INSTITUTE FOR SYSTEMS AND ROBOTICS

Annual Report – 2007

Lisbon Pole

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1. INTRODUCTION

The Institute for Systems and Robotics (Lisbon) is organized in six (6) Laboratories or Research Groups: Intelligent Systems, Computer and Robot Vision, Mobile Robotics, Signal and Image Processing, Evolutionary Systems and Biomedical Engineering, and Dynamical Systems and Ocean Robotics. For each one those Labs/Groups, this report includes the list with the members of the research team, projects, objectives, main achievements, and the list of activities that contributes for internationalization.

2. RESEARCH GROUPS

2.1. INTELLIGENT SYSTEMS LAB

A) RESEARCH TEAM

Pedro Lima, Associate Professor
Carlos Pinto-Ferreira, Associate Professor
Luis Custodio, Assistant Professor
Carlos Filipe Gomes Bispo, Assistant Professor
Matthijs Spaan, Doctoral Researcher

Sónia Marques, Adjoint Professor (IPS), Ph.D. Student
Rodrigo Ventura, Teaching Assistant (IST), Ph.D. Student
Bruno Damas, Teaching Assistant (IPS), M.Sc. St.
Pedro Fazenda, Teaching Assistant (ISEL), M.Sc. St.
Abdolkarim Pahliani, Ph.D. Student
Gonçalo Neto, Ph.D. Student
Hugo Costelha, Ph.D. Student
Marco Barbosa, M.Sc. Student
Nelson Ramos, M.Sc. Student
Matteo Taiana, M.Sc. Student, Politecnico di Milano
João Santos, M.Sc. Student
João Estilita, M.Sc. Student

B) PROJECTS

FCT Projects:
DecPUCS - Decentralized Planning Under Uncertainty for Cooperative Systems, FCT PTDC/EEA-ACR/73266/2006, Oct/2007–Sep/2010

C) OBJECTIVES

The driving theme of the Intelligent Systems Laboratory is the R&D on decentralized decision-making and control for multi-robot (networked, cooperative) systems (main focus), cognitive robots, human-robot interaction, and large-scale systems. Decentralization is a key issue, as the overwhelming amount of information that must be handled in modern systems, composed of a massive number of embedded sensors, actuators, processors, and wireless communication devices, together with the

well-known weaknesses of centralized systems, call for novel approaches to decentralized decision making at different levels of abstraction, using the "think local, act global" principle. Our research is often driven by practical applications, and the applications include monitoring and decision-making in hazardous/remote environments (e.g., space, contaminated areas, post-disaster scenarios), and services (e.g., ambient assisted living, helping people in public spaces, energy consumption in buildings).

Our distinctive feature is that we bring together people with a common background on systems theory, but different approaches to modelling, analysis and synthesis of intelligent systems, mainly coming from:

• artificial intelligence, with a focus on decentralized and distributed methods, and specific interest on planning under uncertainty, organizational issues, neurosciences-, biology- and social sciences-inspired robot architectures and methods;

• systems and control, with a focus on complex systems consisting of a large number of interconnected embedded systems, e.g., sensor and robot networks, institutional management systems, or biological systems, and specific interest on modelling, analysis and synthesis methods.

ISLab has regularly collaborated with the MRLab within the framework of the Theme B search and rescue deliverable, including the participation in the RESCUE project and Theme B deliverable, in the development of a search and rescue robot (RAPOSA), in the EU project URUS on networked robotics, and in the supervision of a PhD student on reinforcement learning methods. During 2007, the two labs retook a past joint collaboration in Remote Handling R&D in ITER (International Thermonuclear Experimental Reactor).

D) MAIN ACHIEVEMENTS

ISLab has been developing models and methods for single and multiple robot systems (cooperative) plan representation and analysis, based on discrete event systems (DES) concepts, tools and techniques. Such methods have potential to scale up from problems manually designed, with a limited number of behaviours, to realistic applications with automatically designed plans including a considerable number of behaviours, by enabling a systematic approach to plan design from specifications (several analysis tools for DES are available). Plan representation using Petri nets and mixing DES supervision with reinforcement learning are the subject of two running PhD theses. Similar concepts were also applied to the modelling of cell population dynamics, as well as probabilistic modelling and control of robot swarms, using stochastic hybrid automata, in one finished PhD thesis.

The inclusion of uncertainty in DES models leads naturally to problems of sequential decision-making under uncertainty. A significant part of our work has been devoted to extend Markov Decision Problems (MDPs) and Partially Observable MDPs (POMDPs) models and methods to multi-robot coordination problems, using decentralized decision-making (e.g., Dec-POMDPs).

Cooperative perception (CP) based on probabilistic approaches is another topic of research at the ISLab. We are using probabilistic models of sensor measurements and sensor localization, as well as fusion methods, for this purpose. When some of the sensors are mobile (e.g., carried out by a robot), the problem turns into active CP, as decisions can be taken to dispatch some of the sensors to locations where they reduce the team uncertainty about what is being perceived. This work is the subject of an ongoing PhD thesis and is partially being developed under the URUS project. Control and state estimation of robot formations have also been subjects covered in this period. Formation feasibility given the robot kinematics and geometric constraints among the robots was studied in a journal paper, resulting from a PhD thesis finished in 2002. Novel low-communication, decentralized

full-state formation estimation methods were developed and tested in a realistic multi-satellite simulator, under the ESA project FEMDS, and one PhD thesis awaiting defence.

Developed testbeds open to the AL and international communities:
• cooperative soccer robots;
• autonomous blimp hardware and realistic USARSim simulator

E) ORGANIZATION OF CONFERENCES

International Programme Committee
- IJCAI 2007 - International Joint Conference on Artificial Intelligence, Hyderabad, India, 2007.
- ECAL 2007 - European Conference on Artificial Life, Lisboa, Portugal, 2007.
- ICAR 2007 - 4th International Conference on Automation and Robotics, Jeju, South Korea, 2007.
- RoboCup 2007 Symposium, Atlanta, GA, USA
- Robocomm 2007 - 1st International Conference on Robot Communication and Coordination, Athens, Greece, 2007

F) INTERNATIONALIZATION

Invited Talks:
• Pedro Lima - AASS Lab, U. Örebro, Sweden, 2007.
• Pedro Lima – "Cell Populations and Robot Swarms", IEEE ICRA 2007 - Workshop on Collective Behaviors Inspired by Biological and Biochemical Systems, Rome, Italy, 2007.
• Pedro Lima - SWIS Lab, EPFL, Lausanne, Switzerland, 2007.
• Pedro Lima – "Multi-Robot Systems: a Systems Theory Perspective", Workshop de Agentes Físicos 2007, Zaragoza, Spain, 2007.

Board:
- Pedro Lima - Trustee - RoboCup Federation.
- Pedro Lima - Port. repr. to the MG of the European Technological Platform on Robotics, EUROP.
- Pedro Lima - Editorial Advisory Board – Journal of Advanced Robotic Systems, published by ARS

Journal Review:
- IEEE Transactions on Fuzzy Systems
- Transactions on Systems, Man and Cybernetics – Parts B and C
- Robotics and Automation Magazine
- Transactions on Robotics
- ARS International Journal of Advanced Robotic Systems
- Elsevier Journal of Robots and Autonomous Systems
- IEE Proceedings on Control Theory and Applications
- Springer-Verlag Journal of Intelligent and Robotic Systems
- Elsevier AI
- Journal of AI Research
- Wiley Journal of Field Robotics
- Operations Research
- European Journal of Operational Research
- Elsevier Neurocomputing

Awards
P. Silva, P.Lima - Best Philosophy Paper, ECAL 2007 – European Conference on Artificial Life.

2.2. COMPUTER AND ROBOT VISION LAB

A) RESEARCH TEAM

João Paulo Costeira, Associate Professor
José Santos Victor, Associate Professor
Alexandre Bernardino, Assistant Professor
José Gaspar, Assistant Professor
Luis Montesano, Doctoral Researcher
Manuel Lopes, Doctoral Researcher
Giampiero Salvi, Post-Doctoral Student

Jonas Hornstein, Ph.D. Student
Pedro Ribeiro, Ph.D. Student
Plinio Moreno López, Ph.D. Student
Ricardo Oliveira, Ph.D. Student
Ricardo Ferreira, Ph.D. Student
Manuel Marques, Ph.D. Student
Ricardo Beira, M.Sc. Student
Cláudia Soares, M.Sc. Student
Daniela Pamplona, M.Sc. Student
Giovanni Saponaro, Researcher
Hugo Alves, Research Engineer
Jonas Ruesch, Research Engineer
Júlio Gomes, Research Engineer
Luís Vargas, Researcher, Industrial Design
Ricardo Jorge Duarte Nunes, Technician

B) PROJECTS

ROBOT-CUB - ROBotic Open-architecture Technology for Cognition, Understanding, and Behaviour, EU- IST-2004-004370, Sep04 – Aug09.

