

ACTIVITIES REPORT - 20

ISR-LISBON
IMAR-DOP/UAç
IN+
CREMINER



ISR – Torre Norte, IST, Av. Rovisco Pais, 1049-001 Lisboa, PORTUGAL
Fax: 351-21-8418291
Tel: 351-21-8418289
E-mail: vab@isr.ist.utl.pt

General Information	
Name of Research Unit:	(LA-LVT-9) Instituto de Sistemas e Robótica - ISR - Lisboa
Coordinator:	Victor Alberto Neves Barroso
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Other Subdomains:	Engenharia Mecânica

Host Institutions	
Leading Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa
Other Institutions Involved:	Instituto do MarFundação da Faculdade de Ciências - Faculdade de Ciências da Universidade de Lisboa Instituto Superior Técnico - Universidade Técnica de Lisboa

Objectives & Achievements

Unit Description

The Institute for Systems and Robotics is strategically organized in four (4) main focus or thematic areas: Technologies for Ocean Exploration, Robotic Monitoring and Surveillance, Sustainable Technologies and Environmental Systems, and Signal Processing for Communication Networks and Multimedia. It is against this backdrop of key target areas that multidisciplinary research and development work, as well as education activities are carried out to study, create, improve, and evaluate emerging complex engineering and natural systems. This multifaceted approach has contributed very positively to fostering innovation and promoting sustainable solutions in diverse and multidisciplinary fields that build upon Air, Marine, and Terrestrial Robotics, Information Processing, and Oceanic and Environmental Sciences and Technologies.

The management structure of the Associate Laboratory is organized around a number of management bodies that include: i) a Coordinating Board, ii) an Executive Board, and iii) 4 managers, one for each thematic area. The LA has also an External Advisory Board.

The competencies of the Coordinating Board are to: (i) supervise and steer in very general terms the cooperation activities of the four participating R&D units and (ii) clarify and decide in case of questions resulting from different interpretations of the terms of the binding protocol signed by all participating units. The Coordinating Board consists of the scientific coordinators of the units and the managers of the thematic areas and is presided by the President of the Executive Board of the Laboratory, who ensures that the Coordinating Board meets at least once a year. Meetings of the Coordinating Board can be convened by any one of its members.

The Executive Board is composed of the coordinators of the units involved in the LA and is presided over by the scientific coordinator of the ISR-Lisbon. The main functions of the Executive Board are to ensure proper management of the activities pertaining to the cooperation links among the participating units and to ensure that they are carried out adequately.

Each thematic area has a manager who is elected for a 3-year term by the researchers involved in that particular area. The manager does not have responsibilities of executive management but is instead responsible for a number of tasks that include: promoting strategic orientation of the thematic area and planning the activities that must be carried out to meet the specified objectives; obtaining the necessary human resources; ensuring cooperation among the various groups and integration of their activities; preparing, in cooperation with the researchers in the area, project proposals and seeking funding for these projects (FCT, European Union, others); preparing annual activity plans and reports in the domain of the thematic area, to be submitted to the Coordinating Board for their perusal.

The activities of the associate laboratory have been followed by an Advisory Board, consisting of national and international experts selected by the Coordinating Board. Upon proposal of the Executive Board, and whenever the Coordinating Board sees fit, the Advisory Board may be asked to submit a critical evaluation of the LA, together with guidelines for corrective actions and establishment of new directions of R&D.

General Objectives

The LA brings to the core of its activity a large number of different, yet complementary units that share a systems research approach to science and technology.

One fundamental objective of the LA is the development of advanced technologies for heterogeneous sensor networks that play an ever increasing role in the exploration of diversified environments and resources and in the monitoring and surveillance of natural habitats, human activity, and critical infrastructures. To this effect, a multidisciplinary approach has been adopted that exploits strong cooperative links among engineers, scientists, mathematicians, and also economists. Important and actual issues such as the development and evaluation of emerging complex engineering systems for sustainability (e.g., in terms of socio-economic development and environmental quality) that contribute to the creation of a more prosperous and sustainable society are also addressed.

In the field of marine science and technology, we carry out research and development with the objective of better understanding the ocean and its resources, and to use the knowledge thus acquired for the sustainable benefit of society. These activities lay at the intersection of science and engineering and target the Azores as a natural laboratory for the study of a number of challenging scientific issues in the fields of biological, chemical, geological, and physical oceanography. These issues raise in turn new theoretical and technological challenges for the development of advanced autonomous marine platforms and sensor systems, the design of which is rooted in solid mathematical system theory and distributed computing systems.

We also aim at demonstrating the use of robot/sensor networks in real applications. Besides more "classical" challenges such as cooperative robot navigation or vision based activity recognition that we are addressing, we are strongly involved in the development of cognitive robots

Objectives & Achievements

that can interact with humans. This last topic is developed in the context of a large collaborative network including scientific areas such as biology, neuroscience, psychology, medicine and social sciences.

Still in the general context of sensor networks, information processing leads quite often to complex problems in the category of large-scale, nonlinear and often distributed optimization problems. Advanced mathematical tools (dynamic systems, algebra, differential geometry) are used across the research topics addressed within the LA environment, contributing to the development of new (theoretical and/or algorithmic) results.

At present, the LA is undergoing a reorganization phase that will lead to a renovated institution recognized as a laboratory for systems research integrating a diversity of components in science, technology, and policy.

Main Achievements during the year of 2009

OCEAN ROBOTICS

Development of a new algorithms for (i) multiple vehicle cooperative path planning under temporal and energy expenditure constraints, with due account for temporal or spatial deconfliction requirements, and (ii) multiple vehicle time-coordinated path following control in the presence of communication failures.

Demonstration at sea of: (i) cooperative vehicle motion control with four autonomous marine robots in the scope of the EU GREX project, and (ii) a completely "retrofitted" version of a GPS Intelligent Buoys Positioning System, in the scope of the FCT RUMOS project.

Design, development, and test of an integrated Ultra Short Baseline (USBL) and Inertial Navigation System (INS) to be used as a low cost navigation system for underwater robotic vehicles.

ROBOTICS

Multidisciplinary research conducted with experts in the areas of neuroscience, biology, psychology, medicine and social sciences.

(Muti-)robot task plan representation using discrete event systems; Social sciences inspired approaches to collective robotics (Institutional Robotics); Development of middleware for multi-robot systems and build-up of an experimental testbed for networked robot systems (ISRobotNet).

Methodologies for recognizing human activity from video with learning capability.

Model for (top-down and bottom up) attention in humanoid robots.

Installation of the iCub robot at ISR; tracking and software developments with the iCub.

INFORMATION PROCESSING IN LARGE SCALE SENSOR NETWORKS AND MULTIMEDIA

New collaborative projects: (i) to create a mobile network of pollution sensors using a bus fleet, and (ii) for recognizing and categorization of a large (1M+) database of images of art.

Some achievements that enable those projects are the development of: (i) algorithms for sensor and target localization and tracking from range data in a WSN setting(e.g. firefly),which can handle outliers; (ii) a new non-combinatorial optimization algorithm to tackle the sensor selection problem in WNS's that finds a sub(nearly)-optimal solution with polynomial complexity.

3D reconstruction of non-rigid/articulated objects from video sequences with direct application in biomechanics. This was a direct consequence of several mathematical developments obtained in cooperation with mathematicians.

SCIENCE

Through IMAR Azores, the Associated Lab has become the world leading research center for the study of the deep-sea chemo-synthetic mussel Bathymodiolus and the 14th Web of Knowledge ranked institution (as University of the Azores) on the study of hydrothermal vent extreme ecosystems. The implementation and refurbishing in 2008 of LabHorta (a new international laboratory for the study of hydrothermal vents) were major milestones, for they opened a new window on the studies of extreme ecosystems of the deep-sea.

In what concerns marine geology, the areas of work included the Azores Sea and the Arctic Ocean (Loki's Castle), the latter discovered in 2008 with the participation of Creminer. Additionally, work continued on topics and samples from the Southwest Pacific. Public outreach through Creminer continued to be particularly noteworthy, with involvement in the National Museum of Natural History and in the setting-up of the Lousal "live science" center in Southern Portugal and the Quartz Museum in Viseu.

Additional Comments

Research Groups

Reference	Title / Principal Investigator
RG-LVT-50009-3422	<u>Evolutionary Systems and Biomedical Engineering</u> (Agostinho Claudio da Rosa)
RG-Centro-50009-3433	<u>Centre of IMAR of the University of the Azores/ Department of Oceanography and Fisheries (IMAR-DOP/UAz)</u> (Ricardo Piedade Abreu Serrão Santos)
RG-LVT-50009-3438	<u>DSORL - Dynamical Systems and Ocean Robotics Laboratory</u> (António Manuel dos Santos Pascoal)
RG-LVT-50009-3447	<u>Signal and Image Processing Group</u> (Isabel Maria Gonçalves Lourtie)

Research Groups

Reference	Title / Principal Investigator
RG-LVT-50009-3503	<u>Mobile Robotics Laboratory - MRLab</u> (Maria Isabel Lobato de Faria Ribeiro)
RG-LVT-50009-3505	<u>Intelligent Systems Laboratory</u> (Pedro Manuel Urbano de Almeida Lima)
RG-LVT-50009-3508	<u>VisLab - Computer and Robot Vision Laboratory</u> (Jose Alberto Rosado Santos Victor)
RG-LVT-50009-3583	<u>Laboratory for Energy and Environmental Studies at IN+ Center for Innovation, Technology and Policy Research</u> (Paulo Manuel Cadete Ferrao)
RG-LVT-50009-3584	<u>Laboratory of Thermofluids, Combustion and Energy Systems, at IN+ Center for Innovation, Technology and Policy Research</u> (Antonio Luis Nobre Moreira)
RG-LVT-50009-3585	<u>Laboratory of Technology Policy and Management of Technology, at IN+ Center for Innovation, Technology and Policy Research</u> (Rui Miguel Loureiro Nobre Baptista)
RG-LVT-50009-3589	<u>Centre of Mineral Resources, Mineralogy and Crystallography of the Faculty of Science of Lisbon University (CREMINER)</u> (Fernando José Arraiano de Sousa Barriga)

Research Lines

Reference	Title / Principal Investigator
RL-EEI-LA09-133	<u>Robotic Monitoring and Surveillance</u> (Jose Alberto Rosado Santos Victor)
RL-EME-LA09-137	<u>Sustainable Technologies and Environmental Systems</u> (Paulo Manuel Cadete Ferrao)
RL-EEI-LA09-145	<u>Signal Processing for Communicatio Networks and Multimedia</u> (Joao Paulo Salgado Arriscado Costeira)
RL-EEI-LA09-151	<u>Technologies for Ocean Exploration</u> (António Manuel dos Santos Pascoal)

Other Activities

Internal Services and Resources

The ISRobotNet is a testbed for Networked Robot Systems developed by MRLab together with VisLab and ISLab, composed of an indoor area of around 160 m² with 10 webcams placed at the ceiling such that some of the fields of view do not overlap. The cameras are distributed in 4 groups, each of which is managed by its own computer, namely for image acquisition. The managing computers are connected to the ISR/IST network and can be accessed by duly authorized external parties. Ongoing work will extend the number of cameras and the usable indoor space to include multiple floors. Robots will use the same elevators as ordinary people to move between floors. Besides the camera sensors, four Pioneer AT and one ATRV-Jr robots are available. Each of the robots is equipped with sonars, onboard cameras, laser range finder and is Wi-Fi connected to the network. The testbed is open to, and has been used by, ISR, other national and international researchers.

Researchers from IN+ and IAR have been collaborating on the use of sensor+robot networks to monitor energy efficiency in buildings and dynamically take decisions to minimize it. A sensor network is being deployed at IST/Tagus park.

The equipment acquired in the scope of the Re-Equipment program of the FCT has been extensively used in cooperative sea missions at sea. Namely, the sidescan and the multibeam sonar have been used for seabed mapping in the scope of geological and marine habitat studies.

The marine robots DELFIM and DELFIMx and associated equipment have played a key role in the execution of cooperative robotic missions at sea in Sesimbra,

Portugal with an international team of scientists and engineers brought together in the scope of the EU funded GREX and FREESUBNet projects. This important milestone has received considerable attention with the marine robotics community worldwide.

External Services and Resources

- Isabel Ribeiro: Adviser to the Board of FCT (Portuguese Foundation for Science and Technology) for the area of R&D projects
- José Santos-Victor: IST Vice-President for International Affairs
- José Santos-Victor; IST Director for the IST-EPFL Joint Doctoral Program
- Pedro Lima: IST Scientific Board Vice-President for Scientific Affairs (until July 2009), then elected member of IST Scientific Council
- Pedro Lima; National Delegate to the ESA-Aurora/Exploration Program (PB-HME)

Other Activities

- Pedro Lima: National Delegate to the EC FP7-Space Committee
- Paulo Ferrão; National Director of the MIT | PORTUGAL program
- João Paulo Costeira; IST Director for the Electrical and Computer Engineering Dual Doctoral Program with Carnegie Mellon University
- Pedro Ferreira; IST Director for the Engineering and Public Policy Dual Doctoral Program with Carnegie Mellon University
- Rui Baptista; IST Director for the Technological Change and Entrepreneurship Dual Doctoral Program with Carnegie Mellon University
- Fernando Barriga, Director National Museum of Natural History
- Fernando Barriga, National delegate ECORD and member of IGW+, charged with organizing the next decade of IODP
- Antonio Pascoal - Chair of the IFAC Technical Committee on Marine Systems
- Antonio Pascoal - Member, European Science Foundation (ESF) pannel in charge of evaluating the Bulgarian Academy of Sciences, 2009.
- Carlos Silvestre - Member of the IFAC Technical Committee on Aerospace
- Carlos Silvestre Member of the IEEE Technical Committee on Aerospace Control
- Antonio Pascoal - Member of the IFAC Technical Committee on Intelligent Autonomous Vehicles.
- Antonio Pascoal - Associate Editor, IEEE Oceanic Engineering.
- Antonio Pascoal - Vice-President of EurOcean, the European Portal for Marine Science and Technology.
- Involvement of one ISR researcher in the MIT-Portugal/Critical Move/FCT Critical Challenge initiative, as member of the Steering Committee
- Ricardo Santos - Co-chair of the Deep Sea Research Group of the Ministry of Science and Technology (Lisboa) (appointed by the President of COI).
- Ricardo Santos - Member of the Ad-Doc Group for Marine Research Infrastructures at the ESFRI. (2002-2003).
- Ricardo Santos - Member of BIOMARE SC - Network of large-scale long-term marine biodiversity research in Europe (EU).
- Ricardo Santos - Co-Chair of the Working Group on Monitoring and Observatories of InterRidge.
- Ricardo Santos - Member of MAR-ECO SC - Patterns and processes of the ecosystems of the northern mid-Atlantic (Census of Marine Life –CoML).
- Ricardo Santos - Member of ChEss SC - Biogeography of Chemosynthetic Ecosystems (Census of Marine Life –CoML).
- Ricardo Santos - Member of the Steering Committee of MARBEF (NoE: Marine Biodiversity and Ecosystem Functioning).

Networking Actions

ISR-AL has been involved since 2001 in the Portuguese Robotics Society, whose main goal is to promote Robotics in Portugal, through I&D and outreach activities, including the annual organization of the Portuguese Robotics Open, that counts with the participation of around 800 people, approximately 700 of which come from High-Schools and 100 from Universities and Polytechnic Institutes. The event includes a Scientific Meeting and it is jointly organized by Professors from other Portuguese groups with activity in Robotics, namely from U. Minho, U. Porto, Polytechnic Institute of Porto, U. Aveiro and U. Coimbra. ISR-AL member Pedro Lima is currently the President of the Portuguese Robotics Society.

The DSORL and the IMAR/DOP/UAzores have been participating actively in FREESUBNET, a Marie Curie Research Training Network, the purpose of which is to provide a European-wide excellence in quality training to young and experienced researchers in the emerging field of Cooperative Autonomous Intervention Underwater Vehicles (AUVs), which are steadily becoming the tool par excellence to carry out missions at sea without tight human supervision.

Intensive networking and cooperative links were established among the IMAR/DOP/UAzores, the DSORL, the Signal and Image Processing Group, and a large number of scientists and engineers abroad, in the scope of the EU GREX project (Coordination and Control of Cooperating Heterogeneous Unmanned Systems in Uncertain Environments). The project was a landmark in the development, integration and testing of middleware systems for cooperative marine vehicle control under stringent communication constraints

FP6-RTN/2003/505026: MoMARNET – Monitoring deep sea floor hydrothermal environments on the Mid-Atlantic Ridge: A Marie Curie Research Training Network

ISR and SPIG and DSOR in particular co-organized and actively participated in the "O 1º encontro da Rede Temática de Matemática em Ciência e Engenharia – <http://www.dcc.fc.up.pt/mathise/>" - First Encounter of the Thematic Network of Mathematics in Science and Engineering. The event had talks and discussion panels on themes lying on the interface between mathematics and engineering to promoting joint work between these communities.

Training Activities

- Strong involvement in the IST-EPFL Joint doctoral program, established in 2008, in the areas of Distributed and Cognitive Robotics as well as Biological and Biomedical imaging.
- Involvement of ISR researchers in the double Master Degree Program on Systems, Decision and Control between IST and the Royal Institute of Technology in Stockholm.
- Strong involvement in the MIT | Portugal master and doctoral programs
- Strong involvement in the CMU | Portugal dual doctoral programs
- ISR organized the first Tutorial on Computer Vision in a Non-rigid World which took place in ISR-Lisboa. (<http://users.isr.ist.utl.pt>)

Other Activities

/~adb/?page_id=14) with Prof. Adrien Bartoli and Dr. Lourdes Agapito as invited speakers.

Outreach/Science and Society

Programme Ciência Viva – “Ocupação de Jovens nas Férias”, organized by ISR, 1 week in July, on the topic of building and programming a small robot.

Involvement in the National Museum of Natural History and in the setting-up of the Lousal “live science” center in Southern Portugal and the Quartz Museum in Viseu. The Underground Visit to Lousal, a large, Qren funded, multi-million project, is presently being discussed with Creminer and MNHN.

