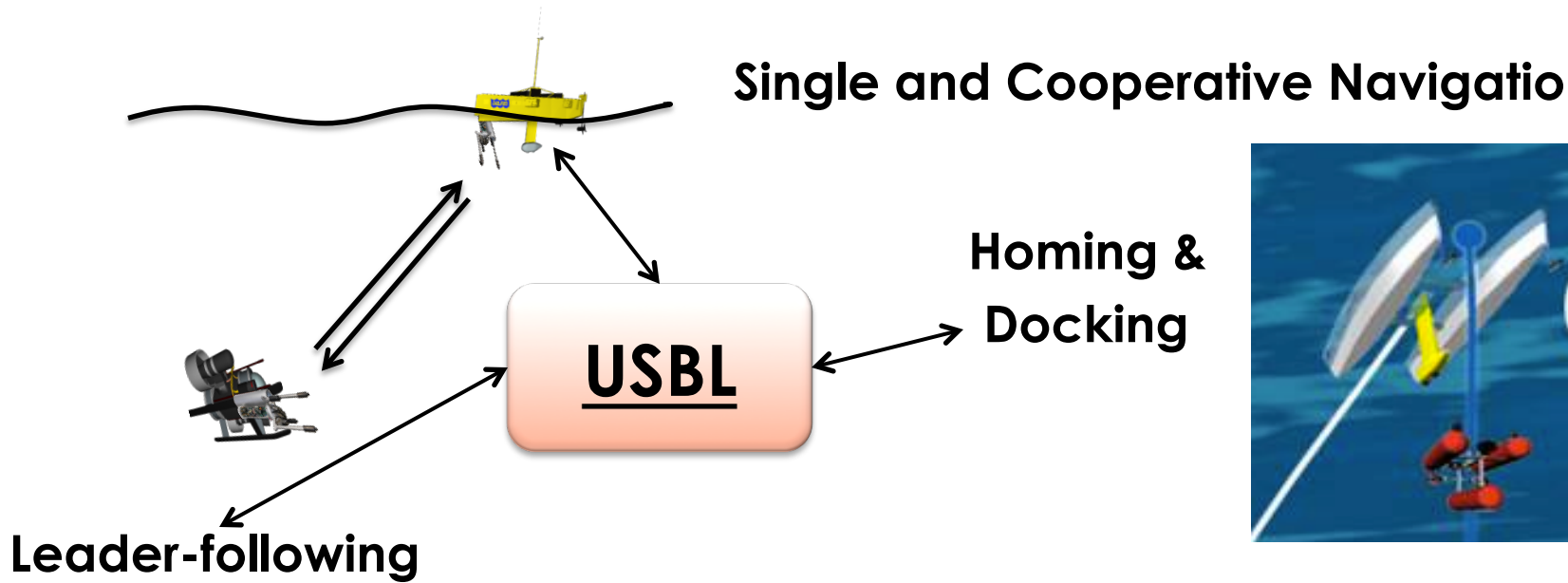


- **Bathymetric Surveys**
- **Marine Habitat Mapping**

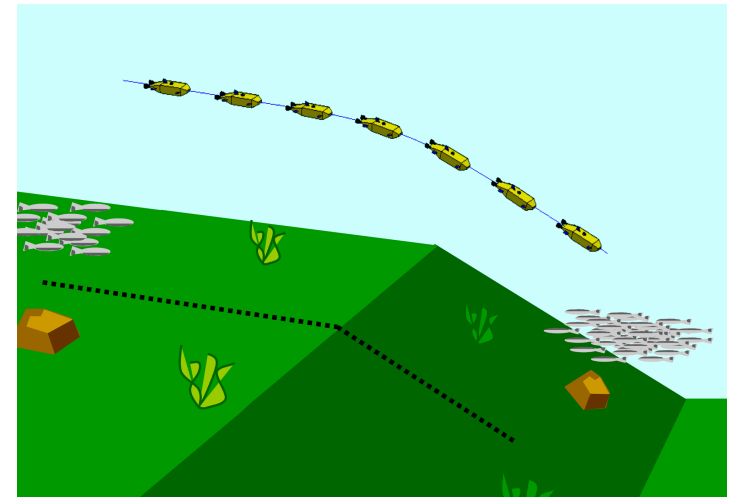
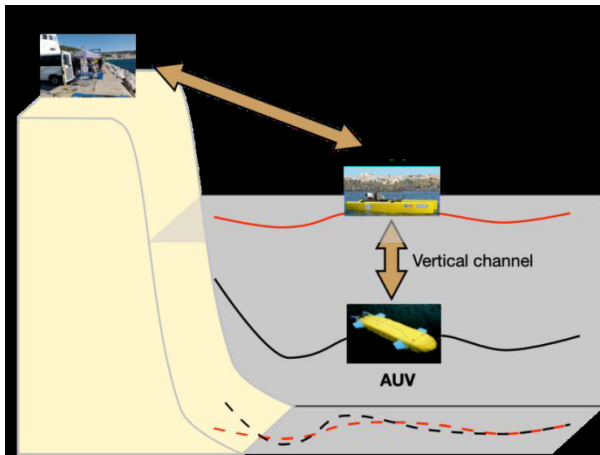