CONTACT - Learning and Development of Contextual Action, EU- NEST-5010, Sep05–Aug08.

VEMUCARV – Spatial validation of complex urban grids in virtual immersive environments, POCTI/AUR/48123/2002, May05–June08.

GESTINTERACT - Gesture Interpretation for the Analysis of Interactions Humans/Robots/Humans, FCT - POSI/EEA-SRI/61911/2004, Sep05–Aug08.

BIOLOOK - Biomimetic Oculomotor Control for Humanoid Robots, FCT - PTDC/EEA-ACR/71032/2006, Oct.07-Sep.2010.

MMCAC - Advanced Monte Carlo Algorithms for Computational Control, FCT - PTDC/EEA-ACR/ 70174/2006, Sep.07–Aug.10.

C) OBJECTIVES

The ultimate goal of our research is twofold: understanding (natural and artificial) vision and building systems/applications that "see". This research agenda requires a multidisciplinary approach, combining science, engineering, computer science, neuroscience, physiology and psychology, to name a few.
Through vision, one perceives the three-dimensional world encoded in two dimensional surfaces. Hence one of the key questions is that of understanding the underlying geometry, to develop image processing methods, parameter estimation, etc. Such an effort encompasses research in 3D reconstruction from video, video tracking, image matching, camera modelling/design, feature extraction, object recognition and categorization, etc.
Understanding vision requires going beyond geometrical modelling. As current technology affords researchers with unique possibilities in terms of processing power and storage, the vision community is now exploring massive amounts of data for extracting useful information from images. One example is detecting events from video, e.g. human activity recognition. Understanding this type of events requires working with camera networks and to develop innovative calibration and tracking techniques as well as learning and adaptation over time and to different contexts. Another challenging aspect in this domain is the balance between bottom-up and top-down processes concurring for a specific visual routine. How much does context bias the solution of a given problem and to what extent can visual understanding be purely data driven? Can vision be addressed separately from other processes? We know that human infants for instance learn about objecthood not only through vision information but also by interacting with the physical world. Hence, the analysis or synthesis of vision systems whose ultimate purpose is to understand the world and/or allow an embodied system to act, implies a much more general analysis than thinking about vision alone. That is the case of e.g. human(oid)s where vision and learning are studied together with motor control, attention, interaction and other cognitive processes, which is one of the strong research lines in the laboratory. Most of this research is carried out in the context of large-scale multidisciplinary international projects.

D) MAIN ACHIEVEMENTS

The work at VisLab includes the development of new methodologies and applications (a source for new challenges) in a multidisciplinary approach with close links to biology, neuroscience or psychology. The lab has been involved in large-scale, ambitious projects with international partners (e.g. EU). The group regularly hosts international post-doc, doctoral or visiting students.

Some of the main achievements over the past few years are listed below:
Feature selection and object recognition – We have developed models for feature detection and selection based on Gabor filters, whose responses resemble that of cells in the human visual system.

(Omnidirectional) camera design and camera networks – We proposed new designs for the geometry of omnidirectional cameras, yielding simplified image properties or observation geometries. This approach includes the fusion/analysis of information between multiple (heterogeneous) cameras.

3D Matching and reconstruction - Imposing world rigidity as a prior model, we developed a multi-view matching algorithm, producing pixel assignments among images. By introducing a multidimensional assignment structure we were able to tackle this combinatorial problem in an efficient way.

Human activity analysis - computer vision systems can now go beyond geometry & tracking and provide an interpretation of the observed scenes. We developed learning approaches for recognizing human activity from video in different scenarios.

Anthropomorphic robotic platforms – We designed several anthropomorphic robots, including the head of the iCub, the most sophisticated humanoid robot currently under development that will be duplicated and used world wide.

Computational Neuroscience –We developed a model for action recognition using motor information and visuomotor maps, supporting the hypothesis that action execution and (visual) recognition are performed by the same brain circuitry, as suggested by the discovery of the mirror neurons in the primate's brain.

Motor learning and developmental robotics – Inspired after the cognitive and motor development of human infants, we provided models and an implementation for the different stages of development of a humanoid robot: sensorimotor coordination, learning about objects and interaction with humans.

Modelling object affordances – we developed a stochastic model that captures the interplay between observed objects, actions and action outcomes, used for learning in humanoid robotics.

E) INTERNATIONALIZATION

Invited Talks
• EU-Cognition: General Meeting, Munich, DE, 2007.

TC memberships, Editorial Boards, other boards of scientific organizations:
José Santos-Victor - National Delegate, Aurora Board of Participants (ESA).
José Santos-Victor - Associate Editor, IEEE Transactions on Robotics.

Journal Reviewing:
- Adaptive Behavior
- Advanced Robotics
- Autonomous Robots
- IEEE Transactions on Biomedical Engineering, Circuits and Systems, Circuits and Systems for Video Technology, Image Processing, Intelligent Transportation Systems, PAMI, Robotics, Robotics & Automation, Signal Processing, System Man & Cybernetics.
- International Journal on Computer Vision
- Internatioanl Journal Humanoid Robotics
- Real-Time Imaging
- Robotics & Auton. Systems
- Pattern Analysis & Applications
- Signal Processing

Foreign thesis and projects reviewing

PhD Thesis Committee

- José Santos-Victor – Member of the Ph.D. Thesis Committee of Teresa Vidal, U. Politecnica Catalunya, Spain, 2007.
- José Santos-Victor – Member of the Ph.D. Thesis Committee of Chen Xin, University of Macau, 2007.

Project Reviewing/Evaluation

- José Santos-Victor – Evaluator, EU-FET Project Proposals.

Others

- Participation in the CMU-Portugal proposal
- IST-EPFL Joint Doctoral initiative, Focus Area "Distributed and Cognitive Robotics".
- ATHENS Course, Robotics, Learning, Vision.

F) ORGANIZATION OF CONFERENCES

International Organizing Committee - Member

• A.Bernardino, M.Lopes, J.Santos-Victor - 4th Intl. Symposium on Imitation in Animals and Artifacts, AISB'07 Convention, Newcastle upon Tyne, UK, April 2007.

International Program Committee - Member

• Alexandre Bernardino - International Symposium on Imitation in Animals & Artifacts, AISB'07 Convention, UK, April 2007.
• Alexandre Bernardino - International Conference on Image Analysis & Recognition, ICIAR, 2007
• Alexandre Bernardino - International Conference on Computer Vision Theory & Applications, VISAPP, 2007.
• José Santos-Victor - IEEE International Conference on Robotics and Automation, ICRA 2007.
• José Santos-Victor - IEEE Conference on Computer Vision and Pattern Recognition, CVPR 2007.
• José Santos-Victor - Intelligent Robots and Systems, IROS 2007.
• João Paulo Costeira - International Conference on Image Analysis and Recognition ICIAR 2007.

2.3. MOBILE ROBOTICS LAB

A) RESEARCH TEAM

Maria Isabel Ribeiro, Full Professor
João Sequeira, Assistant Professor
Nelson Gonçalves, Ph.D. Student
Francisco Melo, Ph.D. Student
Luís Tavares, M.Sc student
Michael Salgueiro, M.Sc. Student
Miguel Lombo, M.Sc. Student
André Godinho, M.Sc. Student
André Gonçalves, M.Sc. Student
Pedro Godinho, M.Sc. Student
Nuno Gonçalo Ferreira, Underg. Student

B) PROJECTS

RIOL–Robotic Inspection over Power Lines, FCT POSC/EEA-SRI/60775/2004, Set/2005-Aug/2008

URUS–Ubiquitous Networking Robotics in Urban Settings, FP6-EU-IST-045062, Dec/2006 – Nov/2009 Coordinator

Swarm intelligence for cooperative control of multiple robots - Anglo-Portuguese Prog. for Joint Research - Windsor Treaty, 2007

INFRANET II - Power Line Modeling and Inspection, LABELEC–Electricity of Portugal (EDP), Oct/2007-Mar/2008

C) OBJECTIVES

The objective is to undertake research in the area of mobile robotics, with emphasis on the navigation of single and multi-robot systems and human-robot interaction. Our research is often driven by the applications, and combines theoretical and implementation issues with the design and assembly of real robots.