Organization of International Events

Co-organization, with the University of S Paulo, Brasil, of the MCMC 2009 Conference, Guarujá, Brazil, September, 2009.

Co-organization of the Workshop “Networked embedded and control system technologies: European and Russian R&D cooperation”, July 4-5, 2009- Milan, Italy.

Organization of the ICES Symposium Issues Confronting the Deep Oceans: The Economic, Scientific, and Governance Challenges and Opportunities of Working in the Deep Sea Amor da Pátria Hall, Horta, Faial Island, Azores, Portugal, April 27 – 30, 2009

Co-organized the Carnegie Mellon |Portugal conference in which all partner universities, industrial affiliates and Carnegie Mellon research groups participated. Also as part of this event we co-organized the Doctoral Consortium where all PhD students of the program (50+) participated in research discussions.

Internal Evaluations

Summary of internal evaluations during 2009

NA

We didn't have any internal evaluation during 2009 because that was the year when ISR should have been evaluated by an independent international panel.

It is important to note that due to a last minute cancellation of one of the members, not all thematic areas were adequately covered by the Advisory Board visit. The plan to nominate an additional member of this board and the corresponding visit have been postponed since then, as it was found desirable to wait for LA evaluation that is still pending. During 2007 and 2008 this concern has been communicated to FCT together with a proposal for possible Advisory Board Members that could cover the missing areas and topics.

Future internal Evaluations plan for 2010

NA

The 2009 international evaluation was once more postponed. We hope that can take place during 2010. This is the reason why we didn't plan any internal evaluation to take place during 2010.

Future Objectives

Summary of proposed future objectives

Cooperative links already established with marine scientists will be further exploited with the objectives of: (i) intensifying the transfer of technology to scientific end-users, effectively affording marine scientists better tools for ocean exploration and mapping, (ii) defining mission scenarios that warrant the use of advanced technology, and (iii) executing common missions at sea in the Azores and in the continent. The following are representative examples of planned activities: (i) marine habitat mapping / observation and tracking of marine mammals and fish schools; (ii) harbour security and dam / coastal area surveying and monitoring; and (iii) ecosystem studies, more specifically, bio-telemetry studies of top predators together with habitat mapping at the level of seafloor and water column.

We will continue the strong involvement in topics such as human-robot interaction, cognitive architectures, cooperative perception, decision-theoretic decentralized planning under uncertainty, human activity surveillance and recognition, and gesture recognition. One distinctive feature of this research line is the exploration of multidisciplinary, thought-provocative research topics, which have demonstrated potential for introducing breakthrough concepts in several areas, from cognitive and collective robotics to biomedical image processing.

We will develop a mobile sensing ecosystem consisting on a network of pollution measuring system using the bus fleet, which can evolve to a multi-sensing mobile platform applied to urban environments, including several sensing modalities, such as video cameras and microphones. The approach will require a whole new set of tools deeply rooted in mathematical disciplines which the past cooperation and selective hiring assures.

One other line of research will be the exploration of formal analogies between different fields in the natural, social and engineering sciences, e.g., the analogy between ecosystems and industrial systems, or between coordination in (human and non-human) social systems and “societies” of autonomous robots. We also aim at developing integrated models of environment-energy-economy interaction, at multiple spatial scales, using models such as input-output, computable general equilibrium modes, and economic growth.

Group Description	
Title of Research Group:	(RG-LVT-50009-3422) Evolutionary Systems and Biomedical Engineering
Principal Investigator:	Agostinho Claudio da Rosa
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa
Funding, source, dates	
Funding, source, dates	
FCT Pluri-anua, Agostinho C da Rosal, 2009	
FCT Project OpenMicroBio PTOC/BIO/693/2006, 2009	
Objectives & Achievements	
Objectives	
<p>The long term objective of LaSEEB group is to develop model-based real-time detection and classification of brain states using the multi-channel Electroencephalogram (EEG) signal, where models and classifiers are optimized by bio-inspired algorithms. The final goal is not only to provide a better understanding of the brain functions but also providing affordable efficient training, prevention and therapy techniques. Modeling and Classification of brain States during awake and sleep for Neurocognitive training using Self-Organized Swarm Intelligence techniques.</p>	
Main Achievements	
<p>ALife:Agent Based Modelling of the Dengue transmitting mosquito aedes aegypti adding the interaction with moving population and also the infection dynamics.</p> <p>Particle Swarm Optimization and Genetic Algorithm parameters and structure tuning of a Model for bio-reactors of D. Hansenis using real data set.</p> <p>Evolutionary Optimization:Adaptive Population size Evolutionary Algorithms for Dynamic Problem. Self-Organized Criticality theory applied to a new mutation operator.</p> <p>Image Processing: Statistical model was developed for Confocal Microscopy Images Segmentation</p> <p>BioMedicine: Working Memory training by EEG Biofeednback. Epileptic spikes detection using continuous wavelets and Fuzz classification. Automatic K-Complex detection in human sleep EEG.</p>	
Group Productivity	
Publications in peer review Journals	
<ol style="list-style-type: none"> 1. C Isidoro, N Fachada, F Barata, AC Rosa. Agent Based Model of Aedes aegypti Population Dynamics. EPIA-ALEA, LNAI 5816, pp 53-64, 2009. 2. Juan L.J. Laredo, Carlos M. Fernandes, Antonio M. Mora, Pedro A. Castillo, Pablo García-Sanchez, J.J. Merelo. Studying the Cache Size in a Gossip-Based Evolutionary Algorithm, in G.A. Papadopoulos and C. Badica (Eds.), Proceedings of the 3rd International Symposium on Intelligent Distributed Computing, Studies in Computational Intelligence, vol. 237, pp. 131-140, 2009. 3. C Isidoro, N Fachada, F Barata, AC Rosa. An Agent Based Model of Dengue Disease Transmission by Aedes aegypti Populations. ECAL, 2009 LNCS, To appear. 4. CM Fernandes, CF Lima, JIJ Gimenez, AC Rosa, JJ Merelo. An Ant-based Rule for UMDA's update Strategy. ECAL 2009. LNCS, to appear. 5. Calapez A, Rosa A. A Statistical Pixel Intensity Model for Segmentation of Confocal Laser Scanning Microscopy Images. IEEE Trans Image Processing, to Appear 6. AC Rosa and JP Rodrigues. "Dream therapy: correlation of dream contents with encephalographic and cardiovascular activations". In "States of Consciousness: Experimental Insights into Meditation, Waking, Sleep and Dreams", Dean Cvetkovic (edt), Springer-Verlag Physics Edition of "The Frontiers Collection". To appear. 	
Other publications International	
<ol style="list-style-type: none"> 1. Fachada N, Lopes V, Rosa AC. Influenza A modeling and simulation. Proc ACM SAC - SIM Tracks, pp 2093-2100, 2009. 2. C Isidoro, N Fachada, F Barata, AC Rosa. Artificial Life Model of Dengue Host-Vector Disease Propagation. . Proc of IJCCI - ICEC, pp 243-247, 2009. 3. António Dourado, Agostinho C. Rosa, Kurosh Madani (eds): IJCCI 2009 - Proceedings of the International Joint Conference on Computational 	

Group Productivity

Intelligence, Funchal, Madeira, Portugal, October 5-7, 2009 INSTICC Press 2009

4. Juan L.J. Laredo, Pedro A. Castillo, Antonio M. Mora, Carlos M. Fernandes, J.J. Merelo. Improving Genetic Algorithms Performance via Deterministic Population Shrinkage, in Proceedings of the 11th Genetic and Evolutionary Computation Conference (GECCO 2009), ACM Press, pp.819-826, 2009.

5. Daria G Migotina, Agostinho C Rosa, Ana LN Fred. Automatic K-complex detection using Hjorth parameters and fuzzy decision. ACM Proc. SAC 2010 – CIIA, to appear.

6. João PM Rodrigues, Daria G Migotina, Fernando M Melicio, Agostinho C Rosa. Monitoring Electrocardiac Activity during EEG Biofeedback. IEEE HCI 2010, to appear.

Master and Ph.D. thesis completed

1. Carlos M Fernandes, PhD. Thesis.

“Diversity-Enhanced Genetic Algorithms for Dynamic Optimization”

2. João Pedro de Matos Rodrigues, MSc Thesis

Monitoring Electrocardiac Activity During EEG Biofeedback.

3. Andre Ramalho Santos Rosado, MSc Thesis

Detecção Automática de Actividade Epileptiforme Interictal no EEG.

4. Dulce Isabel Viegas Calçada., MSc Thesis

“Modeling of the Physiology of *D. hansenii* Using Population-based Search Methods for Parameter Estimation”

Organization of conferences

ACM SAC 2009 – Computational Intelligence Image Analysis track, Honolulu, Hawaii

APIA 2009 – Artificial Life and Evolutionary Algorithms Track, Aveiro, Portugal

INSTICC - International Conference on Evolutionary Computation 2009 – Programme Chair, Funchal, Portugal

Internationalization

University Of Granada, Spain.

Juan L.J. Laredo, Carlos M. Fernandes, Antonio M. Mora, Pedro A. Castillo, Pablo García-Sánchez, J.J. Merelo. Studying the Cache Size in a Gossip-Based Evolutionary Algorithm, in G.A. Papadopoulos and C. Badica (Eds.), Proceedings of the 3rd International Symposium on Intelligent Distributed Computing, Studies in Computational Intelligence, vol. 237, pp. 131-140, 2009.

Juan L.J. Laredo, Pedro A. Castillo, Antonio M. Mora, Carlos M. Fernandes, J.J. Merelo. Improving Genetic Algorithms Performance via Deterministic Population Shrinkage, in Proceedings of the 11th Genetic and Evolutionary Computation Conference (GECCO 2009), ACM Press, pp.819-826, 2009.

CM Fernandes, CF Lima, JLJ Gimenez, AC Rosa, JJ Merelo. An Ant-based Rule for UMDA's update Strategy. ECAL 2009. LNCS, to appear.

UMIT, Melbourne, Australia.

AC Rosa and JP Rodrigues. "Dream therapy: correlation of dream contents with encephalographic and cardiovascular activations". In "States of Consciousness: Experimental Insights into Meditation, Waking, Sleep and Dreams", Dean Cvetkovic (ed), Springer-Verlag Physics Edition of "The Frontiers Collection". To appear.

Future Research

Objectives

LaSEEB future main research activity is oriented towards the development of novel and integrative approaches for the modelling and simulation of biological systems. LaSEEB research activities have been focused mainly in the development of agent based models/algorithms inspired by nature to be used in a variety of different engineering tasks, such as: optimization algorithms, simulation of biological systems and modelling, identification and classification of biomedical signals. The future research goals defined for the next years are a natural consequence of the work developed so far. Research effort will be focused in four synergistic research areas, describe in the next 4 paragraphs.

1.1 Development of a new framework for the simulation of biological systems (LAIS II) based on agent based methodologies – this framework aims to assist the biological research in test qualitatively and quantitatively new biological theories. The framework will be developed as part of an ongoing research project with the University of Minho – OpenMicroBIO. Specifically, it aims to describing cell dynamics (cycle and metabolism), cell to cell communications and networking and colony dynamics (quorum sensing) inside bio-reactors for modelling and simulation of flocculating yeast (*Saccharomyces cerevisiae* - eukaryotic cell) growth during fed-batch fermentations. ABM also targets the *D. hansenii* and *Bractrocera Oleae*

1.2 Development of novel multi-way data decomposition algorithms to help in the characterization of biological samples and assist in the validation of experimental biologic analytical data (process analytical techniques – PAT) – the development of novel computational tools to assist to process of biological data collection and validation is an important aspect identified from our existent collaborative research. Techniques based on the low rank data decomposition can provide an important role in dealing with the high-throughput biological analytical methods such as the gas chromatography - mass spectroscopy or hyper-spectral chemical imaging (under the collaboration with the project

Future Research

CLARO: cancer light assisted receding oncological therapies which aims at using hyper-spectral FTIR microscopic data for tumorous tissue classification). After the development of the statistical model for the Confocal Microscope, the next step is the model based segmentation.

1.3 Development of new algorithms that can exploit the computational capabilities of the new multi-core and many-core processing hardware of heterogeneous systems (GPU, Cell and multi-core Intel processors) – the development of agent based modelling strategies for the simulation of biological systems requires an huge computational power. Research will address the development of special purpose algorithms that will allow distributing the computational workload characteristic of ABM systems among different heterogeneous processing units. This research will benefit from the existent high-performance computational capabilities at LaSEEB (5 PS3 and 10 multi-GPU Quad & Core7 machines). Currently a pilot application is developed to test the OpenCL and CUDA specifications for Artificial Life and ABM simulations.

1.4 Development of a fully automatic analysis system for Advanced Diagnosis of Sleep Disorders in collaboration with industry partners incorporating a new model for the micro structural organization of the Sleep process in partnership with Stanford University and State University of Sao Paulo, culminating with the proposal of a new Paradigm for Sleep Classification. Neuro-Feedback and individual rhythms monitoring is currently under development.

1.5 Four new Members at Doctoral level is underway to join the lab, will therefore leverage the Laseeb actions in the Biomedical arena, namely on fMRI imaging and Mobile diagnostic and monitoring devices, Renewable Energies Sources and Neuro-Feedback.

Funding, source, dates

The research will be partial supported by OpenMicroBIO research project and by the existent pluri-annual base funding. The Laseeb has no effective participation on the ISR-LA research files (no fundings too) since 2003 and the stal situation of the LA since 2007 is difficult to plan more ambitious activities.

Future research activities will benefit from data collected from the existent collaborative research projects and, thus magnify the existent research collaboration initiatives with: a) the Centro de Biologia Molecular and Centro de Engenharia Biologica of the Instituto de Biotecnologia e BioEngenharia at Universidade do Minho; b) Departamento de Biotecnologia at LNEG. c) Faculdade de Motricidade Humana.

Special requirements

For the LaSEEB research is necessary be integrated and access to a fair share of the ISR programmatic “pluri-anual” research funding in order to take full advantage of the existent research environment conditions. It is believed that this additional funding would: a) provide an additional contribution from ISR to the complex systems research field; b) increase ISR leverage in existent and future scientific research collaborations; and c) increase ISR aptitude to be integrated new multidisciplinary research networks. In a short time period, it could magnify the scientific outcome of existent collaborations.

For a more synergetic effort inside ISR human resources, LaSEEB is proposing the formation of a new Bio-Systems Group in 2010 integrating current member, all other members interested to join and specially boosted by new contracted researchers in order to achieve the necessary critical mass to address more ambitious longer term objectives.

This new group will comprise horizontal activities in most bio related areas and more important to strive for excellence in a specific domain to be defined by the institution strategic policy.

Group Description	
Title of Research Group:	(RG-Centro-50009-3433) Centre of IMAR of the University of the Azores/ Department of Oceanography and Fisheries (IMAR-DOP/UAz)
Principal Investigator:	Ricardo Piedade Abreu Serrão Santos
Main Scientific Domain:	Ciências do Mar
Group Host Institution:	Instituto do Mar

Funding, source, dates	
Funding, source, dates	<p>EEA Financial Mechanism PT0040/2008: CONDOR</p> <p>EU - Programa Nacional de Amostragem Pesqueira</p> <p>INTERREG - PCT/MAC/1/6070 - BANGENE – Rede BANGENE Macaronesia</p> <p>INTERREG - MAC/2/M065 - MARPROF</p> <p>INTERREG - Project no. 2009-1/110 MESH</p> <p>FP6-IST/2005/035223: GREX: 2006-2009.</p> <p>FP6-GOCE/2005/036851-1: ESONET/NoE</p> <p>FP7 ENV/2008/1/226354: HERMIONE</p> <p>FP6 RTN/2006/2/036186-2: FREESUBNET</p> <p>FP7 KBBE/2007/1/210496: MADE</p> <p>FP7 ENV/2007/1/213144: CORALFISH</p> <p>FCT PTDC/MAR/74071/2006: TRACE</p> <p>FCT PTDC/MAR/72169/2006: CORAZON</p> <p>FCT PTDC/MAR/65991/2006: IMUNOVENT</p> <p>ESF/EUROCORES – Proposal 06-EuroDEEP-FP-008 & FCT: EURODEEP/0002/2007 - DEECON</p> <p>FCT- Pluriannual + Programatic</p> <p>DRCT – Pluriannual</p>

Objectives & Achievements	
Objectives	<p>The conservation of marine life and the sustainable use of living resources in the North-East Atlantic Ocean and the ecosystems of islands slopes, the Deep-Sea and Open Ocean at large are the main objectives of the research and outreach activities developed at the Centre of IMAR of the University of the Azores/Department of Oceanography and Fisheries (IMAR-DOP/UAç). Those objectives are shared with the generations of young students and newly graduated researchers in marine sciences that integrate IMAR-DOP/UAç. The members of IMAR-DOP/UAç have been involved in the development of different activities within these fields, in a multidisciplinary effort to integrate the research for a better understanding of the dynamics of this region, and its biological, physical, chemical and geological backgrounds.</p> <p>The Research Group operates in 5 flexible Working Groups and 6 Laboratories. The actual WGs are dedicated to: "Ecosystem Based Approaches to Marine Habitats & Biodiversity", "Ecosystem Based Management to Fisheries", "Chemosynthetic Ecosystems", "Seamounts and Cold Water Corals", "Oceanography". The main fields of research are: molecular genetics and biotechnology, eco-toxicology, satellite oceanography, fisheries dynamics, behavioural ecology, bio-telemetry, acoustic of the seabed and water column in view of the mapping of habitats and biodiversity and scenarios for sea-going technologies.</p> <p>This centre supports and helps pure and applied research. It is highly involved in co-operation activities with public and private institutions from Portugal and other countries, including universities, research centres and institutes, enterprises and professional associations. IMAR-DOP/UAç also carries out services for industry and public administration. It is also involved in activities of promotion and divulgation of research activities in media, museums, at the primary and high school system and through the internet.</p>

Main Achievements	
Main Achievements	<p>Given the space available, this time I will focus on bio-technology related achievements only:</p> <p>More recently we begun a series of studies aimed at investigating gene expression and physiological reactions in deep sea vent animals utilizing the vent mussel as a model of reference. From these studies, results emerged pointing at the potential use that some of the genes and molecules could have in biotechnology. In addition to deep-sea hydrothermal vent, other marine environments in the Azores islands were considered for bioprospecting as it is the case for the D. João de Castro bank, between the island of Terceira and São Miguel. A partnership between colleagues at DOP and the National Institute of Oceanography in Goa, India has led to the identification and characterization of marine microorganisms (bacterial, protists, microalgae, fungi) with high biotechnological value. We have continued over the recent years the bioprospection of the shallow hydrothermal waters at the D. João de Castro Bank and collected various samples of microbial mats for</p>

Objectives & Achievements

metagenomic analyses in the near future. The same applies to the deep-sea hydrothermal vents where we have been sampling the deep sea sediments and microbial communities on the surface of deep sea hydrothermal vent animals. An increasing number of scientific articles and successful grant applications earned DOP its international recognition and excellence in marine sciences, setting the course for new opportunities to explore and excel in areas of such great interest as in marine biotechnology.