# R&D capabilities / major achievements

## Single and Cooperative Navigation



## Bottom-following

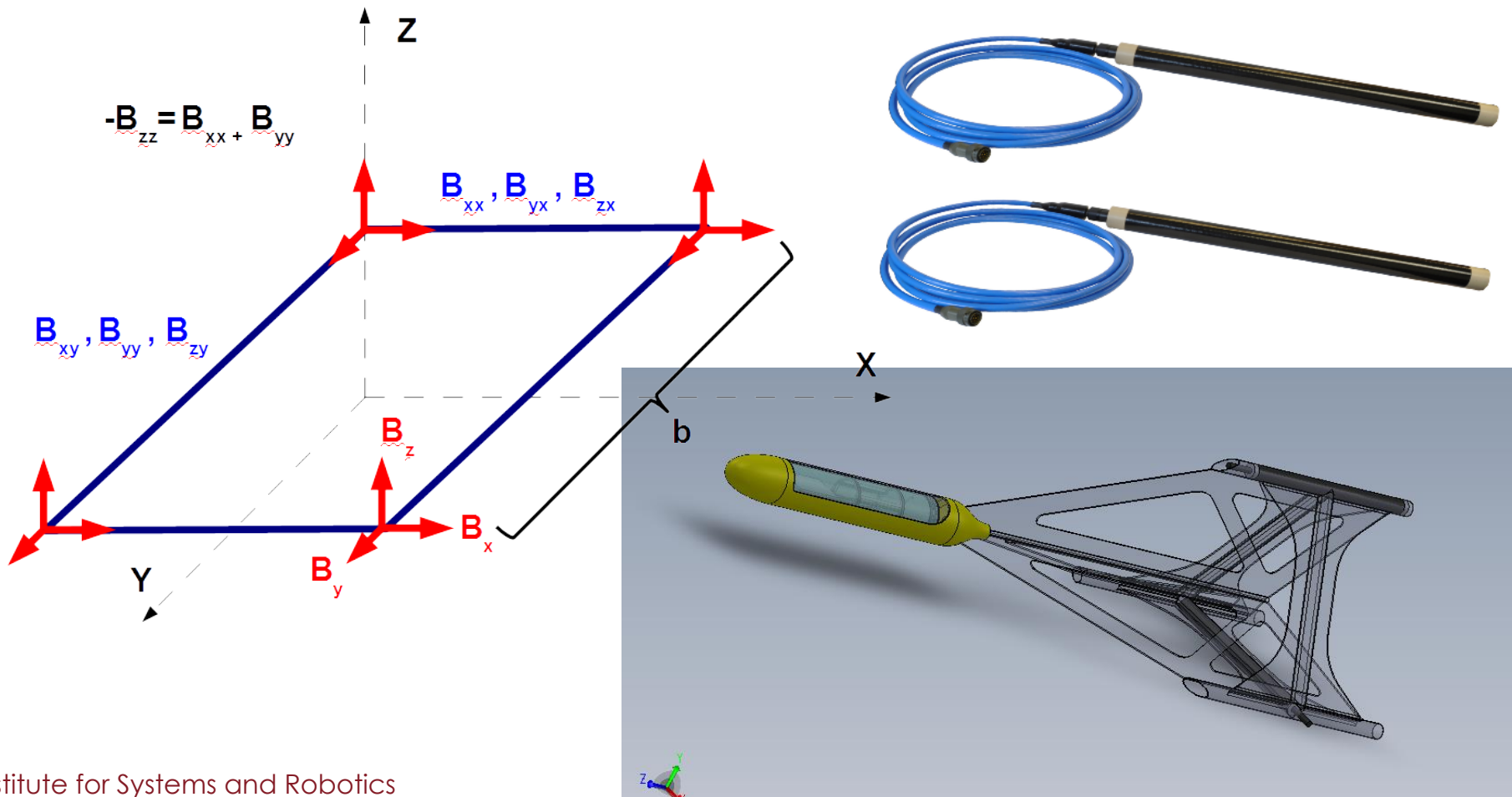






# R&D capabilities / major achievements

## Magnetic-based navigation





# R&D capabilities / major achievements

## Sensor-based SLAM

- Sensor-based dynamics
- Linear Time Varying Kalman filter
- Global stability guarantees
- Experimentally validated



## Vision and Sensor-based Control

- Vision and Lidar-based kinematics
- Trajectory tracking error-space
- Stabilizing controllers
- Nonlinear techniques

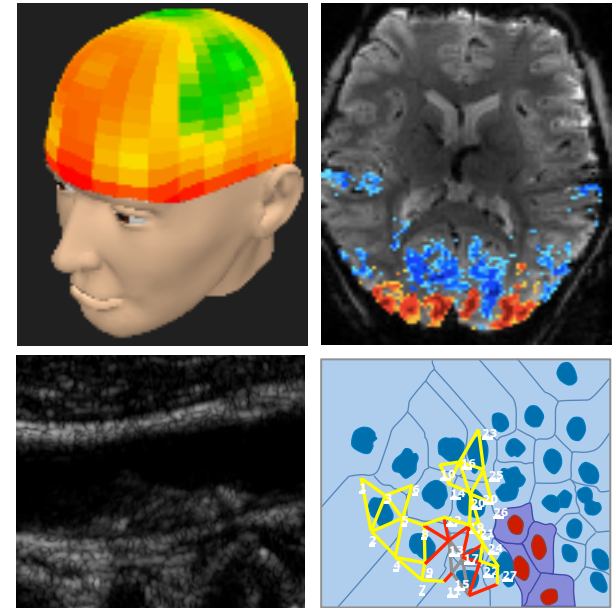




# Evolutionary Systems and Biomedical Engineering (LASEEB)

Research areas:

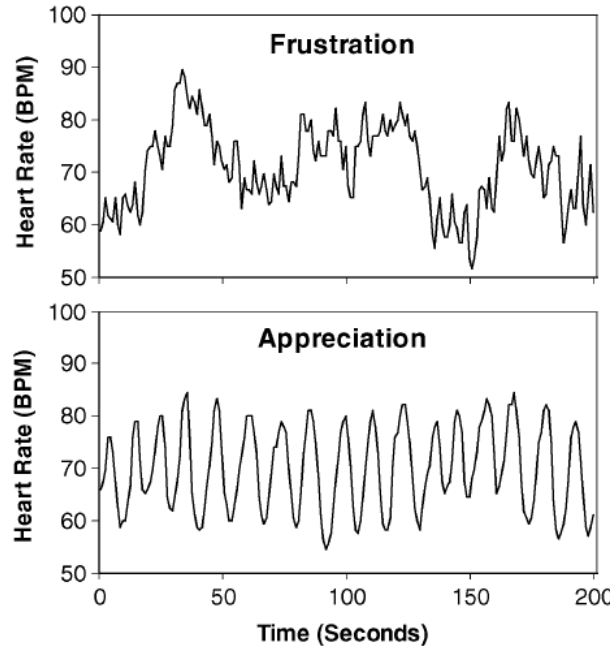
1. Neuroengineering (sleep, emotions, neurofeedback)
2. Neuroimaging (EEG, fMRI, brain dynamics and networks)
3. Biological and medical imaging
4. Biologic inspired optimization and complex systems simulation