The navigation of mobile robots is addressed in structured and unstructured environments. Environment mapping, localization and navigation in outdoors scenarios are studied for single robots, using probabilistic approaches to deal with uncertainty. In multi-robot systems, focus is on learning and coordination using reinforcement learning techniques, and navigation strategies for cooperative localization.

Human-Robot Interaction is the external layer that encapsulates all other subsystems in a robot. It is likely that using human-based models, with formal descriptions of concepts that have been intensively studied in social sciences, will foster the development of social robots. The focus of our research is the mathematical modeling of concepts that can model human interactions and their extension to the modeling of human-robot and robot-robot interactions.
Semantics is extensively used by humans and provides a typical example of such key concepts as it contains the mechanism for robots to engage socially with non-expert humans. Hybrid systems and nonsmooth calculus provide the main tools for modeling and analysis.

Applications, with robot or product development, include monitoring in hazardous/remote environments with a tele-operated robot, and power line inspection.

MRLab has regularly collaborated with the ISLab within the framework of the Theme B search and rescue deliverable, including the participation in the RESCUE project and Theme B deliverable, in the development of a search and rescue robot (RAPOSA), in the EU project URUS on networked robotics, and in the supervision of a PhD student on reinforcement learning methods. During 2007, the two labs retook a past joint collaboration in Remote Handling R&D in ITER (International Thermonuclear Experimental Reactor).

D) MAIN ACHIEVEMENTS

Reinforcement learning methods in cooperative navigation tasks was addressed in a PhD thesis (2007). We proposed new methods to address learning and coordination in problems with infinite

state-spaces or with partial observability. Cooperative localization strategies have also been developed (one journal paper). Within the URUS project MRLab and ISLab have been developing middleware for robots to interact with people in urban areas. This middleware integrates information from a network of fixed cameras, distributed processing, and robots. High level decision strategies are being addressed using economic market models (ongoing PhD). This line of work seems particularly important in multiple robot applications to yield a team behavior as natural as that of a team of humans. MRLab contributed to the development of robotic methodologies applied to power line inspection. It was involved in the development of a product to measure power line obstacle clearance based on laser scanning and performing on-line fault detection and classification during helicopter bas ed normal inspections. In addition, the robot developed within the RIOL project, able to move on suspended cables and monitoring a variety of aspects, represents an alternative methodology for power line inspection. It received a national patent and corresponds to a significant effort to show that innovative university designs can be transported to the non academic world.

E) ORGANIZATION OF CONFERENCES

General Chair

• Isabel Ribeiro - RobotMat2007 - Workshop on Robotics and Mathematics, Portugal, 2007.

International Program Committee - Member

• Isabel Ribeiro - ICAR - IEEE Int. Conf. on Advanced Robotics, Korea, 2007.
• Isabel Ribeiro - ICINCO - International Conference on Informatics in Control, Automation and Robotics, France 2007.
• Isabel Ribeiro - Scientific Meeting of the Portuguese Robotics Festival, Portugal, 2007.

F) INTERNATIONALIZATION

• Organization of the course “Introduction to Robotics”, included in the ATHENS program, Lisbon, March and November 2007 (31 European students).

Invited talks

Francisco Melo – “Predictive State Representations” and “Guarantees for Value Function Approximation”, MPI 2007: Workshop on Analytical Challenges in Reinforcement Learning, Germany, 2007.

Reviewing in the journals:

IEEE Transactions on Robotics
IEEE Transactions on Robotics and Automation
IEEE Robotics & Automation Magazine
IEEE Transactions on Intelligent Transportation Systems
IEEE Control Systems Technology
Robotics and Autonomous Systems
International Journal of Systems Science
Scientia Iranica Journal
Elsevier Journal of Sound and Vibration

• Isabel Ribeiro – Chair of IFAC Technical Committee on Intelligent Autonomous Vehicles, Member of the Education Board of FP6 NoE EURON-II, 2007.

2.4. SIGNAL AND IMAGE PROCESSING GROUP

A) RESEARCH TEAM

Victor Barroso, Full Professor
Sergio Jesus, Full Professor
Johannes du Buf, Associate Professor
Isabel Lourtie, Associate Professor
Jorge Salvador Marques, Associate Professor
Francisco Garcia, Assistant Professor
João Xavier, Assistant Professor
João Sanches, Assistant Professor
João Pedro Gomes, Assistant Professor
Margarida Silveira, Assistant Professor
Pedro Aguiar, Assistant Professor
Rui Dinis, Assistant Professor
Orlando Rodriguez, Assistant Professor
Paulo Felisberto, Adjoint Professor
António Silva, Adj. Professor (EST-UAlg), Ph. D. St.
João Rodrigues, Adjoint Professor (EST-UALG), Ph.D. Student
Paulo M. Santos, Adjoint Professor (EST-UALG), Ph.D. Student
Roberto Lau Lam, Adjoint Professor (EST-UALG), Ph.D. Student
Alessio Del Bue, Doctoral Researcher
Marko Stosic, Doctoral Researcher
Jacinto Nascimento, Post-Doctoral Student
Cristiano Soares, Ph.D. Student
Nelson Martins, Ph.D. Student
Pedro Mendes Jorge, Ph.D. Student
Isabel Rodrigues, Ph.D. Student
Samuel Nunes, Ph.D. Student
Paulo G. M. Silva, Ph.D. Student
Teresa Araújo, Ph.D. Student
Cesaltina Ricardo, Ph.D. Student
José Seabra, Ph.D. Student
Marko Beko, Ph.D. Student
Daniel Almeida, Ph.D. Student
Nuno Pinho da Silva, Ph.D. Student
Ricardo Ribeiro, Ph.D. Student
Miguel Ramos Pereira, Ph.D. Student
Pinar Oguz Ekim, Research Assistant
Dragana Bajovic, Research Assistant
Dusan Jakovetic, Research Assistant
Celestino Martins, Research Assistant
Friedrich Zabel, Research Assistant
Gustavo Lopes, M.Sc. Student
Liliana Caldeira, M.Sc. Student
Pedro Pedrosa, M.Sc. Student

Ricardo Cabral, M.Sc. Student
Augusto Santos, M.Sc. Student
João Filipe de Castro Mota, M.Sc. Student
João Fayad, M.Sc. Student
José Jerónimo Rodrigues, M.Sc. Student
Pedro Guerreiro, M.Sc. Student
Sílvia Quina Nobre, M.Sc. Student
Artem Khmelinskii, M.Sc. Student
David Afonso, M.Sc. Student
Indira Andrade, M.Sc. Student
Isabela Silva, M.Sc. Student
Joana Coelho, M.Sc. Student
José Lema Santos, M.Sc. Student
José Machado Dores, M.Sc. Student
Pedro Pires, M.Sc. Student
Nuno Miguel Monteiro, Undergr. Student

B) PROJECTS

European
ESONET (EU-FP6), Mar 2007- Feb 2011

FCT Projects:
PHITOM (PTDC/EEA-TEL/71263/2006), Dec 2007 - Nov 2010
WEAM (PTDC/ENR/70452/2006), Nov 2007 - Oct 2010
U-BOAT (PTDC/EEA-TEL/67066/2006), Oct 2007 - Sept 2010
SIPM (PTDC/EEA-ACR/73749/2006), Oct 2007 - Sept 2010
NCOR (PTDC/PSI/67381/2006), Oct 2007 - Sept 2010
UAB (POCTI/MAR/59008/2004), Jan 2006 -Dec 2007
RADAR (POCTI/CTA/47719/2002), Oct 2004 - Dec 2007
NUACE (POSI/CPS/47824/2002), Jan 2004 - Sept 2007
MC-CDMA (POSI/CPS/46701/2002), Dec 2003 - June 2007

C) OBJECTIVES

SIPG at IST broad areas of research are: Wireless Communications, Image and Video Processing, and Medical Image Analysis.