Our research topics also include a set of open-ocean and other deep-sea habitats and species like seamounts, cold water coral reefs and gardens, sponge aggregations, and microbiology of deep-sea sediments. More recently we came out with the installation of new laboratory (CoralLab), dedicated to the husbandry and experimentation with cold-water corals, making possible the study of certain aspects of the biology and physiological processes of cold-water corals and associated fauna, which are difficult in situ. For example, in CoralLab seawater temperature and pH can be independently controlled in different aquaria, enabling the simulation of seawater temperature and acidity increases predicted as consequences of climate change, and the study of physiological responses by means of gene expression studies and or transcriptomic analyses and direct observations of hemocytes reactions to oxidative stress.

Planned experiments at CoralLab include studies on: (i) physiological responses of scleractinian and corals to increased seawater carbon dioxide partial pressure (pCO₂) and temperature; (ii) the sensitivity/resilience of gorgonians to mechanical injury under different temperature conditions; (iii) gene expression analysis of relevant genes known to be directly involved in immune and stress responses to the presence of pathogens and or environmental stressors.

Current status

Some projects and research lines are being developed to address several biotechnological related issues at DOP:

1. Marine enzymes from environmental microbes (Deep-sea vents and shallow water vents): mostly through a DNA-based approach using metagenomic analyzes, i.e the sequencing of all the genomes present in microbial communities. Some of the enzymes we are targeting have a direct implication in industry: proteases; amylases, pullulanase, glucoamylases, glucosidases, cellulases, xylanases, Lipases, esterases.
2. Enzymatic activities detected by screening methods using bulk extracts from microalgae, fungi, bacteria and marine invertebrates collected in the Azores. We have given special emphasis to the detection of antibacterial activities and we are setting new protocols for the purification of natural antibiotics of marine origin.
3. The establishment of global gene expression analyses or transcriptome analyses using state-of-the-art technologies such as the 454-sequencing to generate several thousands of DNA sequences corresponding to new genes whose putative biological functions may be biotechnology relevant.

Examples of genes identified in *Bathymodiolus azoricus* with potential use in biotechnology:

-heparin (blood anti-coagulant); -hemoglobin (iron transport, oxygen carrier); -foot protein with strong adhesive properties; -Tumor Necrosis Factor (anti-tumoral); -cytolysin (cytotoxic, destroys cells); -glycoproteins (immune recognition, immune system booster); -epidermal growth factor (tissue forming); -extracellular matrix proteins (bone development, tissue repair); -antibacterial, antifungal, antiviral factors.

Group Productivity

Publications in peer review Journals

ALL PDFs OF 48 PAPERS AT: <http://www.horta.uac.pt/temp9/papers2009/>

- A. R. C. Abecasis, A. Canha, D. Reis, M. R. Pinho, J. Gil-Pereira, *Journal of the Marine Biological Association of the United Kingdom* 89, 629 (May, 2009).
- D. Abecasis, F. Cardigos, F. Almada, J. M. S. Goncalves, *Marine Biology Research* 5, 605 (2009).
- P. Afonso et al., in *Tagging and Tracking of Marine Animals with Electronic Devices*, J. L. Nielsen et al., Eds. (2009), vol. 9, pp. 423-443.
- P. Afonso, J. Fontes, K. N. Holland, R. S. Santos, *Marine Ecology-Progress Series* 381, 273 (2009).
- J. N. Amat, F. Tempera, *Marine Pollution Bulletin* 58, 761 (May, 2009).
- P. Amorim et al., *Ices Journal of Marine Science* 66, 29 (Jan, 2009).
- J. Aristegui et al., *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2646 (Dec, 2009).
- S. P. Avila et al., *Palaeogeography Palaeoclimatology Palaeoecology* 274, 18 (Apr, 2009).
- J. P. Barreiros et al., *Journal of Coastal Research* 25, 1114 (Sep, 2009).
- I. Bashmachnikov, F. Machin, A. Mendonca, A. Martins, *Journal of Geophysical Research-Oceans* 114, (May, 2009).
- I. Bashmachnikov et al., *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2593 (Dec, 2009).
- A. A. Bertoncini, L. F. Machado, J. P. Barreiros, M. Hostim-Silva, J. R. Verani, *Journal of the Marine Biological Association of the United Kingdom* 89, 859 (Jun, 2009).
- R. Bettencourt et al., *Comparative Biochemistry and Physiology a-Molecular & Integrative Physiology* 152, 278 (Feb, 2009).
- J. Bried, M. P. Dubois, P. Jouventin, *Waterbirds* 32, 590 (Dec, 2009).
- J. Bried et al., *Ecological Restoration*, 27, 27 (March, 2009).
- G. P. Carreira, J. Gonçalves, *Marine Biodiversity Records* 2, e114 (2009).
- M. Carreiro-Silva, T. R. McClanahan, W. E. Kiene, *Marine Ecology-Progress Series* 392, 1 (2009).
- A. Colaco et al., *Marine Environmental Research* 67, 146 (Apr, 2009).
- V. Costa et al., *Scientia Marina* 73, 77 (Dec, 2009).
- D. Cuvelier et al., *Deep-Sea Research Part I-Oceanographic Research Papers* 56, 2026 (Nov, 2009).
- J. Fontes, J. E. Caselle, P. Afonso, R. S. Santos, *Journal of Fish Biology* 75, 1271 (Oct, 2009).

Group Productivity

- J. Fontes, J. E. Caselle, M. S. Sheehy, R. S. Santos, R. R. Warner, *Marine Ecology-Progress Series* 387, 51 (2009).
- L. S. Gordo et al., *Scientia Marina* 73, 89 (Dec, 2009).
- K. C. Hamer et al., *Journal of Animal Ecology* 78, 880 (Jul, 2009).
- E. Kadar, A. Lobo-da-Cunha, C. Azevedo, *Marine Biology* 156, 959 (Apr, 2009).
- H. Knutsen et al., *Molecular Ecology* 18, 3151 (Aug, 2009).
- J. Machado et al., *Journal of Shellfish Research* 28, 899 (Dec, 2009).
- F. Machin et al., *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2606 (Dec, 2009).
- I. Martins et al., *Journal of Experimental Marine Biology and Ecology* 376, 1 (Jul, 2009).
- A. Mendonca et al., *Journal of Applied Remote Sensing* 4, (Feb, 2010).
- G. M. Menezes, A. Rosa, O. Melo, M. R. Pinho, *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2683 (Dec, 2009).
- C. Mohn, M. White, I. Bashmachnikov, F. Jose, J. L. Pelegri, *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2582 (Dec, 2009).
- T. Morato, C. Bulman, T. J. Pitcher, *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2713 (Dec, 2009).
- S. Murphy et al., *Marine Ecology-Progress Series* 388, 273 (2009).
- V. C. Neves, K. Griffiths, F. R. Savory, R. W. Furness, B. K. Mable, *European Journal of Wildlife Research* 56, 95 (Feb, 2010).
- C. Ojeda-Martinez et al., *Ocean & Coastal Management* 52, 89 (Feb, 2009).
- C. K. Pham et al., *Journal of the Marine Biological Association of the United Kingdom* 89, 171 (Feb, 2009).
- A. M. Pinela et al., *Canadian Journal of Zoology-Revue Canadienne De Zoologie* 87, 802 (Sep, 2009).
- D. Pontier, D. Fouchet, J. Bried, *Journal of Theoretical Biology* 262, 90 (Jan, 2010).
- R. S. Santos, S. Christiansen, B. Christiansen, S. Gubbay, *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2720 (Dec, 2009).
- M. A. Silva, C. Brito, S. V. Santos, J. P. Barreiros, *Mammalia* 73, 60 (Mar, 2009).
- M. A. Silva, S. Magalhaes, R. Prieto, R. S. Santos, P. S. Hammond, *Marine Ecology-Progress Series* 392, 263 (2009).
- S. Stefanni, R. Bettencourt, H. Knutsen, G. Menezes, *Molecular Ecology Resources* 9, 528 (Mar, 2009).
- V. M. Tuset et al., *Journal of Crustacean Biology* 29, 507 (Nov, 2009).
- J. C. Vilas et al., *Deep-Sea Research Part II-Topical Studies in Oceanography* 56, 2618 (Dec, 2009).
- P. P. E. Weaver et al., *Oceanography* 22, 178 (Mar, 2009).
- T. A. White, S. Stefanni, J. Stamford, A. R. Hoelzel, *Molecular Ecology* 18, 2563 (Jun, 2009).
- L. C. Woodall, H. J. Koldewey, S. V. Santos, P. W. Shaw, *Journal of Fish Biology* 75, 1505 (Oct, 2009).

Other publications International

- Schmiing, M., P. Afonso, F. Tempera & R.S. Santos 2009. Integrating recent and future marine technology in the design of Marine Protected Areas: The Azores as case study. *Oceans 2009 - Europe*, IEEE Conference Proceedings, doi: 10.1109/OCEANSE.2009.5278178
- Carreiro-Silva, M., E. Giacomello, A. B. Henriques, J. Jakobsen, K. Jakobsen, G. Menezes, T. Morato, F. M. Porteiro, F. Tempera & R. S. Santos 2009. Seamount Research in the Azores - Sea based and land based observatories: New approaches for the integrated study of biodiversity and ecosystem functioning of seamounts. *MARS Newsletter*, 9 (Autumn 2009): 12-15.
- Bried, J. 2009a. Pingouin torda *Alca torda*. In *Oiseaux marins et cétacés du Golfe de Gascogne. Répartition, évolution des populations et éléments pour la définition des aires marines protégées* (Castège, I. and Hémerly, G., eds.), Biotopie, Mèze; Muséum National d'Histoire Naturelle, Paris (Collection Parthénope). Pp 129-133.
- Bried, J. 2009b. Guillemot de Troil *Uria aalge*. In *Oiseaux marins et cétacés du Golfe de Gascogne. Répartition, évolution des populations et éléments pour la définition des aires marines protégées* (Castège, I. and Hémerly, G., eds.), Biotopie, Mèze; Muséum National d'Histoire Naturelle, Paris (Collection Parthénope). Pp 134-138.
- Bried, J. 2009c. Macareux moine *Fracrula arctica*. In *Oiseaux marins et cétacés du Golfe de Gascogne. Répartition, évolution des populations et éléments pour la définition des aires marines protégées* (Castège, I. and Hémerly, G., eds.), Biotopie, Mèze; Muséum National d'Histoire Naturelle, Paris (Collection Parthénope). Pp 139-142.
- Carreiro-Silva M, Giacomello E, Braga-Henriques A, Jakobsen J, Jakobsen K, Menezes G, Morato T, Porteiro FM, Tempera F., Santos RS (2009) Sea based and land based observatories: new approaches for the integrated study of biodiversity and ecosystem functioning on seamounts. *MARS Newsletter* No 9: 12-15.
- Carreiro-Silva, M., Braga-Henriques A (2009) IMAR/DOP-UAç sets up the CoralLab. *HERMIONE newsletter* No. 1
- Carreiro-Silva, M., Braga-Henriques A (2009) CoralLab first trials. *HERMIONE newsletter* No. 2
- Stobberup, K.A., T. Morato, P. Amorim, and K. Erzini. 2009. Predicting weight composition of fish diet's: converting frequency of occurrence of prey to relative weight composition. *The Open Fish Science Journal* 2:42-49.

Other publications National

- Santos, R. S. 2009. O Conhecimento Científico do Mar. *Nação e Defesa* (Instituto de Defesa Nacional), 122 (4ª série): 89-100.
- Santos, R. S., P. Afonso, A. Colaço, T. Morato, M. Silva & F. Tempera 2009. A Investigação Científica e a Conservação do Ambiente Marinho nos Açores: Dos Primórdios à Actualidade. *Boletim do Núcleo Cultural da Horta*, 18: 29-60.

Group Productivity

Santos, R. S. 2009. Portugal e as Ciências do Mar. Revista de Marinha, 952 (Outubro/Novembro): 18-20.

Santos, R. S. 2009. Critérios científicos da CDB adoptados pela ONU. Fazendo - Boletim do que por cá se faz (Horta). 14 Maio 2009, edição 17: 7.

Santos, R. S. 2009. O conhecimento do mar profundo. Fazendo - Boletim do que por cá se faz (Horta). 28 Maio 2009, edição 18: 7.

Braga-Henriques, A., M. Carreiro-Silva, F. Porteiro, V. Matos, Í. Sampaio, O. Ocaña & S. Ávila. (2009) Nota sobre a associação entre o gastrópode *Pedicularia sicula* (Caenogastropoda: Ovulidae) e o hidrocoral *Errina dabneyi* (Hydrozoa: Stylasteridae) nos Açores. Portugala, 13: 9-10.

Carreiro-Silva, M. (2009) As alterações climáticas e o futuro dos recifes de coral. Jornal Fazendo, No. 13 (http://fazendofazendo.blogspot.com/2009_03_01_archive.html)

Carreiro-Silva, M., Braga-Henriques, A. (2009) Corallab. Secção de notícias e eventos do website do Oceanário de Lisboa (<http://www.oceanario.pt/cms/1394/?news=1202>)

Master and Ph.D. thesis completed

MSc

- Cátia Isabel Moura da Silva 2009. Variations of biochemical conditins in the hydrothermal vent mussel, *Bathymodiolus azoricus*, in different experimental conditions. 84 pp.

- Marta Beatriz Oliveira Pimpão 2009. Quantification and comparison of mud content in different beaches of the West region of mainland Portugal. 94 pp.

- Nuno Vasco Rodrigues 2009. Evaluation of the structure of fish community of the Natural Reserve of Berlega and Peniche coast. 82 pp.

- Erica Andreia Amaral Matos de Sá 2009. Estimation of catches and fishing technologies of coastal fisheries of the Peniche region. 142 pp.

- António Manuel Dinis Fernandes 2009. Introduction of macro-invertebrate exotic species in Estuaries and Coastal Portuguese zones: Characterization of the actual situation and study of ballast waters as main vector of introduction. 82 pp.

- Joana Filipa Valério dos Santos Pacheco 2009. Variation of the structure of the macro-benthic community of the rocky coast of Peniche across a gradient of pollution. 89 pp.

- Sílvia Patrícia Pena Lino 2009. Planktonic microbial diversity associated to the Azores Front/Current. 96 pp.

PhD

Jorge Fontes – SFRH/BD/12788/2003: Larval dispersal and recruitment patterns in Azorean coastal fishes (Implications for Marine Reserves).

Virginie Riou - MoMARNet (FP6-RTN/2003/505026) Marie Curie Fellowship 2005: Trophic ecology of the hydrothermal vent mussel *Bathymodiolus azoricus*.

Patents/protopypes

Denomination: Chitosan Active Pad

Description: coating for implantable satellite transmitters, based on a chitosan matrix (polysaccharide produced by deacetylation of chitin) enriched with an antibiotic (gentamicyn)

Function: reduce the rejection response to satellite tags implanted sub-dermally in cetaceans

Operation: it is expected that the coating will create a prolonged antibiotic effect around the tag, reduce tissue lubrication by phagocytes and promote soft tissue regeneration around the tag, increasing retention time.

Prototype development stage: prototypes were developed by the Department of Polymer Engineering, University of Minho in 2009. Tags with and without prototypes are being implanted in whales by the IMAR Centre at the Un. Azores to test for efficiency.

Organization of conferences

The ICES Deep-sea Symposium: Issues Confronting the Deep Oceans (ICDO): The Economic, Scientific, and Governance Challenges and Opportunities of Working in the Deep Sea. 27-30 April 2009, Horta, Azores, Portugal

- Operational Marine Methods (FreeSubNet), Horta, Faial, Azores, 11-12 June 2009

- Introduction to the software "R" (FreeSubNet), Horta, Faial, Azores, 08-10 June 2009

Industry contract research

Morato T., Hoyle S.D., Allain V., Nicol S.J. 2009. Tuna longline fishing around West and Central Pacific seamounts. Oceanic Fisheries Program, Secretariat of the Pacific Community, Noumea, New Caledonia, 212pp.

Morato T., Hoyle S.D., Allain V., Nicol S.J. 2009. Pelagic biodiversity on West Central Pacific seamounts. Oceanic Fisheries Program, Secretariat of the Pacific Community, Noumea, New Caledonia, 58pp.

Morato T., Allain V., Hoyle S., Nicol S. 2009. Tuna longline fishing around west and central Pacific seamounts. Fifth regular session of the Scientific Committee of the Western and Central Pacific Fisheries Commission. 10-21 Aug. 2009. Port Vila, Vanuatu. WCPFC-SC5 – EB IP-4: 1-19. Available at <http://www.wcpfc.int>

Morato T., Allain V., Nicol S. 2009. Short Report on tuna fishing on High-seas pocket seamounts. 2009. Oceanic Fisheries Program, Secretariat of the Pacific Community, Noumea, New Caledonia, 21pp.

Internationalization

Group Productivity

Co-chair of the Deep Sea Research Group of the Ministry of Science and Technology (Lisboa) (appointed by the President of COI).

Member of the Ad-Doc Group for Marine Research Infrastructures at the ESFRI. (2002-2003).

Member of BIOMARE SC - Network of large-scale long-term marine biodiversity research in Europe (EU).