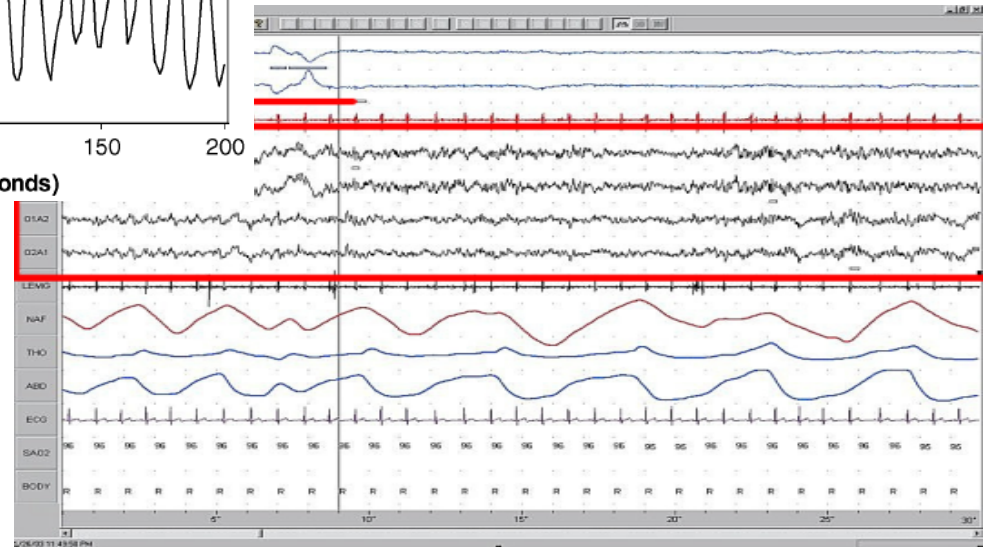
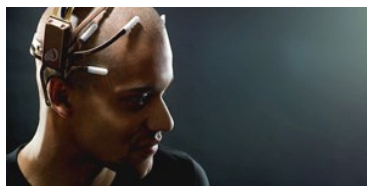
- 4 Faculty
- 2 Postdocs
- 14 PhD students
- 4 Active Projects



# Research @ LASEEB: Neuroengineering - sleep, emotions, neurofeedback



EEG

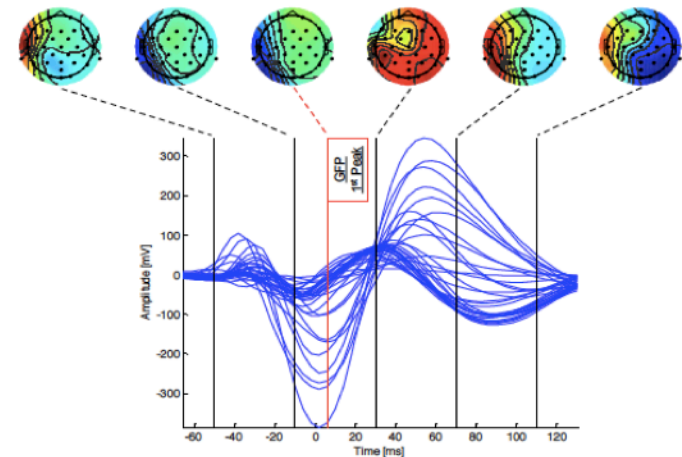
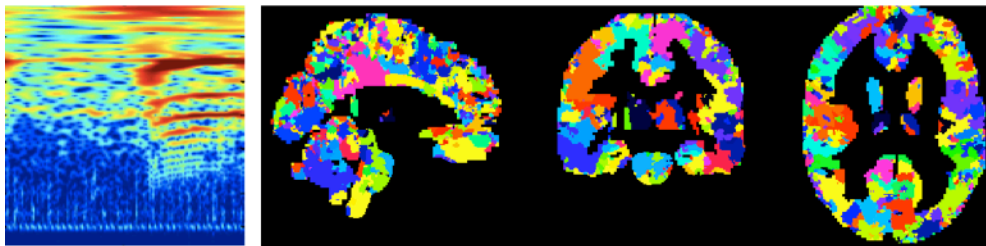
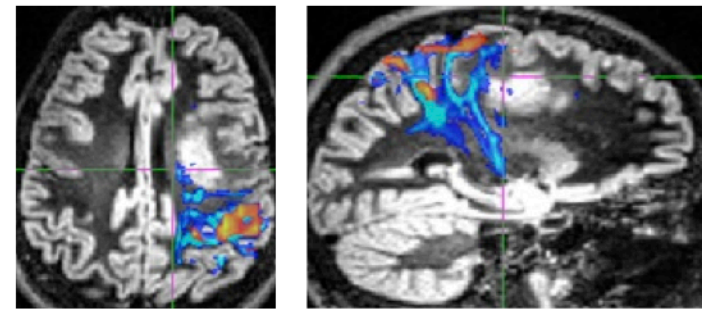
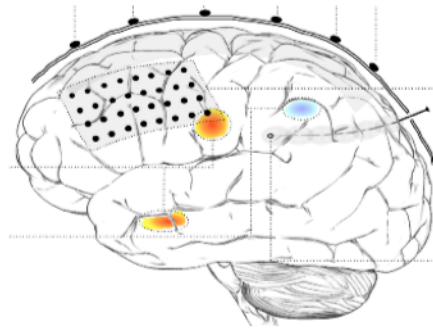






# Research @ LASEEB: Neuroimaging

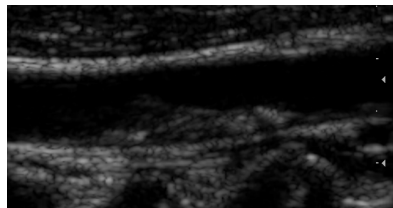
- Multimodal EEG-fMRI integration
- Brain physiology: spatiotemporal dynamics and networks
- Neuroimaging biomarkers of disease (aging, dementia)
- Presurgical mapping in epilepsy