Wireless Communications
Wireless communications is the driving technology of existing and emergent key applications such as mobile cell phones for ubiquitous communication, GPS location systems, smart homes and indoor appliances, autonomous sensor networks, automated highways, underwater habitat monitoring and ecosystem mapping, etc. Our research focus on designing reliable, bandwidth efficient wireless links to enable these applications. This requires addressing a plethora of multidimensional signal processing challenges in order to cope with the space-time-frequency fading channels which support the data flow between the transmitter and receive multiple-antenna arrays.

Image and Video Analysis

The objectives in image and video analysis are the development of fundamental tools for inferring high level content from image sequences. These tools find applications in several fields. For example, in digital video, content-based representations, i.e., representations based on high-level content, rather than on pixels and images, enable powerful video editing and compression. Also, for surveillance applications, an automatic analysis in terms of human activity recognition, e.g., tracking pedestrians or recognizing human activities, is nowadays fundamental.

Medical Image Analysis
This is an emerging area in the SIPG which tries to capitalize previous experience in image and video analysis. The goal is to develop semi-automatic tools to improve medical diagnosis using several imaging modalities (ultrasound, C, MRI, fMRI). The work was focused in three goals: estimation of data volumes from ultrasound data (3D ultrasound), image pre-processing (noise reduction) and development of 2D and 3D models of organs using deformable models.

SIPG at UALG areas of research relate to underwater acoustic signal processing applications for ocean monitoring and forecasting, arr ay processing, inverse problems in geoacoustics, source detection, localization and tracking and, more recently, underwater acoustic data communications. One of the distinctive characteristics is that we aim at integrating in depth scientific research with hardware system development and at sea testing. Specific elements of the equipment include marine electronics, telemetry units, acoustic sensor arrays, data acquisition and communications systems.

D) MAIN ACHIEVEMENTS

SIPG at IST
Wireless Communications
1. Theoretical foundations: new framework for analysing MIMO wireless channel estimators, based on Riemmanian geometry: the Cramér-Rao bound, AR processes and fast PCA tools were generalized to this setup;
2. Single carrier systems: new space-time codebook design technique for noncoherent multiple antenna receivers and new equalizers of underwater channels based on the time reversal principle
3. Multicarrier systems: new techniques for coping with nonlinearity in OFDM architectures.

Image and Video Analysis
One of our long term goals has been the automatic inference of 3D content from video. We proposed an original method, based on the factorization of a large observation matrix that is highly rank deficient. Other achievements in 3D video analysis are methods to infer 3D orientation directly from the statistics of the image intensities and to include priors in 3D reconstruction. We also proposed new algorithms for motion estimation and segmentation. We developed algorithms for adaptive shape analysis, using deformable models. For surveillance, we developed a new tracker, able to deal with multiple pedestrians in challenging situations, and algorithms for the recognition of human activities using stochastic dynamical models.

Medical Image Analysis
We developed a volume reconstruction system based on ultrasound images (3D ultrasound) as well as algorithms for the reconstruction o f the carotid atherosclerotic plaque. We have also developed denoising algorithms using a novel approach (Lyapunov equation) and diagnosis methods using MRI images of the liver, heart, and brain and diagnosis methods for genetic diseases using cytogenic techniques. This was done in collaboration with the Institute of Molecular Medicine and St. Mary Hospital.

SIPG at UALG

Acoustic Oceanographic Buoy (AOB)

System to be deployed at sea, which interfaces with a remote user in real time. Applications: rapid environmental assessment, bottom profiling and exploration, submarine detection, localization, identification, communication with submerged targets.

Matched-field and vector sensor array signal processing

Multichannel underwater signal processing, with matched-field processing and inversion at low and high frequencies. Processing of vector sensor array data.

Sea Trials

- MREA/BP 07, 20/04 - 2/05 2007.
- RADAR07, 9/07 - 15/07 2007.
- UAB07, 2/09 - 16/09 2007.

E) ORGANIZATION OF CONFERENCES

Researchers from SIPG participated, as Program Committee Members, in the organization of several international meetings:

- IEEE International Conference on Image Processing, 2007
- IEEE/OES Oceans'07 - Europe Conference, 2007
- 2nd ACM International Workshop on Underwarter Networks (WUWNet), 2007
- ICIAR Intenational Conference on Image Analysis and Recognition, 2007
- International Workshop on Underwater Sensors and Systems, 2007
- EMBC - 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.
- CIARP – 12th Iberoamerican Congress on Pattern Recognition, 2007.

F) INTERNATIONALIZATION

Participation in projects

• B-BONE, which involves the collaboration of: PT Inovação, ISCTE, Univ. of Cyprus, Athens Univ. of Economics and Business, Greece Aristotle Univ. of Thessaloniki, Greece Motorola UK, Alcatel Germany.

• ESONET, which represents an European Network of Excelence involving over 50 european institutions during 4 years.

• AO-Buoy in collaboration with NURC (Nato Undersea Research Center), UALG, Instituto Hidrográfico, Univ. de Bruxelles and Royal Netherlands Naval College.

• High Frequency Initiative, in collaboration with NURC, UALG, SPAWAR (San Diego – USA), Univ. of Delaware (USA), HLS Research (USA).

Collaboration with:

• Broadband Commun. and Wireless Syst. Centre, Carleton Univ., Canada (Prof. David Falconer).

• INRIA/Paris Sud Univ., France (Prof. Gilles Celeux)

• Evolutionary Developmental Biology Lab. of Yale Univ.

Supervision of Students

• Gershon Dublon, Yale Univiversity, June/July 2007

• Eleni Damianou, Imperial College of London, July/August 2007.

Invited Lectures

• Imaging and Image Processing Conference, 2007.

Associate Editor

• Statistics and Computing Journal, Springer.
• Intern. J. of Pattern Recogn. and Artif. Intellig. (IJPRAI)

Reviewers for International Journals, such as:

- IEEE Transactions on Image Processing
- IEEE Transactions on Information Theory
- IEEE Transactions on Signal Processing
- IEEE Transactions on Multimedia
- IEEE Transactions on Circuits and Systems
- IEEE Transactions on Medical Imaging
- IEEE Transactions on Image Processing
- IEEE Transactions on Robotics
- IEEE Transactions on Communications
- IEEE Journal on Selected Areas in Communications
- IEEE Journal on Oceanic Engineering
- IEEE Signal Processing Letters
- Kluwer International Jounal of Computer Vision
- Springer Journal of Mathematical Imaging and Vision
- ELSEVIER Computer Vision and Image Understanding
- Wiley Journal of Microscopy Research and Technique
- EURASIP Image Communication
- Journal of the Acoustical Society of America
- IEE/IET Electronics Lett.

- Collaboration in the preparation of the partnership IST/EPFL in the Biomedical field.
- Participation in the creation of a new International Conference (IbPRIA) sponsored by IAPR.
- Visiting professor at Universitat Autonoma and Computer Vision Center, Barcelona.

2.5. EVOLUTIONARY SYSTEMS AND BIOMEDICAL ENGINEERING LAB

A) RESEARCH TEAM

Agostinho Rosa, Professor Associado
Fernando Melicio, Coord. Professor (ISEL), Collaborator
Rogério Largo, Adj. Professor (EST), Ph.D. St.
João Paulo Caldeira, Teaching Assistant (EST), Ph.D. St.
Cristian Gabriel Munteanu, Pos-Doc
Vitor Lopes, Pos-Doc
Ernesto Soares, Ph.D. Student
Carlos Miguel Da Costa Fernandes, Ph.D. student
Daria Migotina, Ph.D. Student
Hongfei Gong, Ph.D. Student
Maria Raquel César, Ph.D. Student
Nelson Pereira, Ph.D. Student
Nuno Fachada, M.Sc. Student
Marco Miranda, M.Sc. Student
Paulo Jorge Roque Silva, M.Sc. Student
Vitorino Ramos, M.Sc. Student

B) PROJECTS

OpenMicroBIO - FCT Project PTOC/BIO/693/2006

C) OBJECTIVES

The group long term objectives are in two inter-related scientific domains:
1) biomedicine – the main research is the development of model-based real-time detection and classification of brain states using the multi-channel electroencephalogram (EEG) signal fused with other neuro signal and imaging techniques (MEG, iEEG, ECoEG, fMRI, DTI, TAC, PET, etc). The final goal is not only to provide a better understanding of the brain functions but also providing affordable EEG based efficient training, prevention and therapy techniques. A specific goal is to propose a new Classification Paradigm for Sleep Classification, based on structural analysis of phasic events.