Co-Chair of the Working Group on Monitoring and Observatories of InterRidge.

Member of MAR-ECO SC - Patterns and processes of the ecosystems of the northern mid-Atlantic (Census of Marine Life –CoML).

Member of ChEss SC - Biogeography of Chemosynthetic Ecosystems (Census of Marine Life –CoML).

Member of the Steering Committee of MARBEF (NoE: Marine Biodiversity and Ecosystem Functioning).

FP6-RTN/2003/505026: MoMARNET – Monitoring deep sea floor hydrothermal environments on the Mid-Atlantic Ridge: A Marie Curie Research Training Network

FP6 RTN/2006/2/036186-2: FREESUBNET – A European Research Training Network on Key technologies for Intervention Autonomous Underwater Vehicles

Government/Organization contract research

The Research Group (RG) has been involved in contracts with Government Bodies concerning, e.g. the following International Policies: International Whaling Commission, Common Fisheries Policies, Habitats and Birds Directives (Natura 2000), OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic, Convention of Biological Diversity, and the International Council for the Exploration of the Seas, the Convention of Biological Diversity.

The RG has several contracts with the Regional Government of the Azores concerning the following studies:

MONIAVES - Monitoring of Seabirds

POPA - Observers Program of the Fisheries of the Azores

Fisheries Monitoring

CAULERPA - Restoration of coastal habitats invaded by the seaweed Caulerpa

DEMERSAL Cruises- Annual monitoring of demersal fisheries by independent scientific cruises

Future Research

Objectives

Research will be focused on key issues of ecosystem functioning in a time of changes, climate change and anthropogenic exploration of ocean biotic resources. We will keep the focus on island slopes, deep-sea ridge systems and open ocean. A lot is still left to do in view to have a synoptic and holistic perspective integrating these components of the ecosystem, and there is a need to accomplish the ecosystems approach for management. Thus said we intend to keep the WGs mention above, since we understand that a global vision still needs sectoral approaches.

Our research will be based on the funded projects listed in the following section. Focus will be given to bio-telemetry studies of top predators together with habitat mapping at the level of seafloor and water column. These studies will serve to characterize essential habitats of priority species namely cold water corals and deep-sea fishes, and large pelagic predators.

New sensors and permanent stations, including landers, will be deployed. Together with the fixed observatory type studies of seamount and vents ecosystems, we will continue tagging several species with acoustic and satellite transmitters incorporating data-loggers for different types of environmental and physiological data acquisition.

We expected to make use of the sea on-going facilities now available in Portugal, in particular in conjunction with our partners of the Institute of Systems and Robotics. Many of the scenarios and work at sea will employ robotic equipments. With this we intend to contribute with answers for some key scientific questions raised by the European Science Group on Deep-sea frontier on whose synthesis a member of the RG was involved: 1) How do deep-sea and other oceanic ecosystems respond to global change? 2) What is the relative importance of biotic and abiotic time-varying factors in structuring deep sea communities? 3) How does biodiversity and ecosystem functioning vary over very small regional and global scales, and with environmental heterogeneity, latitude and depth? 4) What are the effects of geobiological processes on deep-sea ecosystem functioning? 5) What are the life cycles and dispersal for deep-sea/ open ocean organisms, and what are their physiological adaptations? 6) How resilient are deep-sea ecosystems to deep-sea fisheries? 7) Can deep-sea resources be managed in an ecologically sustainable way? What ecosystems/ecoregions should be given conservation priority?

Taking the opportunity of the missions at sea and the conditions available at LabHorta and satellite laboratories we intend to continue developing advanced experimental research in the areas of genomics, proteomics, immunology, eco-toxicology, molecular biology, physiology, processes of calcification, enzymology. The studies will be primarily done under controlled experimental conditions and are intended to explore new molecules for bio-technology with from organisms living at the deep-sea both in chemosynthetic and photosynthetic driven environments. This is also a clear follow up of the capabilities and know how acquired and developed by the team during the last 5 years.

Facing the new global economical reality, special efforts will be also applied in the local economy, namely looking and encourage research initiatives or entrepreneurs aiming to rise the local value chains through the development of new products or services with potential to be commercialized.

Funding, source, dates

There is pending the submission of around 15 projects to FCT

and 3 projects to the FP7

Future Research

- Food, Agriculture and Fisheries, and Biotechnology Calls: FP7-KBBE-2010-4

1. 4AbioMAXIMUM: Anti-inflammatory, Antimicrobial, Antiviral and Antitumoral features by Blue biotechnology, using Micro-Algae eX-loco Intended for novel ManUfacture Methodologies

2. APT: Products from the European Research on Innovative Algal and Protist Technologies

3. CultMar: Culturing the uncultured and rare marine organisms: Cutting the Gordian knot

- FCT

FCT PTDC/MAR/110576/2009 –TRANSCRIVENT: The transcriptome of the deep sea vent mussel *Bathymodiolus azoricus*: unraveling the genes involved in adaptation to extreme environments. PI: Raul Bettencourt

Group Description	
Title of Research Group:	(RG-LVT-50009-3438) DSORL - Dynamical Systems and Ocean Robotics Laboratory
Principal Investigator:	António Manuel dos Santos Pascoal
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
Source Project Reference DSORL Funding in 2009	
National	
FCT RUMOS 2006-2009 PDCT/MAR/55609/2004	
FCT DENO 2007-2010 PTDC/EEA-ACR/67020/2006	
FCT HELICIM 2007-2010 PTDC/EEA-ACR/72853/2006	
FCT OBSERVFLY 2008-2011 PTDC/MAR/64546/2006	
FCT NAV 2007-2010 PTDC/EEA-ACR/65996/2006	
AdI AIRTICI 2009-2012 QREN	
European	
EC GREX- 2006-2009 FP6-EU-IST-035223	
EC VENUS - 2006 - 2009 FP6-EU-IST-034924	
EC FREEsubNET - 2006-2010 MRTN-CT-2006-036186	
EC CO3AUVs 2009-2012 FP720073 ICT2007.2.1	
.	

Objectives & Achievements	
Objectives	
<p>The key objectives of the R&D work carried out at the DSORL are twofold: i) to study a number of challenging theoretical problems in the areas of advanced robotic vehicle systems design, navigation, and control, and ii) exploit the theoretical methodologies developed to yield faster, cheaper, and far more efficient tools for ocean exploration and exploitation than those available today. The tools include surface and underwater robots, as well as aerial vehicles working as communication relays or re-directing the operations of marine vehicles upon detection of relevant episodic events. These goals have motivated the definition of a research and development program addressing theoretical and practical engineering topics, as well as issues that are at the crossroads of marine science and technology, the main focus of the cooperative research and development work set forth under Thematic Area A. Two main lines of action underpin the work carried out at the DSORL:</p>	
<ol style="list-style-type: none"> 1. Contributing to furthering the knowledge in the general area of dynamical system 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 enabling 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 and Positioning Systems for autonomous underwater platforms and human divers. Study of advanced solutions focusing on the: i) development of high performance, 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, with its plethora of phenomena that include multiple path effects, ray bending, and fading. Problems addressed: i) Motion control of autonomous vehicles with inner-outer loop control loops; ii) Visual servoing control; iii) Path Following; iv) Terrain Contour Tracking; v) Coordinated/cooperative control of groups of autonomous vehicles; vi) Diver assisted control by resorting to robot companions; vii) Networked control over faulty communication links.	
E. Development of advanced methods for Cooperative Multiple Vehicle Mission Planning and Execution under energy and temporal constraints, in the presence of stationary and moving obstacles.	

Objectives & Achievements

Practical Objectives:

- A. Design and development of Autonomous Underwater Vehicles (AUVs), Autonomous Surface Craft (ASC), and Unmanned Air Vehicles (UAVs); 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 mission control of heterogeneous platforms.
- C. Tests and scientific missions with the robots developed in cooperation with the scientific partners in Thematic Area A and other international institutions.
- D. Dissemination actions for young students and the general public with the objective of bringing visibility to the challenging area of advanced marine / aerial robotics systems and their application to demanding scientific, surveillance, and security mission scenarios.

Main Achievements

THEORETICAL ACHIEVEMENTS

1. Further advances in the formulation of a Multiple-Model Adaptive Control (MMAC) architecture for linear time-invariant and time-varying plants subjected to structured and unstructured uncertainty. The techniques used exploit, among others, the use of set-valued observers (MMAC-SVO) and Stability Overlay (SO) methods, yielding - under certain conditions - closed loop robust stability and performance guarantees.
2. Study of new algorithms for control and state estimation on SE(3) to: i) extend the LQR problem to non-compact Lie Groups and ii) solve the state estimation problem of left-invariant dynamical system evolving on the special Euclidean group SE(3) with implicit output functions. These techniques have wide ranging applications in control and estimation of autonomous robotic vehicles equipped with vision systems.
3. Derivation of multiple model adaptive estimation (MMAE) and model identification (MMAI) methods that rely on a minimum energy criterion.
4. Development of a new methodology for multiple vehicle cooperative path planning under temporal and energy expenditure constraints, with due account for temporal or spatial deconfliction requirements.
5. Study and assessment in simulation of the efficacy of a set of algorithms for cooperative motion control of multiple autonomous marine vehicles in the presence of communication failures, with due account for collision avoidance in dynamic environments.
6. Study and assessment (in simulation and through field tests) of the performance achievable with time-coordinated path following systems for multiple UAVs over time-varying networks using L1 adaptation (work done in cooperation with the Naval Postgraduate School, Monterey, CA and the Univ. Illinois, Urbana, USA).
7. Development of Lyapunov-based adaptive nonlinear control systems with application to the design of depth tracking and attitude controllers for underwater towed vehicles with parametric uncertainty.
8. Derivation of new algorithms for AUV single beacon acoustic navigation in the presence of unknown ocean currents.
9. Improvement of the capabilities of "NetMarSys: A Networked Marine Systems Simulator for Hardware-In-The-Loop Testing of Cooperative Multiple Vehicle Control and Navigation Systems" developed at the ISR/IST to assess the performance of advanced cooperative and navigation control algorithms prior to system implementation and testing at sea.
10. Study of filtering structures for USBL tightly coupled inertial navigation and development of nonlinear GPS/IMU based observers for rigid body attitude and position estimation.
11. Derivation of a Rotorcraft path following control system for extended flight envelope coverage. The proposed solution consists of a nonlinear state feedback controller for thrust and torque actuations combined with a path following timing law.
12. Development of new methods to prove almost input-to-state stability (ISS) and almost global stability of nonlinear "rotational motion" systems by exploiting the combined use of Lyapunov Functions and Density Functions .
13. Study of algorithms for Nonlinear Attitude Estimation Systems Using Active Vision and Inertial Measurements, as applied to the problem of estimating the attitude of a rigid body equipped with a triad of rate gyros and a pan and tilt camera.
14. Control of Impulsive Renewal Systems. Results were obtained for a class of systems that is especially suited to model networked control systems utilizing CSMA-type protocols, with stochastic intervals between transmissions and packet drops.

PRACTICAL ACHIEVEMENTS

1. Full demonstration of cooperative vehicle motion control with four heterogeneous autonomous marine robots in the scope of the EU GREX project: the DELFIM and DELFIMx ASVs that are property of ISR/IST, and the SeeBee and VORTEX AUVs that are property of ATLAS and IFREMER, respectively. The core of the final tests of the EU GREX project took place in Sesimbra, Portugal from October 26 to November 6, 2009 with the participation of all project partners and the joint coordination of ISR/IST and the IMAR/DOP/UAzores.
3. Demonstration at sea of a retrofitted version of the GPS Intelligent Buoys System, under the framework of the RUMOS project, with involvement of the partners ISR/IST and IMAR/DOP/UAzores.
4. Design, development, and test of an integrated Ultra Short Baseline (USBL) and Inertial Navigation System (INS) to be used as a low cost navigation system for underwater robotic vehicles. Preliminary sea tests were conducted in the Azores, in the framework of the RUMOS project, in cooperation with the IMAR/DOP/UAzores. The performance of the acoustic positioning system obtained, using namely Direct Sequence Spread Spectrum (DSSS) coded signals, was validated.

Group Productivity

Publications in peer review Journals

[J01] Reza Ghabcheloo, António Aguiar, António Pascoal, Carlos Silvestre, I. Kaminer, J. Hespanha, "Coordinated path-following in the presence of communication losses and time delays," SIAM - Journal on Control and Optimization, Vol. 48, No. 1, pp. 234-265, January 2009.

[J02] José Vasconcelos, Michael Athans, Sahjad Fekri, Carlos Silvestre and Paulo Oliveira, "Stability- and Performance-Robustness Tradeoffs: MIMO Mixed-mu vs Complex-mu Designs," International Journal of Robust and Nonlinear Control, vol 19, n° 3, pp. 259-294, February 2009.

[J03] Carlos Silvestre, Rita Cunha, Nuno Paulino, and Antonio Pascoal, "A Bottom-Following Preview Controller for Autonomous Underwater Vehicles," IEEE Transaction on Control Systems Technology, Volume 17, Issue 2, pp. 257 - 266, March 2009.

[J04] António Aguiar and João P. Hespanha, "Robust Filtering for Deterministic Systems with Implicit Outputs," Systems & Control Letters, Vol. 58, No. 4, pp. 263-270, Apr. 2009.

[J05] Pedro Batista, Carlos Silvestre and Paulo Oliveira, "Position and Velocity Navigation Systems for Unmanned Vehicles," IEEE Transactions on Control Systems Technology, vol 17, n° 3, pp. 707-715, May 2009.

[J06] Pedro Batista, Carlos Silvestre and Paulo Oliveira, "A Sensor Based Controller for Homing of Underactuated AUVs," IEEE Transactions on Robotics, vol. 25, No. 3, pp. 701-716, June 2009.

[J07] David Cabecinhas, Rita Cunha, and Carlos Silvestre, "Output-feedback control for almost global stabilization of fully-actuated rigid bodies," Elsevier Systems and Control Letters, Volume 58, Issue 9, pp. 639-645, September 2009.

[J08] João Almeida, Carlos Silvestre, and António Pascoal, "Cooperative control of multiple surface vessels in the presence of ocean currents and parametric model uncertainty," International Journal of Robust and Nonlinear Control, November 2009.

Other publications International

Tiago Gaspar and Paulo Oliveira, "A Single Pan and Tilt Camera Architecture for Indoor Positioning and Tracking," Proc. VISAPP - The International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, 2009, Lisbon, Feb. 2009.

Andreas Häusler, Reza Ghabcheloo, Isaac Kaminer, António Pascoal, and António Aguiar, "Path Planning for Multiple Marine Vehicles," Proc. OCEANS'09 - IEEE, Bremen, Germany, May 2009.

António Aguiar, João Almeida, Mohammadreza Bayat, Bruno Carneira, Rita Cunha, Andreas Hausler, Pramod Maurya, André Oliveira, António Pascoal, Arvind Pereira, Manuel Rufino, Luís Sebastião, Carlos Silvestre, and Francesco Vanni, "A Cooperative Autonomous Marine Vehicle Motion Control in the scope of the EU GREX Project: Theory and Practice," Proc. of OCEANS'09 - IEEE, Bremen, Germany, May 2009.

Vahid Hassani, António Aguiar, Michael Athans, and António Pascoal, "Multiple Model Adaptive Estimation and Model Identification using a Minimum Energy Criterion," Proc. American Control Conference, Saint Louis, USA, June 2009.

Reza Ghabcheloo, Isaac Kaminer, António Aguiar, António Pascoal, "A General Framework for Multiple Vehicle Time-Coordinated Path Following Control," Proc. American Control Conference, Saint Louis, USA, June 2009.

Pedro Batista, Carlos Silvestre, and Paulo Oliveira, "Necessary and sufficient conditions for the observability of linear motion quantities in navigation systems," Proc. American Control Conference, Saint Louis, USA, June 2009.

Duarte Antunes, João P. Hespanha, Carlos Silvestre, "Stability of Impulsive Systems Driven by Renewal Processes," Proc. American Control Conference, Saint Louis, USA, June 2009.

Bruno Guerreiro, Carlos Silvestre, Rita Cunha, Chengyu Cao, and Naira Hovakimyan, "L1 Adaptive Control for Autonomous Rotorcraft," Proc. American Control Conference, Saint Louis, USA, June 2009.

António Aguiar, António Pascoal, Isaac Kaminer, Vladimir Dobrokhodov, E. Xargay, and N. Hovakimyan, "Time-Coordinated Path Following for Multiple UAVs over Time-Varying Networks using L1 Adaptation," in Proc. NATO RTO SCI-202 Symposium on Intelligent Uninhabited Vehicle Guidance Systems, Neubiberg, Germany, July 2009.

Vahid Hassani, António Aguiar, António Pascoal, and Michael Athans, "A Performance Based Model-Set Design Strategy for Multiple Model Adaptive Estimation," 10th European Control Conference, Budapest, Hungary, August 2009.

Pinar Ekim, João Gomes, João Xavier and Paulo Oliveira, "ML-based Sensor Network Localization and Tracking: Batch and Time-recursive Approaches," 17th European Signal Processing Conference (EUSIPCO'09), Glasgow, Scotland, August 2009.

José Vasconcelos, Rita Cunha, Carlos Silvestre and Paulo Oliveira, "Stability of a Nonlinear Attitude Observer on SO(3) with Non Ideal Angular Velocity Measurements," 10th European Control Conference, Budapest, Hungary, August 2009.

Bruno Guerreiro, Carlos Silvestre, Rita Cunha, Antonio Pascoal, "Trajectory Tracking Nonlinear Model Predictive Control for Autonomous Surface Craft," 10th European Control Conference, Budapest, Hungary, August 2009.

Paulo Rosa, Gary Balas, Carlos Silvestre, Michael Athans, "On the Synthesis of Robust Multiple-Model Adaptive Controllers (RMMAC) Using BMI/LPV Controllers," 10th European Control Conference, Budapest, Hungary, August 2009.

Joao Almeida, Carlos Silvestre, Antonio Pascoal, and Panos Antsaklis, "Continuous-Time Consensus with Discrete-Time Communication," 10th European Control Conference, Budapest, Hungary, August 2009.