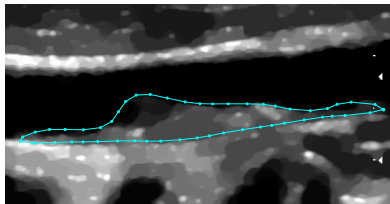


# Research @ LASEEB: Biological and medical imaging

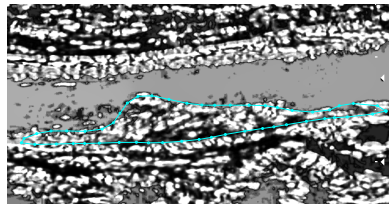
Carotid Atherosclerosis from US



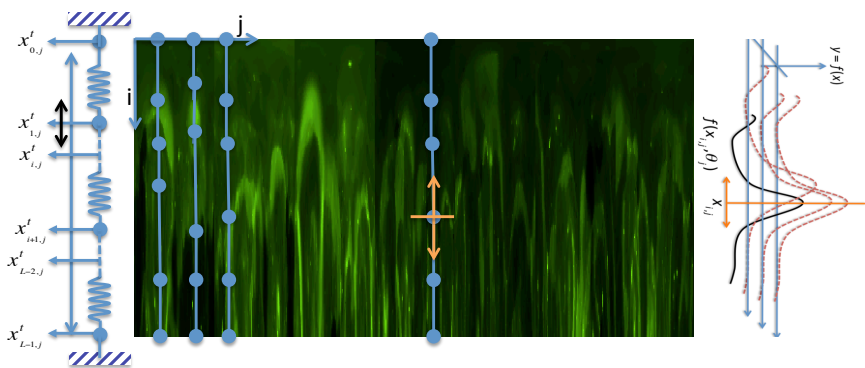
a) B-Mode



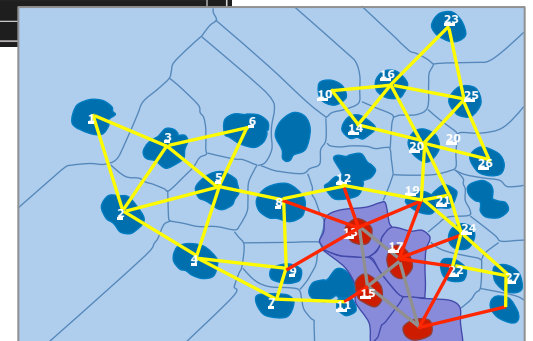
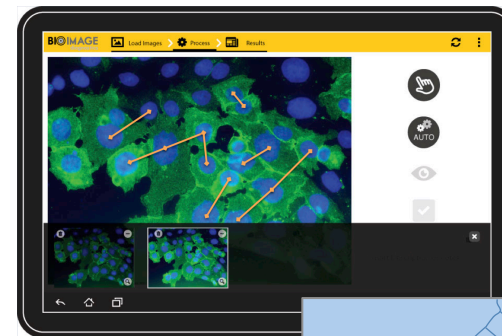
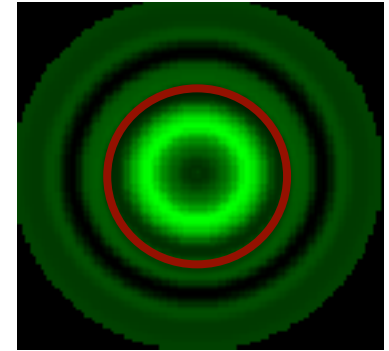
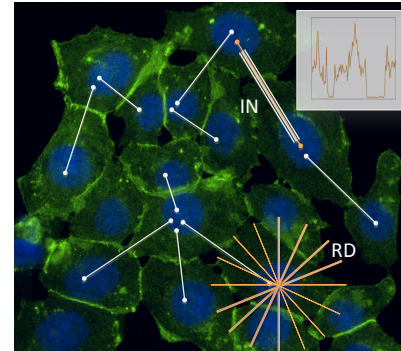
b) Despeckle



c) Speckle



## Cell profiling

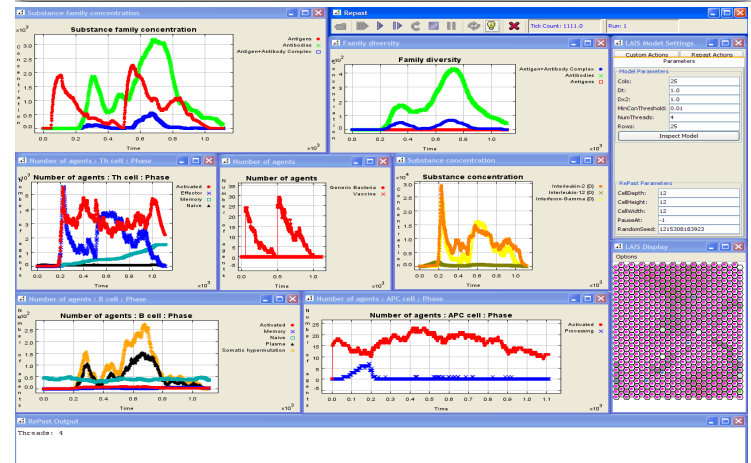
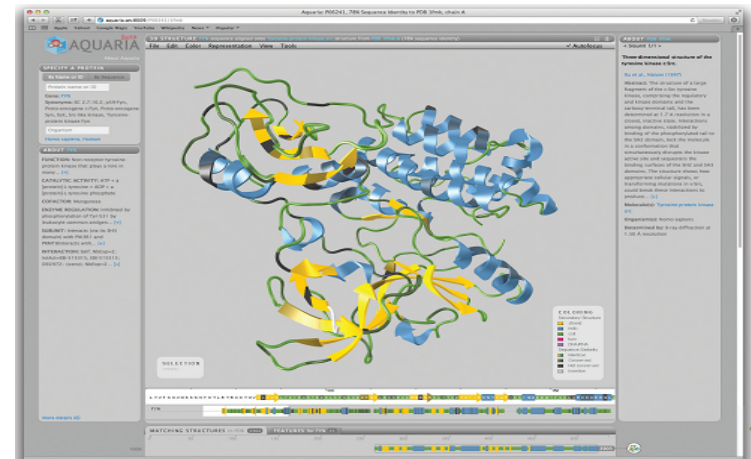
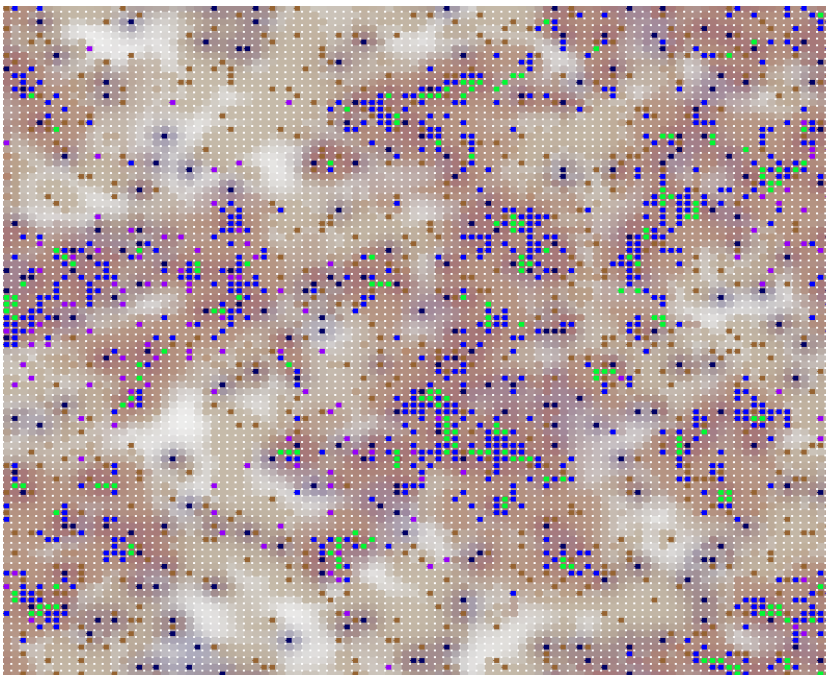