2) biosystems modelling and simulation – the long research goal is to have better understanding of how the complexity inherent of biological systems can be described by inter-individual interactions. There are two lines of research under this topic: a) the development of methodologies based on agent-based models for biosystems – for better monitoring and optimization of bio-process, such as: biological reactor design, processed food quality improvement or insect plague monitoring; and b) bio-inspired algorithms – inspired by the study of biological natural mechanisms, this research topic focus on the development of new methodologies for solving engineering problems, such as population based stochastic optimization algorithms to solve global optimization problems.

D) MAIN ACHIEVEMENTS

The group works can be framed in two main topics:
In the modelling topic we have developed two main different type of models for bio-systems. The first type are mathematical models with many variables where the problem is to fit the model parameters to real data. We have successfully applied this modelling methodology on the fungi Mildium Mildew of the grapevine Plasmopara viticola, to the olive fly Bractocera olea (with Bayer), to the Nile Fever Mosquito (with Cornell) and currently with Dengue and Malaria mosquitoes. The second type of methodology called usually as Artificial Life (ALife), is mainly agent based modelling, where the main objective is to model behaviours of individual agents and its interaction between different agents and with the simulated environment. ALife models gave been developed for the artificial test system similar of polyworld (GAIA) and for the Artificial Immune System (AIS and LAIS). The later a simulator still under development but already produced high potential simulations. In 2007 we started with University of Minho the OpenMicroBio project, where the goal is to model and optimize bio-reactors of bacteria for food-industry using ALife methodology.
On the bio-inspired search optimization methodologies, the group have contributed many new variation operators (Simple Inversion, Infected Gene Crossover and Mutation, PCA mutation, double ladder neighbourhood Simulated Annealing), new selection methods (Variable population selection, assortative and dissortative mating) and global evolutionary search algorithms (Binary Ant System, Digital Landscape ANTS, AREA, ARGA), an open source distributed library in Java for Evolutionary Algorithms (JDEAL) and a new unsupervised hybrid classifier (Kohonen Ants System). These methodologies have been applied with great success to a large variety of search and optimization, static and dynamic problems.
In the neurophysiology signals analysis and classification, the group have been engaged collaborative research with leading sleep labs (Stanford Human Sleep Clinic, Parma Sleep Center and Sleep Institute of of Sao Paulo) developing automatic classification methods for Human Sleep analysis, namely providing the first commercially available automatic classifier for the Cyclic Alternating Pattern paradigm. Currently the group is developing a new paradigm and corresponding classifier for the “Activation Complex” a structured and detailed model of the microstructure of the human sleep process.

E) INTERNATIONALIZATION

Collaborative research and exchange of researchers (AR, CG) since 2000 with the Human Sleep Clinic of Stanford University – United States in the area of Heart Rate Variability analysis and Cyclic Alternating Pattern Classification of sleep polysomnography signals in adults.

Collaborative research and exchange of researchers (AR, RL, DP, GA, VA) since 2004 with the Sleep Institute of the Federal University of Sao Paulo – Brazil, in the area of Heart Rate Variability analysis, Cyclic Alternating Pattern Classification of sleep polysomnography signals in children and also in sleep epidemiology studies.

Collaborative research and exchange of researchers (CF, VR) since 2007 with University of Granada – Spain, in the area of Evolutionary systems for the development of new algorithms in Ant Colony Optimization and Swarm Intelligence.

F) ORGANIZATION OF CONFERENCES

Track Co-Chair
Agostinho Rosa, ACM SAC - Artificial Intelligence and Computational Logic, 2007.
Agostinho Rosa, Artificial Life and Evolutionary Algorithms - ALEA 2007 - EPPIA 2007.

International Program Committee
Agostinho Rosa:
ICEIS – International conference of Enterprise Information Systems
ICANN – International conference of Artificial Neural Networks
IRMA – International conference of Information Resources Management Association,
ACM SAC – Evolutionary Computation and Optimization,
BIOMED - IASTED – Int Conference on Biomedical Engineering
ICINCO – Informatics in Control, Automation and Robotics
IAV – International Conference on Autonomous Vehicles
MIC – IASTED Conference on Modeling, Identification and Control,
BioMed – IASTED International Conference on Biomedical Engineering,
MICEIS- International Conference on Enterprise Information Systems
ICCB – International Conference on Computational Bioengineering
BioMech – IASTED International Conference on Biomechanics
BIC – International Symposium on Bio-Inspired Computing
ICANNGA – International Conference on Adaptive and Natural Computing Algorithms
IEEE WISP – Intelligent Signal Processing

2.6. DYNAMICAL SYSTEMS AND OCEAN ROBOTICS LAB

A) RESEARCH TEAM

Antonio Pascoal, Associate Professor
Carlos Silvestre, Assistant Professor
Paulo Oliveira, Assistant Professor
António Pedro Aguiar, Research Assistant
Rita Cunha, Post-Doctoral Student
Reza Ghabcheloo, Ph.D. Student
Alex Penas, Ph.D. Student
Francisco Teixeira, Ph.D. Student
Bruno Guerreiro, Ph.D. Student
David Cabecinhas, Ph.D. Student
Duarte Antunes, Ph.D. Student
Jose Vasconcelos, Ph.D. Student
Marco Martins Morgado, Ph.D. Student
Paulo Rosa, Ph.D. Student
Pedro Gomes, Ph.D. Student
Pedro Batista, Ph.D. Student
Francesco Vanni, M.Sc. Student
João Machado Almeida, M.Sc. Student
Andreas Häusler, Researcher
João Alves, Research Assistant
Luis Sebastiao, Research Assistant

Manuel Cecílio Rufino, Research Assistant
Mohammadreza Bayat, Research Assistant
Pedro Serra, Research Assistant
Pramod Maurya, Research Assistant
Vahid Hassani, Research Assistant
Andre Oliveira, Research Assistant
Bruno Cardeira, Research Assistant
Loic Bamdé, Administrative

B) PROJECTS

Fct Projects:
ADI **MAYA** - 2003/2007 - POSC
ADI **MEDIRES** 2003-2007 - POSC
SADOGEOROB - 2005-2008 - POCI/MAR/61178/2004
RUMOS 2006-2009 - PDCT/MAR/55609/2004
DENO 2007-2010 - PTDC/EEA-ACR/67020/2006
HELICIM 2007-2010 - PTDC/EEA-ACR/72853/2006
NAV 2007-2010 - PTDC/EEA-ACR/65996/2006

European
EPOCH- 2003-2007 - FP6-EU - 507382
GREX- 2006-2009 - FP6-EU-IST-035223
VENUS - 2006 – 2009 - FP6-EU-IST-034924
FREEsubNET - 2006-2010 - MRTN-CT-2006-036186

C) OBJECTIVES

One of the key objectives of the DSORL is to meet some of the challenges in advanced robotic vehicle systems design and control contributing to the development of faster, cheaper, and far more efficient methods for ocean exploration and exploitation. This motivated the definition of a research and development program addressing theoretical and practical engineering issues, as well as issues related to the interplay between marine sciences and marin e technology that fall in the scope of Thematic Area A. Two main lines of action were set:
1. Contributing to furthering the knowledge in the general area of dynamical systems theory.
2. Developing new analysis and design tools in the areas of navigation, guidance, and control (NGC) and applying them to the development of advanced systems that enable the operation of multiple networked autonomous marine and aerial vehicles.

Theoretical Objectives:
A. Linear and nonlinear systems theory: study and development of theoretical tools for the analysis and design of linear and nonlinear control / filtering systems.
B. Robust Multiple Model Adaptive Control (RMMAC): Development of new methodologies for the design of robust adaptive controllers for plants with structured and unstructured uncertainty.
C. Design of Navigation Systems for autonomous vehicles. Study of advanced solutions focusing on the: i) development of high-performance and moderate cost heading and attitude reference units; ii) study and practical evaluation of acoustics-based systems for underwater vehicle positioning; iii) development of geophysical-based navigation algorithms.