Pedro Batista, Carlos Silvestre, and Paulo Oliveira, "Single Range Navigation in the presence of Constant Unknown Drifts," 10th European Control

Group Productivity

Conference, Budapest, Hungry, August 2009.

Marco Morgado, Paulo Oliveira and Carlos Silvestre, "Posterior Cramér-Rao bounds analysis for INS/USBL navigation systems," Proc. of MCMC 2009 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, September 2009.

Mohammadreza Bayat, Francesco Vanni and António Aguiar, "Online Mission Planning for Cooperative Target Tracking of Marine Vehicles," Proc. of MCMC'09 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, Sept. 2009.

Francisco Teixeira, A. Pedro Aguiar, and António Pascoal, "Nonlinear adaptive depth tracking and attitude control of an underwater towed vehicle," Proc. of MCMC'09 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, Sept. 2009.

Pramod Maurya, António Aguiar, and António Pascoal, "Marine Vehicle Path Following Using Inner-Outer Loop Control," Proc. of MCMC'09 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, Sept. 2009.

Andreas Häusler, Reza Ghabcheloo, António Pascoal, António Aguiar, Isaac Kaminer, and Vladimir Dobrokhodov, "Temporally and Spatially Deconflicted Path Planning for Multiple Autonomous Marine Vehicles," Proc. MCMC'09 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, Sept. 2009.

Sérgio Pequito, António Aguiar and Diogo Gomes, "The Entropy Penalized Minimum Energy Estimator," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009. (Best student paper award finalist).

Vahid Hassani, António Aguiar, António Pascoal, and Michael Athans, "Further Results on Plant Parameter Identification using Continuous-Time Multiple-Model Adaptive Estimators," in Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Sérgio Brás, Rita Cunha, José Vasconcelos, Carlos Silvestre and Paulo Oliveira, "Nonlinear Attitude Estimation Using Active Vision and Inertial Measurements," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

José Vasconcelos, Anders Rantzer, Carlos Silvestre and Paulo Oliveira, "Combination of Primal and Dual Lyapunov Methods for Stability of Rotational Motion," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Pedro Batista, Carlos Silvestre and Paulo Oliveira, "Sensor-based Complementary Globally Asymptotically Stable Filters for Attitude Estimation," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Duarte Antunes, Joao P. Hespanha, Carlos Silvestre, "Control of Impulsive Renewal Systems: Application to Direct Design in Networked Control," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

David Cabecinhas, Rita Cunha, Carlos Silvestre, "Rotorcraft Path Following Control for Extended Flight Envelope Coverage," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Paulo Rosa, Carlos Silvestre, Jeff S. Shamma, Michael Athans, "Multiple-Model Adaptive Control with Set-Valued Observers," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Paulo Rosa, Jeff S. Shamma, Carlos Silvestre, Michael Athans, "Stability Overlay for Linear and Nonlinear Time-Varying Plants," Proc. 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Master and Ph.D. thesis completed

MSc Theses (Pre-Bolonha)

Research Area: Navigation

Title: Architectures for Inertial/GPS Navigation with Application to Autonomous Vehicles

Student: Bruno Cardeira

Concluded 2009.

MSc Theses (Bolonha)

Research Area: Autonomous Vehicles

Title: Software Architecture for Autonomous Vehicles

Student: André Oliveira,

Concluded 2009.

Research Area: Underwater Navigation

Title: Development and Sea Tests Validation of an Acoustic USBL Positioning System,

Student: João Picão,

Concluded 2009.

Research Area: Visual Control

Title: Visual Control Of Unicycle Type Robots,

Student: Ricardo Jorge Baptista Carona,

Concluded 2009.

Group Productivity

Research Area: Cooperative Motion Control

Title: Cooperative Motion Control of multiple autonomous robotic vehicles: Collision Avoidance in Dynamic Environments,

Student: Sérgio Alexandre Carraça Carvalhosa,

Concluded 2009.

Research Area: Estimation theory

Title: The Entropy Penalized Minimum Energy Estimator,

Student: Sérgio Daniel Gonçalves Melo Pequito,

Concluded 2009.

Patents/propotypes

1. DELFIM and DELFIM_X Autonomous Surface Vehicles (ASCs) – designed and built by ISR/IST to carry out experimental research in the area of ocean robotics and to perform scientific missions at sea. These vehicles have 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.

2. INFANTE Autonomous Underwater Vehicle (AUV) – designed and built by ISR/IST and the company RINAVE 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.

3. 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 habitat mapping, inspection of harbours and estuaries. The first prototype has been tested and used extensively in Goa, India.

4. 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).

5. 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.

6. Autonomous Quadrotor– designed and built by ISR/IST. A quadrotor helicopter with payload capability of about one kg. Design in the scope of the AIRTICI project for aerial vehicle hardware and software architectures test and evaluation. This prototype will be used in bridge inspection tasks.

7. Medusa I – designed and built by ISR/IST. First prototype of a class of semi-submerged vehicles of small size for underwater target positioning. A set of vehicles acting cooperatively will be used in the scope of the EU COGAUVs (Cognitive marine robotics) project for assisted diving operations.

Organization of conferences

Chair, International Program Committee, MCMC 2009 Conference, Guarujá, Brazil.

Guest Editor, Special Session on Marine Robotics, ICRA 2010.

IPC Member, IFAC Conference on Manoeuvring and Control of Marine Craft (MCMC'09).

IPC Member, IEEE International Conference on Control Applications (CCA2009).

Convener and Member of the Organizing Committee, Workshop "Networked embedded and control system technologies: European and Russian R&D cooperation", July 4-5, 2009- Milan, Italy.

Member, International Technical Committee of the 17th European Signal Processing Conference - EUSIPCO 2009, Glasgow, Scotland, 24-28 August 2009.

Co-chair, Session on Deep-Sea Technology and Biotechnology Research, ICES Symposium Issues Confronting the Deep Oceans: The Economic, Scientific, and Governance Challenges and Opportunities of Working in the Deep Sea Amor da Pátria Hall, Horta, Faial Island, Azores, Portugal, April 27 – 30, 2009

Chair, Session "Overview of underwater systems: from manned submersibles to AUVs," MCMC 2009, Guarujá, Brazil, Sept. 2009.

Chair, Session " Cooperative navigation and control of Multiple Marine Vehicle Systems ," MCMC 2009, Guarujá, Brazil, Sept. 2009.

Chair, Session "Robust Adaptive Control", 2009 American Control Conference, St. Louis, Missouri, USA, June 10 - 12, 2009.

Co-chair, Session "Time Varying Systems", 2009 American Control Conference, St. Louis, Missouri, USA, June 10 - 12, 2009.

Chair, Session "Estimation II", 2009 American Control Conference, St. Louis, Missouri, USA, June 10 - 12, 2009.

Co-Chair, Session " Observers I", 2009 European Control Conference, Hungary, Budapest, August, 23-26, 2009.

Group Productivity

Chair, Session "Ship Manoeuvring II", MCMC 2009 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, September 2009.

Co-Chair, Session "Sensors and Sensor Integration in Autonomus Robots", MCMC 2009 - 8th Conference on Manoeuvring and Control of Marine Craft, Guarujá (SP), Brazil, September 2009.

Chair, Session "Advanced Nonlinear Control Techniques for Unmanned Air Vehicles", 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Organizer, Special Session on CDC 2009, "Advanced Nonlinear Control Techniques for Unmanned Air Vehicles", 48th IEEE Conference on Decision and Control, Shanghai, China, December 2009.

Internationalization

* Strong cooperation links with

[1] Naval Postgraduate School, Monterey, CA (USA) – a long standing collaborative research program on AUV and UAV Navigation, Guidance, and Control (NGC) as well as cooperative multiple vehicle path planning and control with temporal and spatial deconfliction.

[2] Center for Control, Dynamical Systems, and Computation (CCDC) at the 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 AUV research and development program initiated in 1999.

[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] Dept. Mechanical Engineering, John Hopkins University, Baltimore (USA) – exchange of research personnel and joint initiatives on Underwater Navigation Systems.

[7] Laboratoire I3S - Laboratoire d'Informatique, Signaux et Systèmes Centre National de Recherche Scientifique, de Sophia-Antipolis, NICE France. Exchange of research personnel and joint initiatives on Sensor Based Control for Unmanned Air Vehicles.

[8] Dept. Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh (USA) - exchange of research personnel and joint initiatives on Analysis and Design of Complex Hybrid Dynamical Control Systems.

* The DSORL has played an active role in one European Training Network (ETN): FREesubNET (2006-2010)- A European research network on key technologies for intervention autonomous underwater vehicles (Marie Curie Research Training Network).

* Participation in International Technical Committees

Chair and Member of the IFAC Technical Committee on Marine Systems.

Member, European Science Foundation (ESF) pannel in charge of evaluating the Bulgarian Academy of Sciences, 2009.

Member of the IFAC Technical Committee on Aerospace

Member of the IEEE Technical Committee on Aerospace Control

Member of the IFAC Technical Committee on Intelligent Autonomous Vehicles.

Associate Editor, IEEE Oceanic Engineering.

Vice-President of EurOcean, the European Portal for Marine Science and Technology.

Future Research

Objectives

The key thrust of future research work will continue to be guided by the goal of bringing together dynamical systems theory and engineering practice and applying the resulting methods and tools to the development and operation of ocean robotic platforms and associated enabling systems, including those needed to observe the ocean from the air. The emphasis will also be placed on strengthening cooperation links with research groups worldwide and participating in national and European projects and Training Networks in areas that require an adequate balance between challenging theoretical and practical issues.

Cooperative links with the ISR-Associated Lab partners IMAR/DOP/Azores and CREMINER/FCUL will be further exploited in the scope of Thematic Area A with the triple objective of: i) intensifying the transfer of technology to scientific end-users, effectively affording marine scientists better tools for ocean exploration and mapping, ii) defining mission scenarios that warrant the use of advanced technology, and iii) executing common missions at sea in the Azores and in the continent. In what regards the connections between science and the society, plans have been drawn to intensify dissemination actions for young students and the general public with the objective of bringing visibility to the challenging area of advanced marine / aerial robotics systems and their application to demanding scientific, surveillance, and security mission scenarios.

Future Research

It is expected that 2010 will witness the consolidation of a strong cooperative link established with the municipality of Cascais that will afford the researchers of the Associated Lab a workshop space (Marine Science and Technology Workshop) for large equipment assembling and testing in the vicinity of the ocean. As part of the cooperation agreement, the Associated Laboratory will carry out demonstrations of advanced robotic equipment for the public at large, with real-time transmissions from the sea. The office of EurOcean, the European portal for marine science and technology - with its office in Lisbon - has agreed to be an active partner in the dissemination actions envisioned. Namely, it will disseminate info about the events, including cruise plans and cruise reports, as well info related to "real-time" transmissions, whenever possible. The year of 2010 will also witness the inauguration of a test tank and supporting office space in the IST Tagus Park that will afford researchers the means to carry out experiments with small marine vehicles.

The following theoretical and practical tasks are worth emphasizing:

1- Robust Multiple Model Adaptive Control (RMMAC): solidification of the work done towards the development of new methodologies for the design of robust adaptive controllers for linear time-invariant and time-varying plants with structured and unstructured uncertainty. This will include, among others, the design of multiple model adaptive estimation and identification systems and the use of set-valued observers (MMAC-SVO) and Stability Overlay (SO) methods. Applications will be sought in the area of dynamic ship positioning in cooperation with researchers at the NTNU, Trondheim, Norway.

2- Cooperative path planning and motion control. The work will exploit the use of new techniques for multiple vehicle cooperative control that will address the constraints imposed by the ocean medium, as well as the presence of stationary and moving obstacles. It will also focus on the development of efficient techniques for multiple vehicle path planning in the presence of ocean currents with due account for temporal or spatial deconfliction (non-collisions). Part of the work will be done in cooperation with the NPS, Monterey, CA. Cooperative Path Planning will exploit some of the optimization techniques recently developed by Prof. John Hauser, Univ. Boulder, Colorado, during his 6 month sabbatical leave at the ISR/IST. From a practical standpoint, the above tasks entail the development of software and hardware architectures to seamlessly transition from the lab to the real world.

3- Cooperative navigation and positioning. Work will progress on the development and testing of new algorithms for underwater navigation and target positioning, where the latter includes the position of human divers by resorting to multiple surface or underwater robots. Namely, by exploiting new navigation concepts that are currently receiving widespread attention in the civilian community: cooperative navigation, geophysical based navigation and a combination thereof, resorting in some cases to complementary information such as that obtained with a single or multiple beacons. Part of this work will be done in cooperation with researchers at the Univ. Aveiro, Portugal and at the Jacobs University, Bremen, Germany.

4- Optimal Control and Estimation on Manifolds with Applications to Robotic Vehicles. Study of algorithms for control and estimation on manifolds such as $SO(3)$ and $SE(3)$, that are the natural setting to describe the configuration of robotic vehicles. Development and implementation of discrete time nonlinear kinematic observers for pose estimation, with application to Marine and Air Vehicles equipped with different sensor suites.

5- Continuation of the study of Joint Positioning and Navigation Aiding Systems for Autonomous Underwater Robots with due account of disturbances observed during field operations. The work will build on previous design and analysis results derived for tracking and integrated navigation systems through the use of non-linear time-varying filters. Computationally efficient signal processing techniques will be used to overcome the occurrence of dropouts and delays experienced by the acoustic signals used. Emphasis will also be given to the challenging theoretical problem of deriving the optimal geometrical configuration of a "baseline" of autonomous surface vehicles to position a number of targets underwater, based on vehicle-target range measurements using acoustics. This problem has so far been studied for land robots that can measure ranges to a single target.

6- Further studies on optimal Continuous-Time Filters with Discrete-Time Delayed Measurements for Classes of Nonlinear Time-Varying Systems (such as kinematic systems) with application to the estimation of linear motion quantities (position, linear velocity, and acceleration of gravity), in three dimensions.

7- Development and testing of an Autonomous Helicopter specially tailored for critical infrastructure monitoring under the HELICIM and AIRTICI projects.

8- Development and testing of a Fixed Wing Unmanned Aircraft tailored for marine science applications under the OBSERVFLY project.

9- Completion and testing of a Small Fleet of Semi-Submersible Vehicles of the MEDUSA-type (proprietary of ISR/IST), in the scope of the EU-funded CO3AUVs project, for cooperative missions involving human divers in the loop

10- Execution of Missions at Sea with the Associated Lab partners CREMINER and IMAR/DOP/Azores using robotic vehicles and advanced sensor suites (e.g. multibeam sonar, sidescan sonar, and subbottom profiler) to aid in marine habitat mapping and geological surveying.

Funding, source, dates

Source Project Reference DSORL Approved Funding for 2010

National

FCT AMMAIA 2007-2010 PTDC/HIS-ARQ/103227/2008

FCT DENO 2007-2010 PTDC/EEA-ACR/67020/2006

FCT HELICIM 2007-2010 PTDC/EEA-ACR/72853/2006

FCT OBSERVFLY 2008-2011 PTDC/MAR/64546/2006

FCT NAV 2007-2010 PTDC/EEA-ACR/65996/2006

Future Research

AdI AIRTICI 2009-2012 QREN

European

EC FREESubNET - 2006-2010 MRTN-CT-2006-036186

EC CO3AUVs 2009-2012 FP720073 ICT2007.2.1

EC TRIDENT 2010-2013 FP7

Group Description	
Title of Research Group:	(RG-LVT-50009-3447) Signal and Image Processing Group
Principal Investigator:	Isabel Maria Gonçalves Lourtie
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates
Funding, source, dates
Source Project Reference Funding in 2009
FCT SIPM PTDC/EEA-ACR/73749/2006
FCT PHITOM PTDC/EEA-TEL/71263/2006
FCT MODI PTDC/EEA-ACR/72201/2006
FCT DELKETI PTDC/EEA-TEL/72572/2006
FCT SMARTVISION PTDC/EIA/73633/2006
FCT Neural Correlates of Object Recognition PTDC/PSI/67381/2006
EU SIMBAD FT7-ICT-2007-C
EU ESONET FP6-SUSTDEV SUSTDEV-3
EU UAN FP7, ICT/Security
EU OAE _x FP7, IRSES, PEOPLE
.

Objectives & Achievements
Objectives
<p>Fundamentals.</p> <p>Quadratic optimization problems with Stiefel-like constraints appear in many engineering applications, e.g., inference of non-rigid structure from motion in computer vision. Being a class of nonconvex optimization problems, it is challenging to find global solutions with reasonable computational complexity. The goal is to develop fast, globally convergent algorithms based on novel problem reformulations.</p> <p>Sensor Networks. Energy-efficiency is of critical importance in large-scale wireless sensor networks (WSN), as the in-situ unattended sensors are typically powered by non-rechargeable batteries. Aggressive restraints on sensor usage must be observed to ensure a prolonged WSN lifetime. When the WSN is used for event discrimination (intruder/no intruder, fire/no fire) this translates into finding which minimal subset of the deployed sensing nodes is sufficient to activate for a given query, whilst securing a prescribed detection performance. Finding the optimal subset of sensors represents a formidable optimization challenge (forming all possible combinations of few sensors and checking the respective performance is computationally intractable even for moderate network sizes). The goal is to develop fast (non-combinatorial) optimization algorithms for several sensor selection application scenarios which strike a desirable tradeoff among detection performance and computational complexity.</p> <p>Many applications of sensor networks require some form of surveillance or tracking, and thus critically rely on the availability of spatial information, e.g., knowing the location of a detected point-like or diffusive target, or the positions of sensing nodes. Due to economic constraints conventional solutions for localization based on GPS are usually unfeasible, and calibration of sensor positions is also not practical for several scenarios where a very large number of nodes must be deployed. One of the research goals is to obtain position estimates from unreliable range measurements (or surrogates such as received signal strength, or concentrations of some types of gases) between a source/target and the sensors.</p> <p>Underwater Acoustics.</p> <p>The areas of research related to underwater acoustic signal processing applications include ocean monitoring and forecasting, array processing, inverse problems in geoacoustics, source detection, localization and tracking and underwater acoustic data communications. One of the objectives aims at integrating in depth scientific research with hardware system development and at sea testing..</p> <p>Specific elements of the equipment to be designed, developed, and tested include marine electronics, telemetry units, acoustic sensor arrays, data acquisition and communications systems.</p> <p>Image and Video Analysis.</p> <p>Several fundamental problems in image and video analysis hinge on how to represent and estimate the 3D shape of objects from video sequences. State of the art algorithms can cope well with rigid objects but, if they are non-rigid (deformable), representing the tridimensional characteristics is one of the great challenges in the area. The second level of processing uses these representations in recognition tasks such as image database indexing, information retrieval and object recognition.</p> <p>Other objectives in image and video analysis include the development of fundamental tools for inferring high level content from image</p>

Objectives & Achievements

sequences. These tools find applications in several fields. For example, in digital video, content-based representations enable powerful video editing and visualization, as well as efficient data compression. In document analysis, high level representations, e.g., shape-based, enable automatic classification. Also, for surveillance applications, an automatic analysis in terms of human activity recognition, e.g., tracking pedestrians or recognizing human activities, is nowadays fundamental.