# Research @ LASEEB:

Biologic inspired optimization & complex systems simulation

- Artificial Life Dynamics
- Aquaria - Protein View





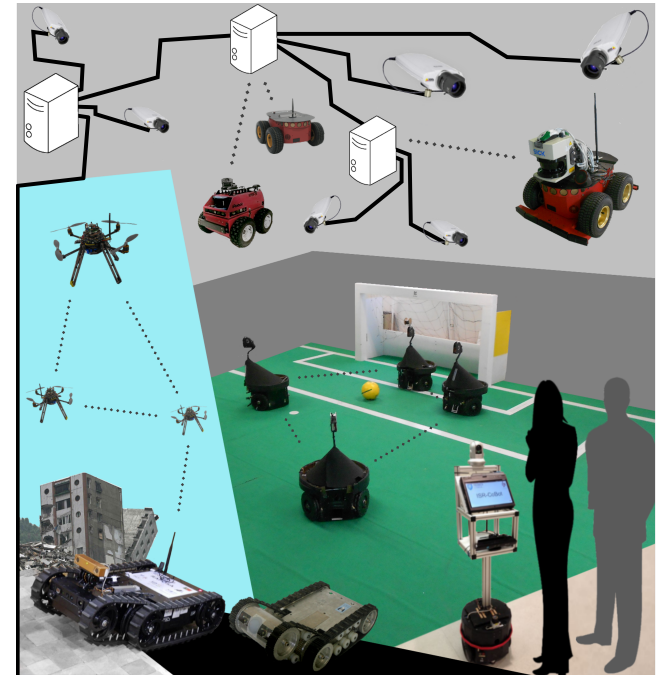
# Intelligent Robots and Systems group (IRSg)

## Research Framework:

Holistic view of complex systems control and coordination, following approaches that fuse Systems, Control, and Decision Theories with Artificial Intelligence.

## Since 2002:

- 16 PhDs finished
- Currently 5 PhD students
- 6 active faculty (IST) and 2 Post-Doctoral Fellows
- ~2.5 M€ in R&D projects (FCT, AdI, EU, ESA) through competitive funding
- 4 Books, 75 journal papers and 315 conference papers





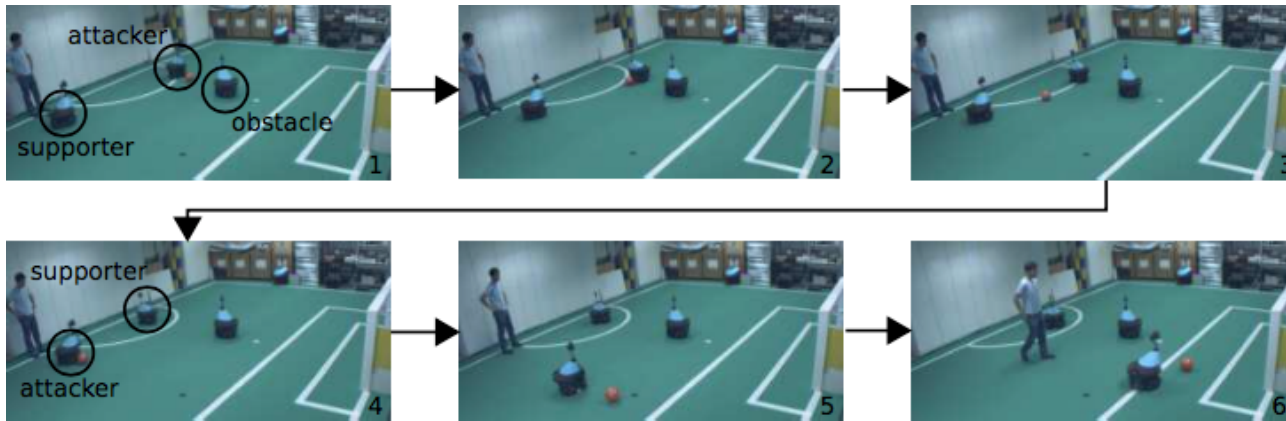


# Research interests @IRSg

cooperative perception



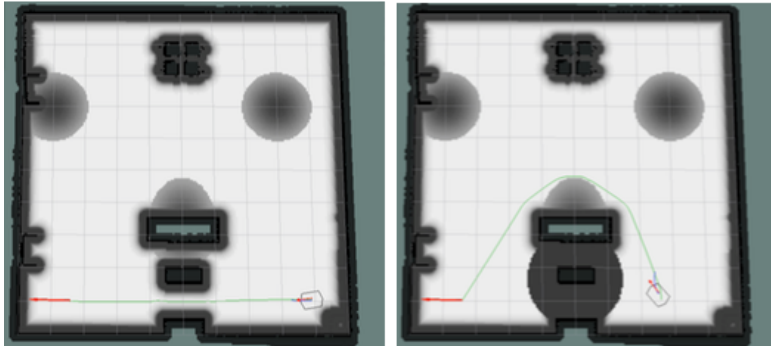
decision-making under uncertainty



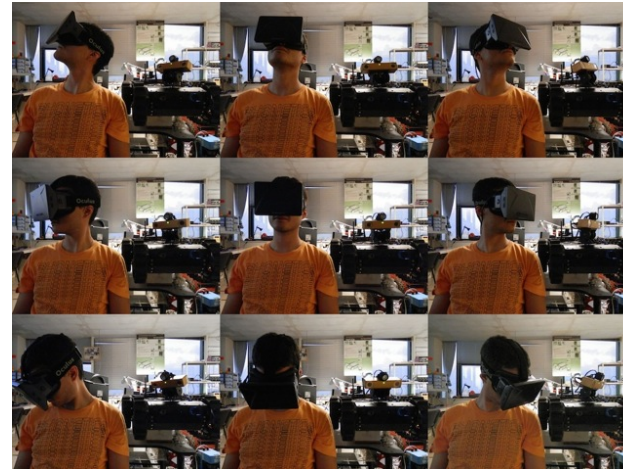


# Research interests @IRSg

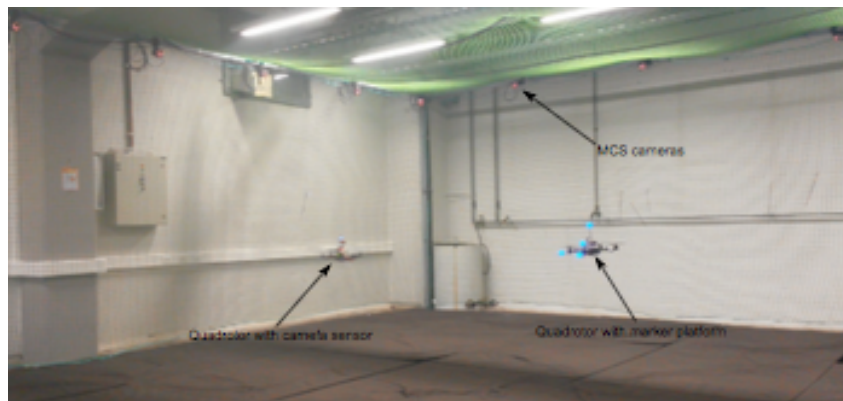
human-aware navigation



symbiotic autonomy (CoBots) and adjustable autonomy



formation control and social-aware multi-robot coordination





# Flagship Projects @ IRSg

## (Networked) Robot Systems for Assisted Living



FP7 STREP MO<sup>n</sup>arCH (Coordinator)