D. Motion Control of single and multiple vehicles under stringent communication constraints, including those imposed by a very special medium: the ocean.
Problems addressed: i) Motion control of autonomous vehicles; ii) Visual servoing control; iii) Path Following; iv) Terrain Contour Tracking; v) Coordinated/cooperative control of groups of autonomous vehicles; vi) Networked control over faulty communication links

Practical Objectives:
A. Design and development of AUVs, ASCs, and UAVs and on-board integration of scientific sensor suites and data acquisition / logging systems.
B. Distributed hardware and software architectures for coordinated navigation and motion control of multiple vehicles as well as for mission control.
C. Tests and scientific missions with the robots developed in cooperation with the scientific partners in Thematic Area A and other international institutions.

D) MAIN ACHIEVEMENTS

Theoretical achievements:
1. Study and development of several nonlinear control algorithms for motion control (point stabilization, trajectory tracking, and path following) of fully and underactuated autonomous robotic vehicles in three-dimensional space.
2. Design of optimal minimum-energy based state estimators for systems with perspective outputs. The convergence and robustness to noise, latency, and intermittency of observations were formally analyzed.
3. Design of a novel nonlinear kinematic observer for pose estimation in SE(3). An almost globally exponentially stable attitude and position observer was obtained.
4. Study of a Robust Multiple-Model Adaptive Control (RMMAC) architecture for linear time-invariant systems subject to structured and unstructured uncertainty.
5. Development and experimental evaluation, in the Catamaran DELFIMx, of a low cost Inertial navigation System (INS) based on nonlinear complementary filters that merge inertial measurements with Earth's magnetic field observations and GPS data.
6. Development and practical evaluation of acoustics-based systems for underwater vehicle positioning and tracking. Estimation algorithms were derived and their performance tested during real missions at sea.
7. Study and assessment in simulation of algorithms aimed at steering a fleet of mobile robots along a set of given spatial paths, while keeping a desired inter-vehicle formation pattern. Decentralized algorithms that explicitly address the dynamics of the cooperating vehicles and the constraints imposed by the nature of the inter-vehicle communications network were derived.
8. Development of feature based navigation algorithms for the execution of long range missions with AUVs in unstructured environments. Integrated navigation solutions based on bathymetric and geomagnetic data were derived.

Practical Achievements:
9. The work developed has led to the design and construction of the robotic ocean vehicles DELFIMx ASC and INFANTE AUV, the miniaturized MAYA AUV (in cooperation with India), the IRIS (automatic surveying tool), and one Autonomous Helicopter. These vehicles have the dual purpose of serving as i) advanced testbeds for field testing new theoretical concepts for single and multiple vehicle navigation and control, and ii) platforms for actual operations at sea, paving the way for a fruitful symbiosis between marine science and technology.

E) ORGANIZATION OF CONFERENCES

Organization, Special Session on Autonomous Vehicles for Ocean Exploration and Exploitation, ISOPE-2007-the 17th International Offshore (Ocean) and Polar Engineering Conference & Exhibition Lisbon, Portugal, 2007.

International Program Committee, IFAC Workshop on Control Applications in Marine Systems (CAMS' 07), Bol, Croatia.

International Program Committee, 6th IFAC Symposium on Intelligent Autonomous Vehicles, IAV 2007, Toulouse, France.

F) INTERNATIONALIZATION

The DSORL has been involved in a number of projects and concerted actions with national and foreign institutions with the objective of advancing the development of engineering methodologies, marine technology, and autonomous robotic vehicles to the point where the latter can be used as versatile tools to expand our understanding of the oceans. This concerted effort is reflected in the co-authorship of publications, participation in international organization committees, networks, co-supervision of graduate work, and invited talks. Selected institutions include the following (8 of 15):
[1] Department of Mechanical Engineering and Aeronautics, Naval Postgraduate School, Monterey, CA (USA) – a long standing collaborative research program on AUV and UAV NGC, as well as multiple vehicle control.
[2] Center for Control, Dynamical Systems, and Computation (CCDC) at University of California, Santa Barbara, CA (USA) – joint work on control, estimation theory, and networked control systems.
[3] National Institute of Oceanography (NIO), Goa (India) – an intensive research and development program was initiated in 1999, leading to the development of the MAYA AUV.
[4] Department of Engineering Cybernetics, Norwegian University of Science and Technology (NTNU), Trondheim (Norway) - exchange of students and research personnel; joint work on cooperative path following control.
[5] IFREMER (French Institute for Ocean Exploitation) – (France). Joint participation in the network of excellence FREESUB and in the EU projects EXOCET and GREX. Joint realization of missions at sea.
[6] Department of Mechatronics, University of São Paulo (Brazil) – joint work on Modeling, Parameter Estimation and Identification of AUVs (Autonomous Underwater Vehicles).
[7] University of Girona, Institute of Informatics and Applications, Escola Politècnica Superior , Girona (Spain) – joint theoretical and pratical work on Mission Control Systems for autonomous underwater vehicles.
[8] Dept. Electrical and Computer Engineering, University of Maryland (USA) – exchange of research personnel and joint initiatives on Networked Control Systems.

In 2007 the DSORL has played an active role in an European Training Network (ETN): FREEsubNET - A European research network on key technologies for intervention autonomous underwater vehicle (Marie Curie Research Training Network).

Participation in International Technical Committees
Member of the IFAC Technical Committee on Aerospace
Member and Vice-Chair, IFAC Technical Committee on Marine Systems
Member, IFAC Technical Committee on Intelligent Autonomous Vehicles
Participating Member, Marine Board, European Science Foundation
Member, SCOR Panel on New Technologies for Observing Marine Life

Member, Steering Committee of EurOcean, the European Centre for Information on Marine Science and Technology

Invited Talks

- Time coordinated path-following for multiple AUVs. Invited Talk, Naval Postgraduate School (NPS), Monterey, CA, USA - September 2007.
- Coordinated Path Following of Multiple Underactuated Vehicles with Communication Constraints. Invited Talk, NTNU, Trondheim, Norway – April 12, 2007.

3. PUBLICATIONS

A) M.SC. THESES (27)

[1] **João Almeida**, “Coordinated control of multiple oceanic vehicles”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[2] **Ricardo Aguiar**, “Design and development of tri-dimensional computer game using VIRTOOLS software and tracking technology”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[3] **Pedro Serra**, “Sensor Based Autolanding Controller for Unmanned Helicopters”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[4] **Francesco Vanni**, “Coordinated Motion Control of Multiple Autonomous Underwater Vehicles”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[5] **Ricardo Beira**, “Mechanical Design of an Anthropomorphic Robot Head”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[6] **Cláudia Soares**, “Recognizing speech with anthropomorphic Models for Voice Synthesis: applications to humanoid robots”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[7] **Matteo Taiana**, “3D model-based tracking with one omnidirectional camera and particle filters,” Master Thesis, Instituto Superior Técnico & Politecnico di Milano, 2007.

[8] **Paulo Carreiras**, “PREDGRAB - Predição de Trajectórias de Alvos Móveis - Aplicação ao controlo de um braço robot,” Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[9] **Constança d'Andrade de Oliveira e Sousa**, "Aprendizagem por Reforço de Sistemas com Múltiplos Objectivos: o Problema da Selecção de Acções", Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[10] **Zita Fernandes**, “Scheduling for single server queues. Variant of the μc-rule”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[11] **Marta Rebello**, “Simulating Activity Networks in Java. Application to Stabilization of Queuing Networks”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[12] **José Pedro Figueiredo**, “Gestão de Tráfego Ferroviário”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[13] **Luís Tavares**, “Avaliação dinâmica do robot RIOL”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[14] **André Dias**, “Sistema de Controlo Embebido para Locomoção de Sistemas Autónomos”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[15] **André Godinho**, “Highway Autonomous Navigation System: Integrating multiple sensors in human-like behaviors”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[16] **João Almeida**, “Rational Trigonometry Applied to Robotics”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[17] **Manuel Marques**, "Reconstrução 3D a partir de imagens 2D com dados incompletos", Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[18] **Nuno Valverde,** “Local/INS navigation for formations of autonomous vehicles”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[19] **Pedro Valverde**, “INS/USBL Tracking System for Unmanned Underwater Vehicles”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[20] **Rui Gusmão**, “Modem flexível baseado em DSP: Conversão de frequências realizada em FPGA”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[21] **Pedro Pedrosa**, “Técnicas de Estimação/Detecção para Transmissões por Blocos em Canais Fortemente Dispersivos com Desvio na Fre quência da Portadora”, Master Thesis, instituto Superior Técnico, Lisbon, Portugal, 2007.