Main Achievements

Fundamentals.

We constructed an exact convex reformulation for a certain class of nonconvex quadratic optimization problems with Stiefel-like quadratic constraints, thereby allowing for their global solution. Previously available convex optimization techniques failed to guarantee this. This achievement enabled the development of a novel algorithm (which outperforms previous state-of-art methods) for recovering the 3D shape and motion of deformable and articulated objects purely from uncalibrated 2D image measurements. We published our results in CVPR'09 and ICIP'09.

Sensor Networks.

We developed a fast sensor selection algorithm for binary Gaussian hypothesis testing in wireless sensor networks (WSN). As the corresponding optimization problem is NP-hard, the optimal selection method has exponential complexity with respect to the network size and cannot be implemented. We developed a nearly-optimal technique with polynomial complexity. As a byproduct, our technique solves a longstanding problem in linear dimensionality reduction applications. We published our results in Allerton'09 and CDC'09. This research was conducted within the Carnegie Mellon-Portugal program in which ISR participates.

We developed centralized algorithms that jointly estimate sensor and target positions from range measurements, and which are robust to the presence of outliers in the data. These do not rely on the availability of prior position information, and are thus particularly useful for application scenarios where even coarse precalibration is unfeasible. One conference paper was published in 2009 (EUSIPCO'09), one is accepted (ICASSP'10). The EUSIPCO'09 paper was ranked among the top 5% and an expanded journal version was invited for EURASIP/Elsevier Signal Processing (in preparation).

Image and Video Analysis.

We stated and proved a new theorem that establishes sufficient conditions and a constructive procedure to match points in an image to previously acquired 3D models of an object. This was published in ICIP09 and ICCV09 and submitted to a journal on mathematics (Linear Algebra and its Applications).

The majority of current methods to recover 3D content from images attempt to match local patches characterized by similar brightness patterns. However, this local approach is ill-posed and sensitive to disturbances like illumination variation, drastic change of perspective, and noise. In contrast, we developed a method that exploits, simultaneously, the brightness constancy and the rigidity of the scene, leading to more robust results. Also, although the majority of approaches to 3D modeling deal only with rigid scenes, we developed methods able to recover deformable objects. Other fundamental problem in image analysis is the representation of shape. We developed a new shape representation scheme, based on complex moments, which exhibits the desired invariance with respect to geometric transformations and the necessary capability of discriminating between distinct shapes.

We also developed a new way of representing 3D objects resulting from isometric deformations of a flat object (ex: a deformed sheet of paper or a flag waving at the wind). A quite innovative contribution was made in representing and estimating these isometric relations.

Group Productivity

Publications in peer review Journals

- Manuel Marques, João Paulo Costeira, "Estimating 3D shape from degenerate sequences with missing data" , Computer Vision and Image Understanding, Vol. 113, Issue 2, pp. 261-272 , 2009.
- André F. T. Martins, Noah A. Smith, Eric P. Xing, Pedro M. Q. Aguiar, and Mário A. T. Figueiredo, "Non extensive Information Theoretic Kernels on Measures", Journal of Machine Learning Research, Vol. 10, 935-975, April 2009.
- Seabra, José C.R.; Pedro, L. Mendes; Fernandes e Fernandes, J.; Sanches, João M; "A 3-D Ultrasound-Based Framework to Characterize the Echo Morphology of Carotid Plaques," IEEE Transactions on Biomedical Engineering, Volume 56, Issue 5, May 2009 Page(s):1442 - 1453.
- Gustavo Carneiro and Allan Jepson, "The Quantitative Characterization of the Distinctiveness and Robustness of Local Image Descriptors", Image and Vision Computing 27 (2009), pp. 1143-1156
- Gustavo Carneiro and Nuno Vasconcelos. "Minimum Bayes Error Features for Visual Recognition", Image and Vision Computing 27 (2009), pp. 131-140.
- Ivica Zalud, Sara Good, Gustavo Carneiro, Bogdan Georgescu, Kathleen Aoki, Lorry Green, Farzaneh Shahrestani and Russel Okumura. "Fetal Biometry: A Comparison Between Experienced Sonographers and Automated Measurements", The Journal of Maternal-fetal and Neonatal Medicine 02/2009 22(1):43-50.
- Jacinto C. Nascimento, Mário A. T. Figueiredo, Jorge S. Marques, "Trajectory Classification using Switched Dynamical hidden Markov Models," IEEE Transactions on Image Processing, Accepted 2009.
- Margarida Silveira, Sandra Heleno, "Separation between Water and Land using Region Based Level Sets," IEEE Geoscience and Remote Sensing Letters, Vol: 6, Number 3, pp, 471-475, 2009.
- Margarida Silveira, Jacinto Nascimento, Jorge S. Marques, André R. S. Marçal, Teresa Mendonça, Syogo Yamauchi, Junji Maeda, Jorge Rozeira, "Comparison of Segmentation Methods for Melanoma Diagnosis in Dermoscopy Images," IEEE Journal of Selected Topics in Signal Processing, Vol. 3, Number 1, pp. 25-35, 2009.
- Margarida Silveira, Antónia Monteiro, "Automatic recognition and measurement of butterfly eyespot patterns," Biosystems, Vol. 95, issue 2, pp.

Group Productivity

130-136, 2009

- Ricardo Martins, Pedro Pina, Jorge S. Marques, Margarida Silveira, "Crater Detection by a Boosting Algorithm," IEEE Geoscience and Remote Sensing Letters, Vol: 6, Number 1, pp, 127-131, 2009.
- Rodrigues, J. and du Buf, J.M.H., "Multi-scale lines and edges in V1 and beyond: brightness, object categorization and recognition, and consciousness." BioSystems, Vol. 95, pp. 206-226, 2009
- Rodrigues, J. and du Buf, J.M.H., "A cortical framework for invariant object categorization and recognition." Cognitive Processing 10 (3), pp. 243-261, 2009.
- N.E. Martins and S.M. Jesus, "Bayesian acoustic prediction assimilating oceanographic and acoustically inverted data", Journal of Marine Systems, Vol.78, Supplement 1, pp. S349-S358, November 2009.

Other publications International

- José Seabra and João Sanches, "A 3D Graph-Cut based Algorithm for Evaluating Carotid Plaque Echogenicity and Texture," Recent Advances in Biomedical Engineering, IN-TECH, ISBN 978-953-7619, 2009.
- Isabel Rodrigues and João Sanches, "Denoising of Fluorescence Confocal Microscopy Images with Photobleaching compensation in a Bayesian Framework," Recent Advances in Biomedical Engineering, IN-TECH, ISBN 978-953-7619, 2009.
- D. Bajovic, B. Sinopoli and J. Xavier, "Robust linear dimensionality reduction for hypothesis testing with application to sensor selection", 47th Allerton Conference on Communication, Control, and Computing, October 2009
- D. Bajovic, B. Sinopoli and J. Xavier, "Sensor selection for hypothesis testing in wireless sensor networks: a Kullback-Leibler based approach", 48th IEEE Conference on Decision and Control, December 2009
- M. Paladini, A. del Bue, M. Stosic, M. Dodig, J. Xavier and L. Agapito, "Factorization for non-rigid and articulated structure using metric projections", IEEE Computer Society Conference on Computer Vision and Patter Recognition, June 2009
- R. Ferreira, J. Xavier and J. P. Costeira, "Reconstruction of isometrically deformable flat surfaces in 3D from multiple camera images", IEEE International Conference on Acoustics, Speech and Signal Processing, April 2009
- M. Beko, J. Xavier and V. Barroso, "Codebook design for communication in spread and nonspread space-time block codes-based systems", 6th IEEE International Symposium on Wireless Communication Systems, September 2009
- P. Ekim, J. Gomes, J. Xavier and P. Oliveira, "ML based sensor network localization and tracking: batch and time-recursive approaches", 17th European Signal Processing Conference, August 2009
- A. del Bue, M. Stosic, M. Dodig and J. Xavier, "2D-3D registration of deformable shapes with manifold projection", IEEE International Conference on Image Processing, November 2009
- J. Mota, J. Xavier, P. Aguiar and M. Puschel, "Distributed algorithms for basis pursuit", 2nd International Workshop on Signal Processing with Adaptive Sparse Structured Representations, April 2009
- Nuno Pinho da Silva, João Paulo Costeira, The Normalized Subspace Inclusion: Robust Clustering of Motion Subspace , 12th IEEE International Conference on Computer Vision, 2009
- Manuel Marques, Marko Stošić, João Paulo Costeira, Subspace matching: Unique solution to point matching with geometric constraints, , 12th IEEE International Conference on Computer Vision, 2009
- J. Fayad, A. Del Bue, and P. M. Q. Aguiar, "A Weighted Factorization Approach for Articulated Motion Modelling," in Multibody Dynamics, 2009.
- J. Fayad, A. Del Bue, L. Agapito, and P. M. Q. Aguiar, "Human body modelling using quadratic deformations," in 7th EUROMECH Solid Mechanics Conference, 2009.
- João F. P. Crespo, Gustavo A. S. Lopes, and Pedro M. Q. Aguiar, "Principal moments for efficient representation of 2D shape", IEEE International Conference on Image Processing, November 2009.
- João F. C. Mota, João M. F. Xavier, Pedro M. Q. Aguiar, and Markus Puschel, "Distributed algorithms for basis pursuit", International Workshop on Signal Processing with Adaptive Sparse Structured Representations, April 2009.
- Isabel Rodrigues and João Sanches, FLUORESCENCE MICROSCOPY IMAGING DENOISING WITH LOG-EUCLIDEAN PRIORS AND PHOTBLEACHING COMPENSATION, IEEE International Conference on Image Processing, November, 2009.
- Sousa I, Sanches J, Figueiredo P. (2009) Sampling strategy for perfusion quantification using PASL. 26th Annual Scientific Meeting of the ESMRMB, 2009.
- Joana Coelho, Martin Lauterbach, Patrícia Figueiredo and João Sanches, A Binary Detection Approach for fMRI, 15th Annual Meeting of the Organization for Human Brain Mapping, June 2009.
- P. Ekim, J. Gomes, J. Xavier and P. Oliveira, "ML based sensor network localization and tracking: batch and time-recursive approaches", 17th European Signal Processing Conference, August 2009.
- J. Gomes, M. Stojanovic, "Performance analysis of filtered multitone modulation systems for underwater communication", Proceedings of MTS/IEEE OCEANS'09, October 2009.
- Michael Wels, Yefeng Zhang, Gustavo Carneiro, Martin Huber, Joachim Hornegger and Dorin Comaniciu. "Fast and Robust 3-D MRI Brain Structure Segmentation", 12th International Conference on Medical Image Computing and Computer Assisted Intervention, 2009.
- Margarida Silveira, Sandra Heleno, Classification of Water Regions in SAR Images using Level Sets and Non-Parametric Density Estimation, IEEE International Conference on Image Processing, pp. 1685-1688, November 2009.
- J. C. Nascimento. M. A. T. Figueiredo, J. S. Marques. Trajectory analysis in natural images using mixtures of vector Fields, IEEE International Conference on Image Processing, 4353-4356, 2009.
- Sousa, R., Rodrigues, J. and du Buf, J.M.H, Correlates of facial expressions in the primary visual cortex. Proc. Bernstein Conference on

Group Productivity

Computational Neuroscience, 30 Sept. - 2 Oct 2009., pp. 85-86. Abstract in: *Frontiers in Computational Neuroscience*.

- Martins, J.A., Rodrigues, J. and du Buf, J.M.H., Object segregation and local gist vision using low-level geometry. Proc. 32nd European Conference on Visual Perception, August 24-28 2009; *Perception* Vol. 38 Suppl, pp. 41-42.
- Martins, J.A., Rodrigues, J., du Buf, J.M.H. Focus of attention and region segregation by low-level geometry. Proc. Int. Conf. Computer Vision, Theory and Applications, February 5-8 2009, Vol. 2, pp. 267-272.
- P. Santos, P. Felisberto, O. Rodríguez and S.M.Jesus, "Geoacoustic Matched-field Inversion using a Vector Sensor Array", in Int. Conf. on Underwater Acoustic Measurements, June 2009.
- A.Silva, J. Huillery and S.M. Jesus, "Multi-node processing for asymmetrical communications in underwater acoustic networks", IEEE International Workshop on Underwater Networks, May 2009.

Other publications National

- Artem Khmelinskii, Rodrigo Ventura and João Sanches, "Chromosome Pairing Using Mutual Information in Bone Marrow Cells," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- David Afonso and João Sanches, "ARMA estimation – a comparison study for fMRI," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- F. Ferro, J. Sanches and E. C. Fernandes, "Flames Spectrum Estimation Based on Gaussian Mixtures: a Bayesian Approach," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- Isabel Rodrigues and João Sanches, "Denoising of Fluorescence Confocal Image Sequences: a Comparison Study," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- Isabel Rodrigues and João Sanches, "Photobleaching and Photoblinking model describing intensity fading in LSFCM images, 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- Inês Sousa, João Sanches and Patrícia Figueiredo, "Optimizing sampling strategies for perfusion quantification using PASL," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- Juliane Farthouat, João Sanches and Patrícia Figueiredo, "Bayesian estimation of perfusion using PASL-MRI," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- José Seabra and João Sanches, "Usefulness of ultrasonic speckle decomposition procedure for tissue characterization," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- José Seabra and João Sanches, "Toward the development of a Web Ultrasonic Plaque Analysis (WUPA) Tool," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- Ricardo Ribeiro and João Sanches, "Automatic Diagnosis of Liver Steatosis by Ultrasound using Autoregressive Tissue Characterization," 15th edition of the Portuguese Conference on Pattern Recognition, 2009.
- Gustavo Carneiro and Jacinto Nascimento. "Detection of the Left Ventricle of the Heart in Ultrasound Images using Deep Neural Networks", 15th Portuguese Conference on Pattern Recognition, 2009.
- Farrajota, M., Rodrigues, J. and du Buf, J.M.H. "Multi-scale keypoint annotation - a biological approach," 15th Portuguese Conference on Pattern Recognition, 2009.

Master and Ph.D. thesis completed

Ph.D. thesis

- António Silva, "Environmental based underwater communications", PhD Thesis, Instituto Superior Técnico, March 2009.

M.Sc. thesis

- Ricardo Cabral, "Joint estimation of correspondence and motion using global rigidity and local descriptors", Instituto Superior Técnico, 2009
- João F. P. Crespo, "A Multidimensional Companding Scheme for Source Coding with a Perceptually Relevant Distortion Measure", Instituto Superior Técnico, 2009.
- Bruno Afonso, "Music Classification - an Exhaustive Analysis of Automatic Genre Classification", Instituto Superior Técnico, 2009.
- Hugo Pinto, "Robotized Microscopy," Instituto Superior Técnico, 2009.
- Diogo Loureiro, "Web based robotized microscopy," Instituto Superior Técnico, 2009.
- André Baptista, "Continuous monitorization and automatic detection of cardiac abnormalities with mobile phone," Instituto Superior Técnico, 2009
- Indira Andrade, " fMRI Sparse Design for Auditive paradigms: Toward a Signal and Stimulus Perception Improvements," Instituto Superior Técnico, 2009
- João Raminhos, "Acquisition of Electrophysiological Signal - Application to a mobile platform from the EOG signal," Instituto Superior Técnico, 2009
- Fábio Silva, "Reconhecimento de Padrões da Doença de Alzheimer em Imagem PET," Instituto Superior Técnico, 2009.
- André Romão Ribeiro, "Seguimento de Jogadores num jogo de futebol," Instituto Superior Técnico, 2009.
- João Domingos Pacheco, "Tracking People and Activities in Video Recordings of Classroom Presentations," Instituto Superior Técnico, 2009.
- Luis Filipe Rosado, "Sistema para Diagnóstico de Lesões Cutâneas Baseado em Imagens Dermoscópicas," Instituto Superior Técnico, 2009.

Group Productivity

- Diogo Vicente, "Event Detection with Pan-Tilt Cameras," Instituto Superior Técnico, 2009.
- A. Oquina, "Modelling underwater acoustic noise as a tool for coastal management", Erasmus Mundus, University of Algarve, 2009.

Patents/propotypes

NACIONAIS

- "Sistema de Monitorização de Temperatura Central para Diagnósticos de Distúrbios de Sono," João Sanches, Teresa Paiva, Bruno Pereira e Rui Neves, PATENTE DE INVENÇÃO NACIONAL Nº 104115.
- "Metodologia de Registo de Eventos em Diário Electrónico, Implementado em Telemóvel, para Auxílio no Diagnóstico de Distúrbios do Sono," Pedro Pires, João Sanches e Teresa Paiva, PATENTE DE INVENÇÃO NACIONAL Nº 104157

INTERNACIONAIS

- "Automated Fetal Measurement from Three-Dimensional Ultrasound Data", Dorin Comaniciu, Bogdan Georgescu, Sara Good, Gustavo Carneiro and Fernando Amat. US Patent Office 20090093717
- "A Method and System for Detection of Deformable Structures in Medical Images", Dorin Comaniciu, Shaohua Kevin Zhou, Feng Guo, Jin-Hyeong Park, Gustavo Carneiro, Constantine Simopoulos, Joane Otsuki and John Jackson, US Patent Office 20090010509

Organization of conferences

Program committees

- International Conference on Computer Vision (ICCV)
- IEEE Conference on Computer Vision and Pattern Recognition (CVPR)
- Canadian Conference on Computer and Robot Vision (CRV)
- Asian Conference on Computer Vision (ACCV)
- International Conference on Computer Vision Theory and Applications (VISAPP)
- 4th ACM international workshop on underwater networks (WUWNet'09)
- Int. Conf. on Mass Data Analysis of Images and Signals in Medicine, Biotechnology and Chemistry.
- Int. Conf. on Computer Analysis of Images and Patterns.
- Iberoamerican Congress on Pattern Recognition.
- Int. Conf. in Central Europe on Computer Graphics, Visualization and Computer Vision.