FP7 CA RoCKIn (Coordinator)

CMU-Pt

- MAIS-S
- INSIDE



Application domains

- Domestic environments
- Hospital environments



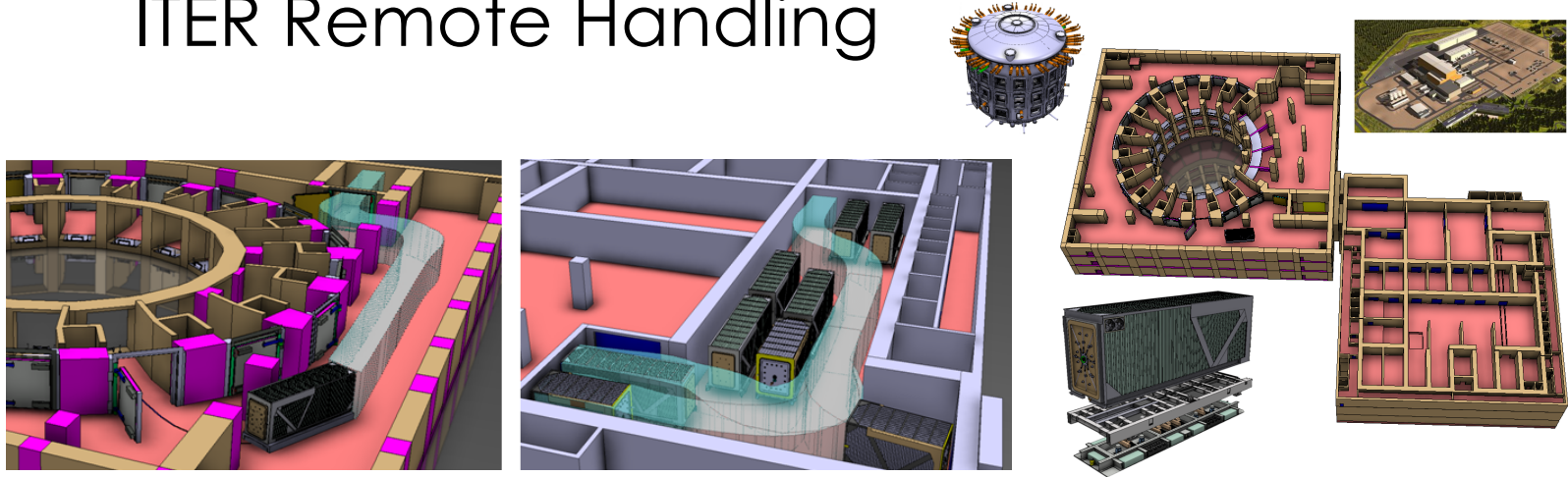
**Key players in Europe on robot competitions  
 (SocRob project: Soccer, Rescue and @Home since 1997)**



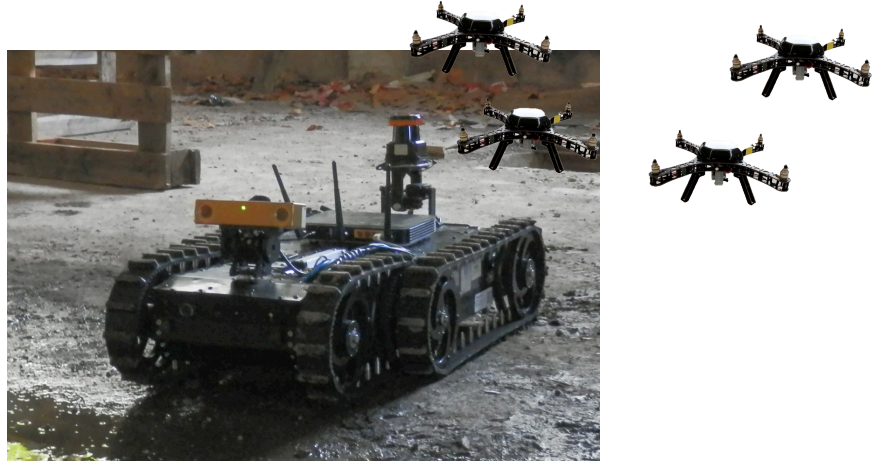


# Flagship Projects @ IRSG

## ITER Remote Handling



## Teams of Land + Air Robots for Field Robotics



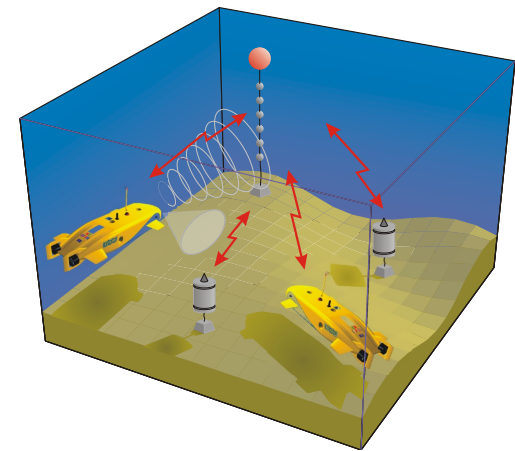
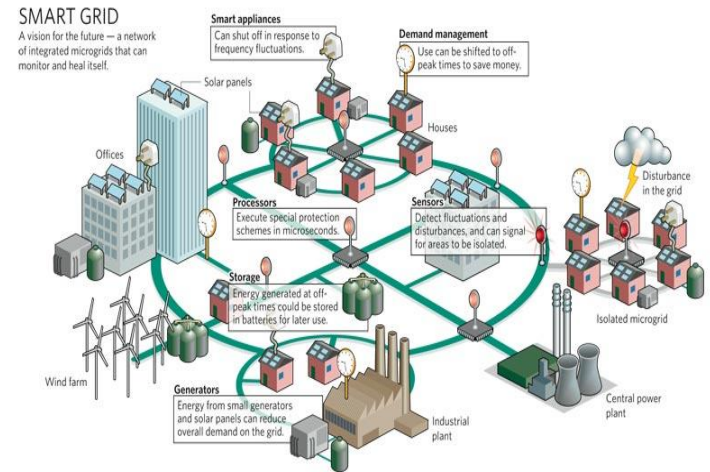