[22] **David Afonso**, “Detection of Brain Activated Regions from Functional MRI, fMRI, and Fusion with structural MRI Information”, Master Thesis, instituto Superior Técnico, Lisbon, Portugal, 2007.

[23]**Artem Khmelinskii**, “Emparelhamento de Cromossomas para Efeitos de Cariotipagem”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[24]**Liliana Caldeira**, “Liver Tumor Assessment from DCE-MRI: Registration and Perfusion Quantification”, Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[25] **Robert Hammond**, “Motion control of an Autonomous Helicopter”, Master Thesis in cooperation with the Imperial College of London, 2007.

[26] **Andrea de Vito**, “An Underwater Acoustic Positioning System Based on Buoys with GPS”, Master Thesis in cooperation with the University of Genoa, 2007.

[27] **Jeremy Wilkinson**, “Coordinated/cooperative control of a group of autonomous vehicles”, Master Thesis in cooperation with the Imperial College of London, 2007.

B) PH.D. THESES (8)

[1] **Rita Cunha**, “Advanced Motion Control for Autonomous Air Vehicles,” Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[2] **Reza Ghabcheloo**, “Coordinated Path Following of Multiple Autonomous Vehicles,” Ph.D Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[3] **Francisco Teixeira**, “Terrain-Aided Navigation and Geophysical Navigation of Autonomous Underwater Vehicles,” Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[4] **Francisco Melo**, "Reinforcement Learning in Cooperative Navigation Tasks", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[5] **Jorge Silva,** "Motion Tracking on Manifolds", Jorge Silva, Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[6] **Pedro Jorge,** "Tracking groups of pedestrians in video signals using Bayesian networks", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[7] **Ernesto Soares,** "On the dynamics of brain states: their influence on gustatory cortical sensory information processing and memory consolidation mechanisms", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2007.

[8] **Cristiano Soares,** "Broadband Matched-Field Tomography using Simplified Acoustic Systems", Ph.D. Thesis, University of Algarve, Portugal, 2007.

C) BOOKS (Author) (1)

[1] **D. Milutinovic, P. Lima**, Cells and Robots - Modeling and Control of Large-Size Agent Populations, Springer Tracts in Advanced Robotics (STAR) Series, Vol. 32, 2007.

D) BOOKS (Editor) (1)

[1] **Pedro Lima**, (Ed.Robotic Soccer), I-Tech Education and Publishing, Vienna, Austria, 2007 .

E) CHAPTERS IN BOOKS (7)

[1] **I. Ribeiro**, "Uma viagem ao mundo dos Robots", in *Despertar para a Ciência: Novos Ciclos de Conferências*, pp.153-192, Gradiva, 2007.

[2] **J. Sequeira, M. I. Ribeiro**, "Semiotics and Human-Robot Interaction", In *Human Robot Interaction*, Nilanjan Sarkar (editor), 325-344, I-Tech Education and Publishing, 2007 (available online at http://s.i-techonline.com/Book/Human-Robot-Interaction/ISBN978-3-902613-13-4-hri18.pdf).

[3] **A. Del Bue and L. Agapito**, "Non-rigid Stereo-Motion", in *Scene Reconstruction, Pose Estimation and Tracking*, Rustam Stolkin (Ed.), 2007.

[4] **F. Melo, M. Isabel Ribeiro**, "Q-learning with linear function approximation", in *Learning Theory: 20th Annual Conference on Learning Theory, Lecture Notes in Artificial Intelligence*, vol. 4539, pp. 308-322, Springer-Verlag, 2007.

[5] **C. Munteanu, A. C. Rosa**, "Symmetry at the Genotypic Level and the Simple Inversion Operator", LNAI 4874, *Progress in Artificial Intelligence*, J Neves, M Santos, J Machado (Eds.), pp 209-222, Springer 2007.

[6] **A. C. Rosa, D. Poyares, C Guilleminault**, "Processamento de sinais eletrofisiológicos para análise e classificação automática do sono", In *Biologia e Medicina do Sono, S. Tufik (Edt),* Manole Editors, SP, Brazil, Chap. 40, pp. 451-469, 2007.

[7] **A. C. Rosa, GR Alves, MC Lopes, D Poyares, C Guilleminault**, "Padrão Alternante Cíclico (CAP)", In *Biologia e Medicina do Sono, S. Tufik (Edt),* Manole Editors, SP, Brazil, Chap. 39, pp. 440-450, 2007.

F) INTERNATIONAL JOURNALS (33)

[1] **A. Aguiar, J. P. Hespanha**, "Trajectory-Tracking and Path-Following of Underactuated Autonomous Vehicles with Parametric Modeling Uncertainty", *IEEE Transactions on Automatic Control,* Vol. 52, No. 8, pp. 1362-1379, 2007.

[2] **A. Aguiar, J.P. Hespanha, A. Pascoal**, "Switched seesaw control for the stabilization of underactuated vehicles," *IFAC Automatica,* Vol. 43, No. 12, pp. 1997-2008, 2007.

[3] **A. Aguiar, A. Pascoal**, "Dynamic Positioning and Way-Point Tracking of Underactuated AUVs in the Presence of Ocean Currents", *International Journal of Control,* Vol. 80, No. 7, pp. 1092-1108, 2007.

[4] **A. Alcocer, P. Oliveira, A. Pascoal**, "Study and Implementation of an EKF GIB-based Underwater Positioning System," *IFAC Journal of Control Engineering Practice,* Vol. 15, no. 6, pp. 689-701, Elsevier, 2007.

[5] **S. Fekri Asl, M. Athans, A. Pascoal**, "Robust Multiple Model Adaptive Control (RMMAC): A Case Study," *International Journal of Adaptive Control and Signal Processing,* Vol. 21, pp. 1-30, 2007.

[6] **R. Ghabcheloo, A. Pascoal, C. Silvestre, I. Kaminer**, "Nonlinear Coordinated Path Following Control of Multiple Wheeled Robots with Bidirectional Communication Constraints," *International Journal of Adaptive Control and Signal Processing,* 20, pp. 133-157, 2007.

[7] **P. Oliveira**, "MMAE Terrain Navigation for Underwater Vehicles using PCA," *International Journal of Control,* Vol. 80, No. 7, pp. 1008-1017, 2007.

[8] **C. Silvestre, A. Pascoal**, "Depth Control of the INFANTE AUV using Gain-Scheduled Reduced Order Output Feedback," *Control Engineering Practice,* 15(7), pp. 883, 2007.

[9] **N. Tsagarakis, G. Metta, G. Sandini, D. Vernon, R. Beira, F. Becchi, L. Righetti, J. Santos-Victor, A. Ijspeert, C. Carrozza, D. Caldwell**, "The Design and Realization of an Open Humanoid Platform for Cognitive and Neuroscience Research," *Advanced Robotics*, special issue on "Robotic platforms for Research in Neuroscience", V.21, N.10, 2007.

[10] **M. Lopes, J. Santos-Victor**, "A Developmental Roadmap for Learning by Imitation in Robots", *IEEE Transactions on Systems, Man and Cybernetics, Part B: Cybernetics*, Vol.37, No.2, 2007.

[11] **D. Milutinovic, J. Carneiro, M. Athans, P. Lima**, "Modeling Dynamics of Cell Population Molecule Expression Distribution", *Journal of Non-Linear Analysis: Hybrid Systems and Applications*, Elsevier, Vol. 1, Issue 1, pp. 81-94, 2007.

[12] **D. Dumitriu, S. Marques, P. Lima, J. C. Bastante, J. Araújo, L. F. Peñin, A. Caramagno, B. Udrea**, "Optimal Guidance and Decentralised State Estimation Applied to a Formation Flying Demonstration Mission in GTO", *IET, Control Theory and Applications*, Vol. 1, Issue 2 , p. 443-552, March, 2007.

[13] **C. Marques, J. Cristovão, P. Alvito, P. Lima, João Frazão, M. Isabel Ribeiro, R. Ventura**, "A Search and Rescue Robot with Tele-Operated Tether Docking System", *Industrial Robot*, Emerald Group Publishing Limited, Vol. 34, No.4, pp. 332-338, 2007.

[14] **P. Lima**, "A Bayesian Approach to Sensor Fusion in Autonomous Sensor and Robot Networks", *IEEE Instrumentation and Measurement Magazine*, Vol. 10, No. 3, pp. 22-27, 2007.