Other International Events

- João Costeira co-organized the Doctoral-Consortium as part of the first Carnegie Mellon-Portugal Conference, Porto June 2009.
- Alessio Del Bue organized First Tutorial on Computer Vision in a Non-rigid World which took place in ISR-Lisboa with Profs A. Bartolli, L. Agapito invited speakers (http://users.isr.ist.utl.pt/~adb/?page_id=14)

Industry contract research

A consulting service was established with MDUSpace for the development of a tracking systems for car assembly. This project is being developed in the framework of a technology transfer project between ESA and MDUSpace http://www.esa.int/esaCP/SEM0AKOJH4G_index_0.html

Internationalization

- M. Dodig, M. Stosic: "Singular systems, state feedback problems," Linear Algebra and its Applications 431 (2009), 1267-1292.
- M. Mackaay, M. Stosic, P. Vaz: "sl(N) invariant of links using foams and the Kapustin-Li formula," Geometry & Topology 13 (2009), 1075-1128.
- M. Stosic: "Khovanov homology of torus links," Topology and its Applications 156 (2009), 533-541.
- M. Dodig, M. Stosic: "Similarity class of a matrix with a prescribed submatrix," Linear and Multilinear Algebra, vol. 57, issue 3 (2009), 217-245.
- Gustavo Carneiro and Allan Jepson, "The Quantitative Characterization of the Distinctiveness and Robustness of Local Image Descriptors", Image and Vision Computing 27 (2009), pp. 1143-1156
- Ivica Zalud, Sara Good, Gustavo Carneiro, Bogdan Georgescu, Kathleen Aoki, Lorry Green, Farzaneh Shahrestani and Russel Okumura. "Fetal Biometry: A Comparison Between Experienced Sonographers and Automated Measurements", The Journal of Maternal-fetal and Neonatal Medicine 02/2009 22(1):43-50.
- Margarida Silveira, Jacinto Nascimento, Jorge S. Marques, André R. S. Marçal, Teresa Mendonça, Syogo Yamauchi, Junji Maeda, Jorge Rozeira, "Comparison of Segmentation Methods for Melanoma Diagnosis in Dermoscopy Images," IEEE Journal of Selected Topics in Signal Processing, Vol. 3, Number 1, pp. 25-35, 2009.
- André F. T. Martins, Noah A. Smith, Eric P. Xing, Pedro M. Q. Aguiar, and Mário A. T. Figueiredo, "Non extensive Information Theoretic Kernels on Measures", Journal of Machine Learning Research, Vol. 10, 935-975, April 2009.
- J. Gomes, M. Stojanovic, "Performance analysis of filtered multitone modulation systems for underwater communication", Proceedings of MTS/IEEE OCEANS'09, 2009.

Group Productivity

- D. Bajovic, B. Sinopoli and J. Xavier, "Sensor selection for hypothesis testing in wireless sensor networks: a Kullback-Leibler based approach", 48th IEEE Conference on Decision and Control, 2009
 - M. Paladini, A. del Bue, M. Stosic, M. Dodig, J. Xavier and L. Agapito, "Factorization for non-rigid and articulated structure using metric projections", IEEE Computer Society Conference on Computer Vision and Patter Recognition, 2009
 - J. Mota, J. Xavier, P. Aguiar and M. Puschel, "Distributed algorithms for basis pursuit", 2nd International Workshop on Signal Processing with Adaptive Sparse Structured Representations, 2009
- J. Xavier (ISR), B. Sinopoli (CMU), M. Rodrigues (IT) and ISA, "Novel information processing methodologies for intelligent sensor networks", FCT project CMU-PT/SIA/0026/2009 (proposal under review)

Future Research

Objectives

Fundamentals.

Many optimization problems can be recast as the projection of a point in the intersection of finitely many convex sets. A striking example occurs in wireless sensor networks for target localization. Moreover, a large collection of engineering problems can be written as conic convex optimization problems, which, in turn, reduce themselves (via KKT conditions and strong duality) to problems of projection onto the intersection of convex sets. Current state-of-art algorithms solve this class of projection problems by projecting successively onto each set and exhibit only a (slow) linear convergence rate. We plan to develop novel solution techniques which yield (faster) super linear/quadratic rates by capitalizing on a problem reformulation (derived in our group) and using nonsmooth analysis. Our algorithms project in parallel onto all sets and are suitable for implementation in distributed platforms such as sensor networks or parallel processors. Our preliminaries results indicate substantial savings in computing time and number of iterations until convergence (in the context of sensor networks, this translates in fewer wireless communications and prolonged node battery lifetime).

Sensor Networks. Distributed optimization in sensor networks is a topic of great practical interest. Typical applications include resource allocation in wireless systems, distributed coordination in multi-robot systems, distributed estimation in wireless sensor networks, etc. Current algorithms do not allow for private constraints (i.e., constraints known only at each node) in the underlying optimization problem. Only so-called public constraints are permitted, which severely limit their applicability. We plan to develop new distributed algorithms for sensor networks which can bypass this restriction. Our algorithms are based on the Augmented Lagrangian (AL) dual. Dual variables are updated by the method of multipliers. Primal variables are updated by block-coordinate randomized algorithms that use unidirectional communication only between immediate neighbours in the network, and the gossip-type of communication protocol. Resilience to random link failures is incorporated. The Basis Pursuit (BP) problem has attracted a lot of attention due to its ability to find, under certain conditions, the sparsest solution of an undetermined linear system $Ax = b$ (A is fat). BP finds direct applications in signal and image denoising and restoration, compression, fitting and approximation of functions, channel estimation and coding, compressed sensing, etc. We plan to solve BP in a distributed way, that is, when the computing platform consists of several interconnected compute nodes with separate memory. This models applications occurring in sensor networks or when multi-core computers are available. The main difficulty is that the matrix A defining the linear system is no longer available at a "central" node. Rather, it is fragmented across the computing nodes (each one thus holding a partial knowledge of A). We plan to use a problem reformulation and a dual framework to solve BP through a distributed algorithm. We make applicable the optimal Nesterov's first-order method (we prove that the augmented dual function has a Lipschitz gradient) and we consider two situations of practical interest: the rows or the columns of A are partitioned across the nodes.

Complementarily, we also intend to develop (i) time recursive and/or decentralized algorithms for simultaneous sensor localization and point-like target tracking based on Euclidean distance matrix completion, and (ii) new approaches for estimation of diffusive fields and diffusive source localization. This, and related work to build a prototype installation for urban pollution monitoring using mobile sensing nodes, will be pursued in the framework of FCT project URBISNET, due to start in March 2010.

Image and Video Analysis.

Following the current achievements, we expect to create a solid theoretical framework to representing 3D shape of non-rigid objects from video. These representations will capture the phenomena in such a way that current state of the art in shape from motion can be derived as particular cases. Leveraging the developments at the fundamental work in optimization we expect to develop new ways of handling large recognition tasks such as retrieving object information from large databases/internet.

In what respects to the inference of 3D content from image sequences, we plan to overcome limitations like the need to compute point wise correspondences between different views. Other fundamental problems in image analysis concern the recognition of objects from their shape. We plan to further address fundamental issues like shape representation and recognition.

Underwater Acoustics

We intend to develop (i) robust underwater communication systems for fixed and mobile underwater networks; (ii) robust and efficient array processing techniques for ocean acoustic inversion, monitoring and estimation; and (iii) efficient models for high-frequency propagation with either two or three dimensional scalar/vector sensor arrays.

Funding, source, dates

Source Project Reference Funding for 2010

FCT SIPM PTDC/EEA-ACR/73749/2006

FCT ADCOD PTDC/EEA-TEL/099973/2008

FCT PHITOM PTDC/EEA-TEL/71263/2006

FCT URBISNET PTDC/EEA-CRO/104243/2008

Future Research

FCT PRINTART PTDC/EEA-CRO/098822/2008

FCT MODI PTDC/EEA-ACR/72201/2006

FCT ARGUS PTDC/EEA-CRO/098550/2008

FCT HEARTRACK PTDC/EEA-CRO/103462/2008

FCT VISTA PTDC/EIA-EIA/105062/2008

FCT ADDI PTDC/SAU-BEB/103471/2008

FCT FIBROMIALGIA PTDC/SAU-BEB/104948/2008

FCT RIVERSAR PTDC/CTE-GIX/099085/2008

FCT SMARTVISION PTDC/EIA/73633/2006

FCT WEAM PTDC/ENR/70452/2006

FCT SENSOCEAN PTDC/EEA-ELC/104561/2008

FCT CERN'09 CERN/FP/109351/2009

EU SIMBAD FT7-ICT-2007-C

EU ESONET FP6-SUSTDEV SUSTDEV-3

EU UAN FP7, ICT/Security

EU OAEx FP7, IRSES, PEOPLE

Group Description	
Title of Research Group:	(RG-LVT-50009-3503) Mobile Robotics Laboratory - MRLab
Principal Investigator:	Maria Isabel Lobato de Faria Ribeiro
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
<p>URUS - Ubiquitous Networking Robotics in Urban Settings, FP6-EU-IST-045062, Dec/2006 – Nov/2009 [together with VisLab and ISLab].</p> <p>ITER TCS/ATS - Activities related to the development of an Air Transfer System prototype and Cask Transfer System Virtual Mockup –F4E-2008-GRT-016 (MS-RH), funded by Fusion for Energy (F4E) (The European Joint Undertaking for ITER and the Development of Fusion Energy), Mar/2009-Jun/2010 [together with ISLab and Instituto de Plasmas e Fusão Nuclear(IPFN)/IST]. IST is the project leader that also involves CIEMAT(Spain) and ASTRIUM (France). Isabel Ribeiro is the project PI.</p> <p>DecPUCS: Decentralized Planning Under Uncertainty for Cooperative Systems, PTDC/EEA-ACR/73266/2006 (FCT funding), Oct/2007-Sep.2010 [together with ISLab].</p> <p>FCT Base component of the pluriannual funding.</p>	

Objectives & Achievements	
Objectives	
<p>The objective of MRLab is to undertake research in the area of mobile robotics, with emphasis on the navigation of single and multi-robot systems in networked environments, robot design, and human-robot interaction. Our research is often driven by a broad range of applications, and combines theoretical and implementation issues with the design and assembly of real robots.</p> <p>The navigation of mobile robots is addressed in structured and unstructured environments. Surveillance and transportation applications provide the context and motivation in both single and multiple robot scenarios. These are problems requiring the integration of multiple techniques, ranging from path planning and trajectory following, environment localization and mapping to high level supervision and decision making and architectures to integrate different components. Standard (EKF and Covariance Intersection) techniques are used for localization and mapping. Robot control is addressed using inclusion systems to model behaviours. High level supervision is supported on market and POMDP based systems.</p> <p>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 human interactions and the extensions 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 non-smooth calculus provide the main tools for modeling and analysis.</p> <p>Applications, with robot or product development, include monitoring in hazardous/remote environments with a tele-operated robot, and Air Transfer System path planning and path following definition for ITER-International Thermonuclear Experimental Reactor.</p> <p>MRLab collaborates with the ISLab and VisLab within the framework of the Associate Laboratory Theme B, including the participation in the EU project URUS on networked robotics, and projects ITER TCS/ATS and DecPUCS and with ISLab.</p> <p>Collaborations outside the academic environment may foster the scientific potential of most of the techniques currently being addressed at MRLab, namely in urban robotics and networked robotics. A protocol between IST and Lisboa E-Nova (the municipal agency that handles environmental issue in Lisbon) promoted by MRLab staff is currently active. Joint project proposals may improve the visibility of the work developed at MRLab and also at ISLab and VisLab.</p>	

Main Achievements	
<ul style="list-style-type: none"> • Networked Robotic Systems integrated most activities and achievements in multi-robot systems. 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. This line of work seems particularly important in multiple robot applications to yield a team behaviour as natural as that of a team of humans. MRLab is currently participating in a number of project proposals intending to be the follow up of the URUS project. Moreover, MRLab proposed a collaboration protocol between IST and Lisbon city authorities to develop urban robotic systems in the same line of that developed by URUS in Barcelona. This protocol has been accepted and MRLab people is working on project proposals related to this theme. • In what concerns robot design, work continues on development of the RIOL robot; the distinctive feature of this robot is its ability to move on suspended cables and monitoring a variety of aspects. • In the project ITER TCS/ATS a complete motion planning methodology for the TCS (Transfer Cask System) to operate in ITER- International 	

Objectives & Achievements

Thermonuclear Experimental Reactor was developed. The TCS is a large mobile robot (2.6 × 3.7 × 8.5 m) (w × h × l) carrying a maximum weight of 100 tones that will be installed in ITER for component transportation. The path optimization criterion implemented is constrained by the highly confined spaces of ITER buildings and the demanding safety requirements of the transportation (due to the radioactive nature of the transported components) yielding smooth trajectories that maximize the clearance to the closest obstacles. A set of 63 trajectories were calculated linking the start and goal locations that the TCS has to serve in ITER. Given the cluttered environment, some trajectories require maneuvers, i.e., changes in TCS orientation direction and motion reversion, whose definition was included in the path optimization algorithm.

Based on the optimized trajectory results, MRLab identified building design features that did not cope with the presence of the TCS and proposed changes in building structures. These modifications were accepted and are now incorporated in ITER building layout. Preliminary work on the specification of a test facility for a TCS prototype was carried out.

This work, leaded by MRLab, was done in collaboration with IPFN-Instituto de Plasmas e Fusão Nuclear/IST.

Group Productivity

Publications in peer review Journals

- Francisco Melo, Isabel Ribeiro "Coordinated Learning in Infinite Markov Games", accepted for publication , Autonomous Agents and Multiagent Systems, published on-line August 2009.

Other publications International

- Matthijs Spaan, Nelson Gonçalves, João Sequeira , "Multi-agent Sequential Decision Making in Uncertain Domains", Proc. of AAMAS 2009 Workshop on Multi-agent Sequential Decision-Making in Uncertain Domains, Budapest, Hungary, May 2009.
- Nelson Gonçalves, João Sequeira. "Expression of Emotions Through Body Motion", Poster presentation at ICINCO 2009-6th International Conference on Informatics in Control, Automation and Robotics, Milan, Italy, July 2009 .
- C. González Gutiérrez, C. Damiani, M. Irving, J-P. Friconeau, A. Tesini, I. Ribeiro, A. Vale "ITER Transfer cask System: status of design, issues and future developments" Proc. of the ISFNT9 - 9th International Symposium on Fusion Nuclear Technology, Dalian, China, October 2009.
- Marco Barbosa, Alexandre Bernardino, Dario Figueira, José Gaspar, Nelson Gonçalves, Pedro Lima, Abdolkarim Pahliani, José Santos-Victor, Matthijs Spaan, João Sequeira , "ISRobotNet: A Testbed for Sensor and Robot Network Systems", Proc. of IROS 2009 - The IEEE/RSJ International Conference on Intelligent Robots and Systems, St. Louis, MO, USA, October 2009.
- Nelson Gonçalves, João Sequeira. "Task Assignment in Active Surveillance". Proc. of the Intelligent Robots Workshop at 12th Portuguese Conference on Artificial Intelligence, EPIA 2009, Aveiro, Portugal, October 2009.
- João Sequeira, Antonios Tsourdos, Samuel Lazarus. "Robust covariance estimation in sensor data fusion". Proc. of the 2009 IEEE International Workshop on Safety, Security, and Rescue Robotics, Denver, Colorado, USA, November 2009.

Other publications National

- José Rodrigues, Dario Figueira, Carlos Neves, Isabel Ribeiro, "Leader-Following Graph-Based Distributed Formation Control, Robótica, Nº 75, invited paper, pp.8-14, July 2009.
- André Dias, José Miguel Almeida, Alfredo Martins, João Sequeira, Eduardo Silva, "A slipping conditions observer in wheeled mobile robot traction". Proceedings of Scientific Meeting of the Portuguese Robotics Festival, Castelo Branco, Portugal, May 2009.

Patents/propotypes

The ISobotNet is a testbed for Networked Robot Systems developed by MRLab together with VisLab and ISLab, composed of an indoor area of around 160 m² with 10 webcams placed at the ceiling such that some of the fields of view do not overlap. The cameras are distributed in 4 groups, each of which is managed by its own computer, namely for image acquisition. The managing computers are connected to the ISR/IST network and can be accessed by duly authorized external parties. Ongoing work will extend the number of cameras and the usable indoor space to include multiple floors. Robots will use the same elevators as ordinary people to move between floors. Besides the camera sensors, four Pioneer AT and one ATRV-Jr robots are available. Each of the robots is equipped with sonars, onboard cameras, laser range finder and is Wi-Fi connected to the network.

Organization of conferences

MRLab researchers were IPC members of the following conferences:

- ROBOTICA2009 - Scientific Meeting of the Portuguese Robotics Festival, Castelo Branco, Portugal, May de 2009.
- SAFEPROCESS'09 - 7th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes, Safeprocess'09, Barcelona, Spain, June 2009.
- ICINCO'09 – 6th International Conference on Informatics in Control, Automation and Robotics, Milan, Italy, July 2009.
- IROBOT'09 - 4th International Workshop on Intelligent Robotics, integrated in the 12th Portuguese Conference on Artificial Intelligence – EPIA '09, Aveiro, Portugal, October2009.
- IECON'09 - 35th Annual Conference of the IEEE Industrial Electronics Society – IECON'09, Porto, Portugal, November 2009.
- SSR'09 - 2009 IEEE International Workshop on Safety, Security, and Rescue Robotics, University of Denver, Denver, Colorado, USA, November 2009.