# Signal and Image Processing Group (SIPg)

## Research Areas

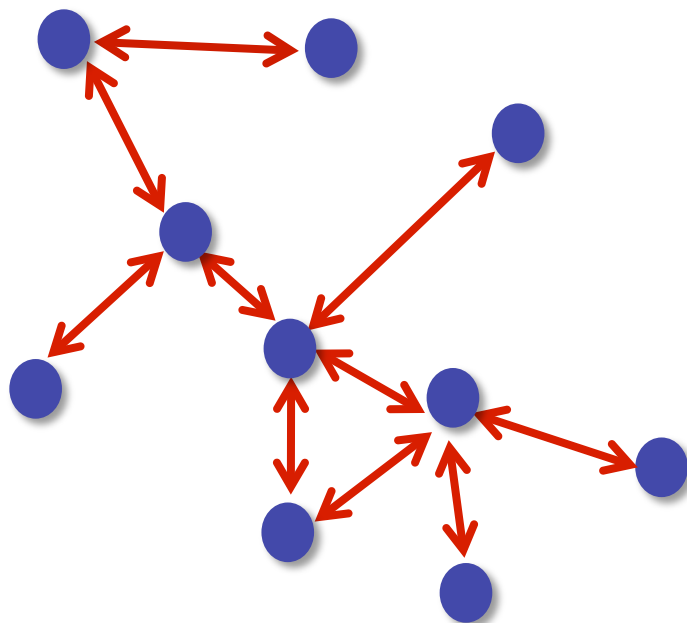
- Large Scale/Nonlinear/Distributed Signal Processing
  - Image/video recognition, 3D reconstruction
  - Underwater Signal Processing
- 
- 17 PhDs (16 Faculty+1 Researcher FCT)
  - 18 PhD students
  - 23 PhDs awarded (2005-2015)





# Research @ SIPg

## Intelligent Sensor Networks



- Power grids
- Critical infrastructures
- Telecommunication networks
- Social networks

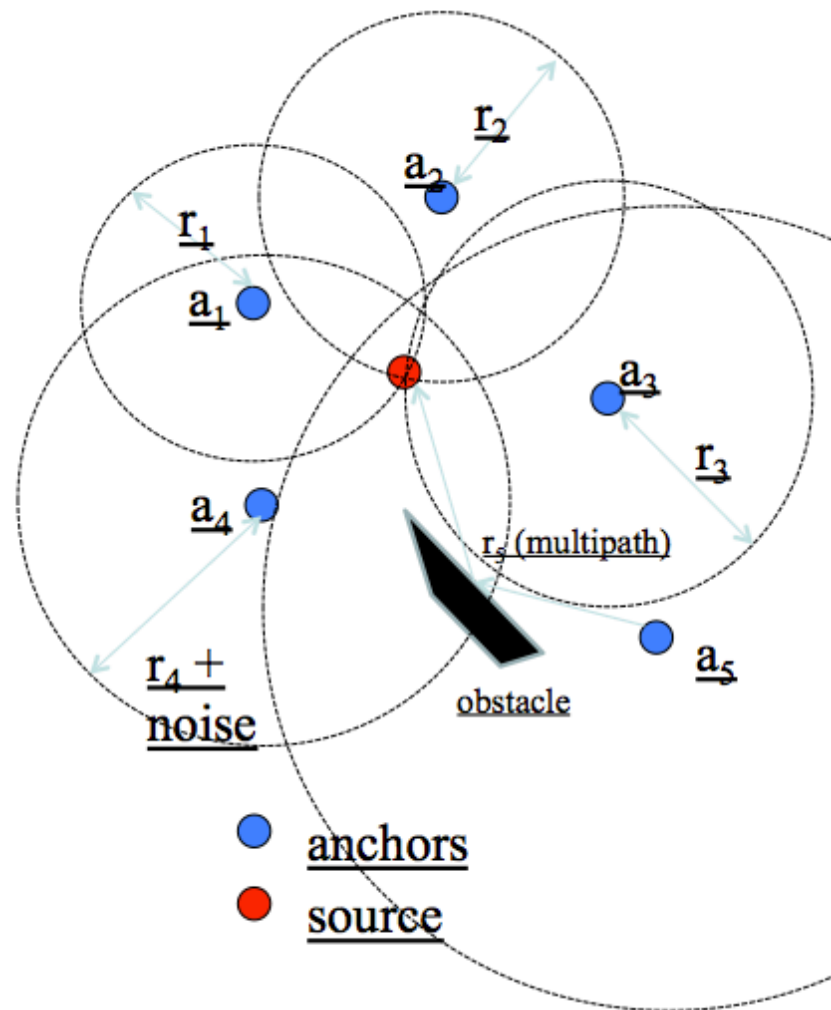
- Smart sensors
- Fast distributed detection
- Attack resilient control systems
- Information-theoretic security





# Research @ SIPg

## Indoor Localization in Sensor Networks



**COMPUTERWORLD** Que benefícios pode a tecnologia trazer ao seu negócio?

Tecnologias Negócios Sectores Carreira Opinião Vídeo Recursos

EM FOCO CLOUD MOBILE BIG DATA SOCIAL BUSINESS

### Pinar Oguz Ekim ganha Prémio Científico IBM 2012

A investigadora do Instituto Superior Técnico é a segunda mulher a receber o galardão, na história da iniciativa que tem 23 anos.

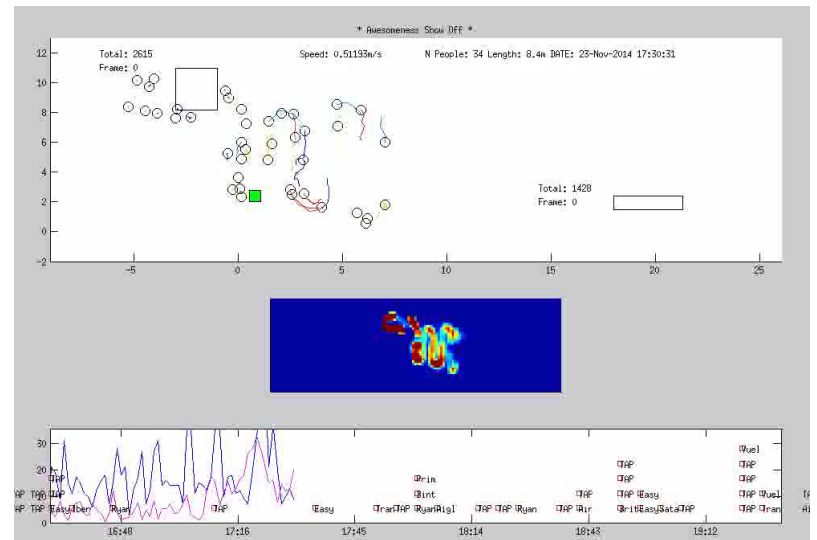
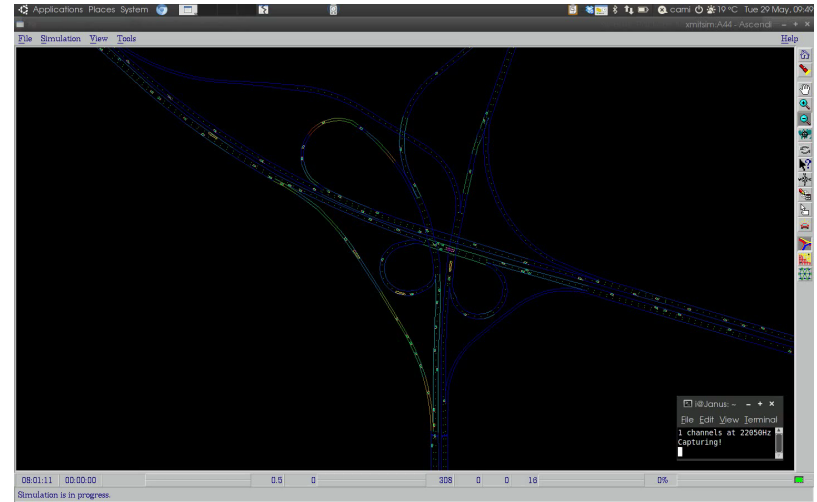
O Prémio Científico IBM referente ao ano de 2012 voltou a distinguir, pelo segundo ano consecutivo, um trabalho de investigação do Instituto Superior Técnico (IST): a grande é Pinar Oguz Ekim, de 33 anos, de nacionalidade turca, a terminar o programa de doutoramento em engenharia electrotécnica e de computadores. É também a segunda vez que uma mulher recebe o galardão.