[15] **F. G. Bravo, A. Vale, I. Ribeiro**, "Navigation Strategies for Cooperative Localization based on Particle Filters", *Integrated Computer-Aided Engineering*, Vol. 14:3, pp. 263-279 IOS Press 2007.

[16] **M. Beko, J. Xavier, V. Barroso**, "Non-coherent communication in multiple-antenna systems: receiver design and codebook construction", *IEEE Transactions on Signal Processing*, vol. 55, no. 12, pp. 5703-5715, December 2007.

[17] **R. Oliveira, J. Xavier, J. P. Costeira**, "Multi-View Correspondence by Enforcement of Rigidity Constraints", *Image Vision and Computing*, vol. 25, no.6, pp.1008-1020, Elsevier, June 2007.

[18] **M. Stošic'**, "Homological thickness and stability of torus knots", *Algebraic and Geometric Topology*, Vol. 7, pp. 261-284, 2007.

[19] **M. Dodig, M. Stošic'**, "The change of feedback invariants under one row perturbation", *Linear Algebra and its Applications,* Vol. 422, 2-3, pp. 582-603, 2007.

[20] **A. Del Bue, F. Smeraldi, L. Agapito**, "Non-rigid structure from motion using ranklet-based tracking and non-linear optimization", *Image and Vision Computing (IVC)* 2007.

[21] **T. Araújo, R. Dinis**, "Analytical Evaluation and Optimization of the ADC (Analog-to-Digital Converter)", in Software Radio Architectures, *IEEE Transactions on Vehicular Technology*, Vol. 56(4), Part 2, pp. 1964-1970, 2007.

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4. PILOT INSTALLATIONS AND PATENTS

4.1. PILOT INSTALLATIONS (21)

[1] *DELFIM* Autonomous Surface Vehicle (ASC) – *designed and built by ISR/IST*. An autonomous surface craft (Catamaran-type) to carry out experimental research in the area of ocean robotics and to perform scientific missions at sea. Length: 3.5m, Width: 2m, Weight: 320 Kg, Propulsion by electric motors. Equipped with on-board resident systems for navigation, guidance, vehicle, and mission control. The vehicle has been used extensively for marine data acquisition and bathymetry operations in the Azores, in cooperation with the partner IMAR/DOP.

[2] *DELFIM_X* Autonomous Surface Vehicle (ASC) – *designed and built by ISR/IST.* An autonomous surface craft similar to the DELFIM, but with improved hydrodynamic characteristics and increased autonomy due to the use of Lithium Polymer batteries. Length: 4.5 m, Width: 2.4 m, Weight: 300 Kg, Propulsion by electric motors. Equipped with on-board resident systems for navigation, guidance, vehicle, and mission control. The vehicle has been used to acquire marine data in the Azores, in cooperation with the partner IMAR/DOP and to carry out experiments on single and multiple vehicle cooperative control.

[3] *INFANTE* Autonomous Underwater Vehicle (AUV) – *designed and built by ISR/*IST *and the company RINAVE*. An autonomous underwater vehicle to carry out experimental research in the area of ocean robotics and to perform scientific missions at sea. The vehicle is 4*.*5m long, 1*.*1m wide and 0*.*6m high. It is equipped with two main thrusters (propellers and nozzles) for cruising and fully moving surfaces (rudders, bow planes and stern planes) for vehicle steering and diving in the horizontal and vertical planes, respectively. It has a payload capability of 50Kg.

[4] MAYA AUV – *designed and built by a Luso-Indian consortium consisting of NIO (Goa, India), ISR/IST, IMAR/DOP/UAzores, and RINAVE*. A small, modular, autonomous underwater vehicle (AUV) for scientific and commercial applications. Missions include geological and oceanographic surveys, marine biology studies, marine habitat mapping for environmental management, inspection of harbours and estuaries, and marine pollution assessment, to name but a few. The first prototype has been tested and used extensively in Goa, India.

[5] *CARAVELA 2000* Autonomous Research Vessel – *designed and built by IMAR/DOP/UAzores, ISR/*IST, *and the companies RINAVE*. and CONAFI Prototype of an autonomous surface craft for long range missions at sea (co-owned by IST/ISR, IMAR/Dept. Oceanography and Fisheries of the Univ. Azores, RINAVE, and CONAFI).

[6] Autonomous Helicopter (Bergen Industrial Twin) - a small-scale industrial helicopter. This is a transformed radio-controlled helicopter, about 1.6m long (including the rotor diameter), with a payload capability of 10 kg, and a top speed of 70 Km per hour.

[7] IRIS TOOL – *designed and built by ISR/*IST. A high accuracy surveying tool for both the above water and submerged parts of semi-submerged structures. IRIS is equipped with an accurate Laser Scanner, a profiler sonar, a high end motion reference unit, and a surveying class GPS. This tool can be used either from a rubber boat in autonomous mode or equip an Autonomous Surface Craft to produce tri-dimensional surveys with the spatial regularity required to this kind of structures.

[8] BALTAZAR: With the purpose of conducting research in several aspects concerning vision, learning and cognition, we have designed and built a humanoid robot torso, consisting of a binocular head

and an articulated arm/hand. It is composed of a total of 19 motors and 25 degree of freedom (some underactuated). In addition to cameras, the robot is equipped with force/torque, inertial and auditory sensors.

[9] iCub Robot: The iCub is the humanoid robotic platform being developed in the context of the EU Project RobotCub. For its size, it is the most complete humanoid robotic platform being developed worldwide. In the consortium there will be platforms available at the University of Genova, VisLab/ISR/IST and EPFL.The robot has the proportions of a 3-year old infant, contains 54 degrees of freedom and will be able to crawl and do fine object manipulation.
[10] iCub Head (2): In addition to the work in vision, learning and cognition, the VisLab/ISR team was responsible for the design of the head, now being used in Italy, Switzerland and Japan. The head is the most sophisticated with this size worldwide, in terms of sensors (inertial, cameras, audition) and degrees of freedom (6).

[11] Vizzy is a mobile humanoid platform being designed at VisLab/ISR. It will have two articulated arms/hands a binocular agile head and will be mounted on a mobile basis, this being able to explore the environment. The mechanical part is built and the electronics are currently being integrated. This platform has already attracted the attention of other research groups who would be interested in having a similar platform/head.

[12] TOBII System: Gaze tracking system that allows measurements of the human gaze direction. This setup is used for research in human visual attention.

[13] Omnidirectional cameras designed a number of omnidirectional catadioptric cameras with the aim of obtaining specific, pre-specified image formation properties.

[14] 1 all-terrain remotely-operated (by wireless or cable LAN) robot (RAPOSA), endowed with several sensors for detection of dangerous gases, humidity, and temperature, a thermal camera, several web cams (some of them with controllable pan).

[15] 5 omni-directional (3 wheels) robots endowed with an on-board laptop with wireless communications, rate-gyro, 16 sonars, omni-directional catadioptric system, optical mouse for odometry, electromechanical kicker and rolling drum systems for robotic soccer applications.

[16] 1 RWI ATRV-Jr mobile robot, 4-wheel drive, equipped with 16 sonars, GPS, inertial navigation module and a compass, pan and tilt vision system and one SICK Laser scanner (shared with the Mobile Robotics and Computer and Robot Vision Labs).

[17] 1 Blimp aerial robot, with pan and tilt vision system, 3 servomotors, RF link for remote control and remote video-link for video transmission (shared with the Mobile Robotics and Computer and Robot Vision Labs).

[18] 4 Nomadic Super-Scout II mobile robots, with updated electronics (by IdMind) equipped with 16 sonars and 2 cameras each, one of them part of an omni-directional catadioptric system.

[19] 1 PUMA 560 manipulator, whose Mark III controller was partially replaced by Trident Robotics TRC 004/6 boards, which allow manipulator control by an external PC.

[20] 1 Small humanoid robot (Robotis Bioloid kit).

[21] **RIOL** (prototype+patent): Robot able to move on suspended cables monitoring a variety of aspects, e.g., faulty insulators in electric power lines, wildlife, and environmental variables. A patent request was submitted to the national authorities, INPI, by Oct. 2007 and was granted by May 2008.

4.2. PATENTS (1)

[1] **RIOL** (prototype+patent): Robot able to move on suspended cables monitoring a variety of aspects, e.g., faulty insulators in electric power lines, wildlife, and environmental variables. A patent request was submitted to the national authorities, INPI, by Oct. 2007 and was granted by May 2008.