"Algoritmos robustos de localização em redes de sensores com aplicações a seguimento de alvos" é o título do trabalho vencedor da 23ª edição da iniciativa. Baseado na tese de doutoramento de Pinar Oguz Ekim, o trabalho aborda a problemática da determinação de posições geográficas de um ou mais agentes (por exemplo, pessoas, veículos ou animais) a partir de medidas de distância mútua e distâncias a pontos de referência, expoclica um comunicado.



# Research @ SIPg

## Critical Infrastructures 2D/3D object tracking



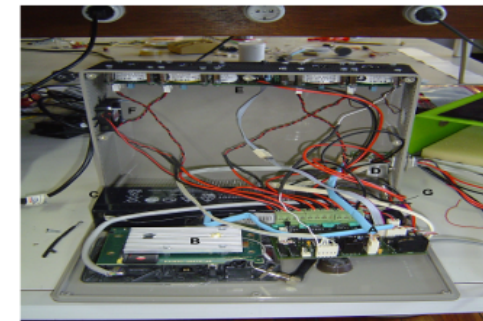




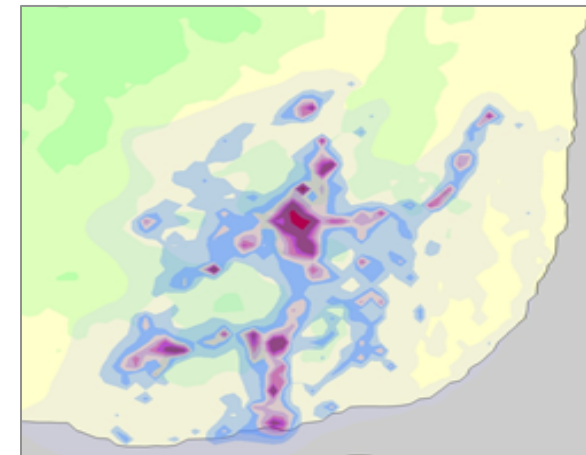
# Research @ SIPg

## Pollution Monitoring: The URBISNET concept

- Air-quality sampling
- Georeferencing
- Wireless communication
- Remote configuration/monitoring



- Line 44 – 19 km
- Line 742 – 15 km
- Line 716 – 7 km
- Line 714 – 17 km
- Line 717 – 15 km



CO distribution  
(simulated,  
Jan. 2007)

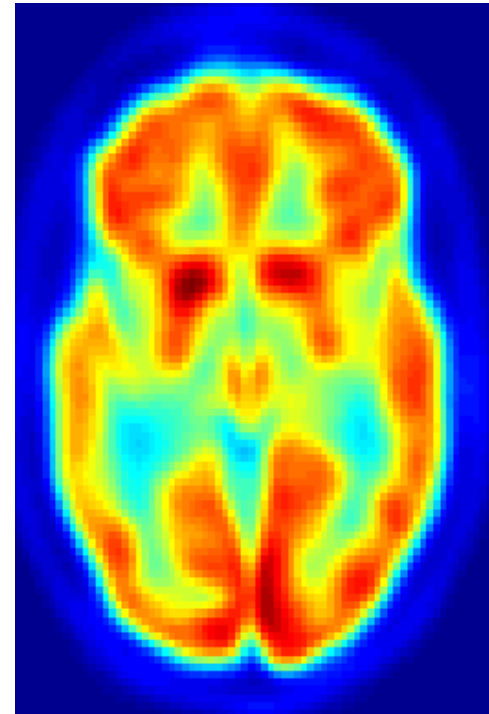


# Research @ SIPg

## Alzheimer Disease: Image Analysis and Recognition

Automatic classification tools for MRI and PET brain images to:

1. Diagnose Alzheimer's disease (AD), Mild Cognitive Impairment (MCI), and normal control subjects (NC)
2. Predict conversion of MCI patients to AD
3. Identify individual patterns of disease evolution, by assessing morphological changes along the time, based on follow up scans for each patient.
4. Incorporate complementary sources of information, namely based on cognitive evaluation tests, into the diagnosis process.





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- Conclusions



# Advanced training/ infrastructures

## Premium partnerships

- CMU – Portugal: Dual PhD Program
- IST-EPFL Joint Doctoral Initiative

- **FCT Doctoral Programs**

- RBCog:Robotics, Brain and Cognition
- NetSys:

- **National Roadmap of Research infrastructures**

- Robotics, Brain and Cognition Lab
- Brain Imaging Network (BIN)
- European Multidisciplinary Seafloor Observatory





# Nurturing innovation: spin-off companies

**observit**  
tecnologias de visão por computador

**mind**

**reverse**  
LEAGUE

**Blue Edge**



**DISTALMOTION**

**selfTech**

**PROBOPTICS**  
TECHNICAL CONSULTING AND RESEARCH



# Outreach

## S&T EDUCATION THROUGH ROBOTICS TO HIGH-SCHOOL STUDENTS

- More than 200 students from more than 40 high schools in Summer activities since 2000
- CIÊNCIA VIVA Projects on Building Robots



## ORGANIZATION OF LARGE S&T EVENTS

- RoboCup 2004 (1500 participants)
- Portuguese Robotics Open
  - Robótica 2003 (600 participants)
  - Robótica 2011 (700 participants)





# END

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