Group Productivity

Internationalization

- Collaboration with Universidad Politecnica de Catalonia (Spain), University of Seville (Spain), University of Zaragoza (Spain), Scuola Superiore de Sant'Anna (Italy), University of Surrey (UK), and LAAS (France), under the framework of the EU FP6 URUS Project.
- Technical consultancy for Fusion for Energy (F4E), the European Joint Undertaking for ITER and the Development of Fusion Energy, in the frame of Remote Handling activities for ITER.
- Collaboration with Cranfield University, UK, in the frame of a sabbatical leave by João Sequeira (4 months starting May 2009).
- Collaboration with EADS-ASTRIUM (France) and CIEMAT – Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Spain) in the frame of the project ITER TCS/ATS-F4E-2008-GRT-016.

Government/Organization contract research

Isabel Ribeiro, acting as adviser for the Executive Board of FCT (Portuguese Foundation for Science and Technology), was co-responsible for the preparation of the Call for Proposals for Scientific Research and Technological Development Projects in all Scientific Domains launched by FCT. One call opened in November 2008, received around 5800 proposals and during 2009 she was responsible for the IT aspects related with the scientific evaluation. She was responsible for the next call that opened in September 2009, and for the new versions of the "Guide for preparation and submission of R&D projects" and the "Guide for Peer Review of R&D projects". During 2009 she was the FCT responsible for all the contacts and negotiations with "Programa Operacional Factores de Competitividade", the funding programme responsible for the allocation of FEDER funds to FCT.

Future Research

Objectives

ISR's ISLab and MRLab have a past experience of collaboration in research projects, and graduate students supervision. Research staff in both labs share common scientific interests, and tackle complementary aspects in the area of intelligent mobile robots. The two groups will merge into a single one, the IRSLab (Intelligent Robots and Systems Lab), starting 2010, proceeding with the effort already started in 2009, with the goal of fostering their collaboration and increasing the critical mass. The Future Research herein presented corresponds to the objectives of this new research group.

The new IRSLab will reinforce the research focus on some of the topics currently studied by ISLab and MRLab:

- i.) the development of decentralized sequential decision making methods based on POMDP models (worldwide cited work, with considerable number of publications already in 2008);
- ii.) using DES for multi-robot plan representation, analysis and synthesis, namely Petri nets based task modeling and temporal logic based multi-robot task specifications;
- iii.) active cooperative perception and cooperative navigation in multi-robot teams using probabilistic approaches, where we expect to introduce novel methods and demonstrate results in unstructured scenarios;
- iv.) systems integration, middleware and robot architecture for networked robot systems;
- v.) exploring models of social behavior in human societies, inspired on semiotics, to devise alternative, human-like, strategies for interaction among robots and between humans and robots.

We are also exploring multidisciplinary, thought-provocative research topics, which have demonstrated potential for introducing breakthrough concepts in areas such as coordination of robot collectives based on concepts borrowed from the social and natural sciences, namely Economy and Biology. In the upcoming 3 years, it is our goal to strengthen those areas by increasing the collaboration with experts in related fields, and by increasing our critical mass in fields lying in the intersection of the contributing disciplines through recruitment of post-docs. Major ideas in these directions concern:

- exploiting the concept of institutional economy to further develop our awarded Institutional Robotics concept, namely its potential for interaction between robot collectives and humans;
- exploiting the immune system ability to detect anomalous situations and to trigger adequate responses, replicating its operation principles in teams of several robots with a large number of virtual sensors that can be reproduced, mutated or eliminated;
- addressing the problem of how a single robot can cope with an unstructured, unpredictable, and dynamic environment, by using bio-inspired cognitive architectures, such as ego-centered spatial representations of the environment, and motivational systems aiming at the sociability of the robot.

Regarding applications, we will continue extending our work in search and rescue to field robotics activities and applications, notwithstanding their relevance for public policies, and potential for innovative results on unstructured environments blending sound theory and technological developments. In addition, generic robotics applications, namely those including networked robot systems, will extend the contributions to the area of integration of complex systems.

The involvement in ITER Remote Handling activities will continue, extending the past contributions of the group, among them the design of the current reference model for ITER cask transportation systems.

Funding, source, dates

Future Research

ITER TCS/ATS - Activities related to the development of an Air Transfer System prototype and Cask Transfer System Virtual Mockup – EURATOM F4E-2008-GRT-016 (MS-RH), Mar/2009-Jun/2010 [together with ISLab and Instituto de Plasmas e Fusão Nuclear(IPFN)/IST]. IST is the project leader that also involves CIEMAT(Spain) and ASTRIMUM (France). Isabel Ribeiro is the project PI.

DecPUCS: Decentralized Planning Under Uncertainty for Cooperative Systems, PTDC/EEA-ACR/73266/2006 (FCT funding), Oct/2007-Sep.2010 [together with ISLab].

FCT Base component of the pluriannual funding.

Group Description	
Title of Research Group:	(RG-LVT-50009-3505) Intelligent Systems Laboratory
Principal Investigator:	Pedro Manuel Urbano de Almeida Lima
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
URUS - Ubiquitous Networking Robotics in Urban Settings, FP6-EU-IST-045062, Dec/2006 – Nov/2009 [together with VisLab and MRLab].	
ITER TCS/ATS - Activities related to the development of an Air Transfer System prototype and Cask Transfer System Virtual Mockup –F4E-2008-GRT-016 (MS-RH), funded by Fusion for Energy (F4E) (The European Joint Undertaking for ITER and the Development of Fusion Energy), Mar/2009-Jun/2010 [together with MRLab and Instituto de Plasmas e Fusão Nuclear(IPFN)/IST]. IST is the project leader that also involves CIEMAT(Spain) and ASTRIUM (France).	
DecPUCS: Decentralized Planning Under Uncertainty for Cooperative Systems, PTDC/EEA-ACR/73266/2006 (FCT funding), Oct/2007-Sep.2010 [together with MRLab].	
FCT Base component of the pluriannual funding.	

Objectives & Achievements	
Objectives	
<p>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 management 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, post-disaster scenarios), and services (e.g., ambient assisted living, helping people in public spaces, energy consumption in buildings).</p> <p>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:</p> <ul style="list-style-type: none"> • artificial intelligence, with a focus on decentralized and distributed methods, and specific interest in 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. 	

Main Achievements	
<ul style="list-style-type: none"> • A significant part of the work accomplished in this period concerned using decision-theoretic methods for planning under uncertainty in different settings. Those included sensor selection and active cooperative perception (i.e., active perception involving multiple sensors and multiple cooperating decision makers) in networks of (visual) sensors and robots. We have demonstrated our techniques on the ISRobotNet network of 10 cameras and several mobile robots. Three papers were published on these topics, namely on intelligent sensor selection, on sensor-aware path planning, and on the overall experimental setup. • Regarding multiagent planning under uncertainty. novel results on Dec-POMDPs were introduced in one paper, which presents the most scalable and fastest exact Dec-POMDP solver develop so far. Furthermore, we combined POMDPs with task auctions, for scalable cooperation in multi-robot systems. • Some other interesting advances were achieved concerning search and rescue robots. Three papers on adjustable autonomy for robot remote operation was carried out using the RAPOSA platform, namely regarding autonomous docking to the robot cable, autonomous stair climbing, and 3D remote operation using a Head Mounted Display and the robot camera pairs to feed stereo video. Furthermore, ISR aerial blimp was endowed with full onboard navigation autonomy, using a DSP and a camera. Successful experiments on tracking a moving land vehicle and ground lines were carried out in indoor environments. • We published a paper on using Linear-Time Temporal Logic (LTL) to specify the performance objectives for a given Discrete Event System (DES) in a more natural language, and build a supervisor that restricts the DES' behaviour to those objectives by construction, with some novel details with respect to prior work. • Significant progresses were achieved on a PhD thesis concerning Petri nets-based modelling and performance analysis over a closed loop model of the robot situated in its environment, using both qualitative (formal verification) and quantitative (stochastic performance) analysis tools. Two book chapters on this work were accepted for publication and will be published in 2010. • Object tracking by single and multiple robots, including fusion of each team member information using particle filters, was also a strong topic of the ISLab research in this period, resulting in one published paper and a journal paper accepted for publication in 2010. An FCT project on 	

Objectives & Achievements

this and related areas was approved and will start in 2010.

- The work on Institutional Robotics (IR), a new strategy to conceptualize multi-robot systems, which takes institutions as the main tool of social life of robots with bounded rationality and bounded autonomy, continued, including consolidation of the applications of IR concepts to real e-Puck robots, with one paper accepted for publication in 2010, supported on a PhD thesis. An FCT project in this a related areas was approved and will start in 2010.
- The group engagement in the research of emotion-based agents, taking a biologically-inspired approach to cognition and exploring an agent architecture based on the role of emotions in decision making, has produced more recently a journal paper.
- Research on cognitive architectures has continued, now exploiting the iCub humanoid platform, in collaboration with VisLab. To this respect, two conference papers emerged, on endowing the iCub attention system with object discovery and recognition capabilities.
- A collaboration with the Image and Signal Processing lab has been carried out concerning the problem of automatic karyotyping, from which a journal paper in the IEEE Transactions of Biomedical Engineering has been accepted for publication (expected in 2010).

Group Productivity

Publications in peer review Journals

- "Responding efficiently to relevant stimuli using an emotion-based agent architecture", Rodrigo Ventura, Carlos Pinto-Ferreira, *Neurocomputing* 72(13-15), 2009

Other publications International

- "LTL Plan Specification for Robotic Tasks Modelled as Finite State Automata", Bruno Lacerda, Pedro Lima, Proc. of Workshop ADAPT - Agent Design: Advancing from Practice to Theory, AAMAS 2009 - the 8th International Conference on Autonomous Agents and Multiagent Systems, Budapest, Hungary, 2009
- "Multi-Robot Cooperative Object Localization - Decentralized Bayesian Approach", J. Santos, Pedro Lima, Proc. of RoboCup2009 Symposium, Graz, Austria, 2009
- "From Pixels to Objects: Enabling a spatial model for humanoid social robots", Dario Figueira, Manuel Lopes, Rodrigo Ventura, Jonas Ruesch, Proc. of ICRA 2009 - IEEE International Conference on Robotics and Automation (ICRA-09), Kobe, Japan, 2009
- "Autonomous docking of a tracked wheels robot to its tether cable using a vision-based algorithm", Fausto Ferreira, Rodrigo Ventura, Workshop on Robotics for Disaster Response, ICRA 2009 - IEEE International Conference on Robotics and Automation, Kobe, Japan, 2009
- "ISRobotNet: A Testbed for Sensor and Robot Network Systems", Marco Barbosa, Alexandre Bernardino, Dario Figueira, José Gaspar, Nelson Gonçalves, Pedro Lima, Abdolkarim Pahlani, José Santos-Victor, Matthijs Spaan, João Sequeira, Proc. of IROS 2009 - The IEEE/RSJ International Conference on Intelligent Robots and Systems, St. Louis, MO, USA, 2009
- "Decision-Theoretic Robot Guidance for Active Cooperative Perception", Abdolkarim Pahlani, Matthijs Spaan, Pedro Lima, Proc. of IROS 2009 - The IEEE/RSJ International Conference on Intelligent Robots and Systems, St. Louis, MO, USA, 2009
- "A Decision-theoretic Approach to Dynamic Sensor Selection in Camera Networks", Matthijs Spaan, Pedro Lima, Proc. of ICAPS 2009 - 19th International Conference on Automated Planning and Scheduling, Thessaloniki, Greece, 2009
- "Multi-agent Sequential Decision Making in Uncertain Domains", Matthijs Spaan, Nelson Gonçalves, João Sequeira, Proc. of AAMAS 2009 Workshop on Multi-agent Sequential Decision-Making in Uncertain Domains, Budapest, Hungary, 2009
- "Lossless Clustering of Histories in Decentralized POMDPs", F. Oliehoek, S. Whiteson, Matthijs Spaan, Proc. of AAMAS 2009 - 8th International Conference on Autonomous Agents and Multiagent Systems, Budapest, Hungary, 2009
- "Robust Autonomous Stair Climbing by a Tracked Robot Using Accelerometer Sensors", Jorge Ferraz, Rodrigo Ventura, Proc. of CLAWAR 2009 - 12th International Conference on Climbing and Walking Robots, Istanbul, Turkey, 2009
- "Immersive 3-D Teleoperation of a Search and Rescue Robot Using a Head-Mounted Display", Henrique Martins, Rodrigo Ventura, Proc. of EFTA 2009 - 14th IEEE International Conference on Emerging Technologies and Factory Automation, Mallorca, Spain, 2009
- "Decision-theoretic Planning under Uncertainty for Cooperative Active Perception" Matthijs T. J. Spaan and Pedro U. Lima, NIPS Workshop on Adaptive Sensing, Active Learning and Experimental Design, Vancouver, Canada, 2009.
- "An Intelligent Assistant for Power Plants based on Factored MDPs", Alberto Reyes, Matthijs T. J. Spaan, and L. Enrique Sucar, Int. Conf. on Intelligent System Applications to Power Systems, 2009.
- "Emotions: A bridge between nature and society?", Rodrigo Ventura, In *Biologically Inspired Cognitive Architectures, Papers from the 2009 AAAI Fall Symposium*, pages 184–187. The AAAI Press, 2009.
- "Social interaction with robots and agents: Where do we stand, where do we go?", Eva Hudlicka, Sabine Payr, Rodrigo Ventura, Christian Becker-Asano, Kerstin Fischer, Iolanda Leite, Ana Paiva, and Christian von Scheve, In *Proceedings of 2009 International Conference on Affective Computing & Intelligent Interaction (ACII-2009)*, 2009.
- "Towards a spatial model for humanoid social robots", Dario Figueira, Manuel Lopes, Rodrigo Ventura, and Jonas Ruesch, In *Progress in Artificial Intelligence (EPIA-2009)*, volume LNAI 5816, pages 287–298. Springer, 2009.

Other publications National

- "Line Following and Ground Vehicle Tracking by an Autonomous Aerial Blimp", D. Jerónimo, Ricardo Alcácer, F. Alegria, Pedro Lima, Proc. of ROBOTICA 2009 - 9th Conference on Autonomous Robot Systems and Competitions, Castelo Branco, Portugal, 2009
- "Instituição", P. Silva, P. Lima, *Revista de Comunicação e Linguagens*, 40 (Outubro 2009), pp. 97-107

Group Productivity

Master and Ph.D. thesis completed

- Decentralized Low Communication 6DoF Full State Formation Navigation, Sónia Marques, Ph.D. Thesis, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009
- Extração de Preferências por Meio de Avaliações de Comportamentos Observados, Valdinei Silva, Ph.D. Thesis, co-tutela Universidade de São Paulo and Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009
- Multi-Robot Cooperative Object Localization: Decentralized Bayesian Approach, João Santos, M.Sc. Thesis, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009
- Hardware Architecture and Fast Deployment Methods for Soccer Robots, João Antunes, M.Sc. Thesis, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009
- Navegação Autónoma e Percepção Cooperative Entre Robots Aéreos e Terrestres, Hugo Augusto, M.Sc. Thesis, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009
- Augmented Reality for the Teleoperation of Robot RAPOSA, Henrique de Castro Martins, M.Sc. Thesis, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009
- Increasing Autonomy For The Robot RAPOSA, Jorge Miguel de Freitas Ferraz, M.Sc. Thesis, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2009

Patents/propotypes

The ISobotNet is a testbed for Networked Robot Systems developed by ISLab together with VisLab and MRLab, composed of an indoor area of around 160 m² with 10 webcams placed at the ceiling such that some of the fields of view do not overlap. The cameras are distributed in 4 groups, each of which is managed its by its own computer, namely for image acquisition. The managing computers are connected to the ISR/IST network and can be accessed by duly authorized external parties. Ongoing work will extend the number of cameras and the usable indoor space to include multiple floors. Robots will use the same elevators as ordinary people to move between floors. Besides the camera sensors, four Pioneer AT and one ATRV-Jr robots are available. Each of the robots is equipped with sonars, onboard cameras, laser range finder and is Wi-Fi connected to the network.

Organization of conferences

ISLab researchers were co-organizers of the following workshops:

- AAMAS'09 Workshop on Multi-agent Sequential Decision-Making in Uncertain Domains (MSDM 2009) (Matthijs Spaan)

ISLab researchers were IPC members of the following conferences:

- IROS 2009 (Pedro Lima, Senior PC member)
- 8th Int. Conf. on Autonomous Agents and Multi-Agent Systems (AAMAS'09) (Pedro Lima, Senior PC member)
- RoboCup Symposium 2009 (Pedro Lima)
- IJCAI09 Workshop on Hybrid Control for Autonomous Systems Integrating Learning, Deliberation, and Reactive Control (Pedro Lima)
- ICRA 2009 (Pedro Lima)
- Robocomm2009 (Pedro Lima)
- ROBÓTICA 2009, 9th Conference on Autonomous Robot Systems and Competitions (Pedro Lima)
- 19th Int. Conf. on Automated Planning and Scheduling (ICAPS'09) (Matthijs Spaan),
- 21st Int. Joint Conf. on Artificial Intelligence (IJCAI'09) (Matthijs Spaan)
- 8th Int. Conf. on Autonomous Agents and Multi-Agent Systems (AAMAS'09) (Matthijs Spaan)

Internationalization

- See international collaborative publications in the publications' list
- Collaboration with Universidad Politecnica de Catalonia, University of Seville, University of Zaragoza and LAAS, under the framework of the EU FP6 URUS project
- Technical consultancy for Fusion for Energy (F4E), the European Joint Undertaking for ITER and the Development of Fusion Energy, in the frame of Remote Handling activities for ITER.
- Collaboration with EADS-ASTRIUM (France) and CIEMAT – Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Spain) in the frame of the project ITER TCS/ATS-F4E-2008-GRT-016.
- Collaboration with the University of Amsterdam
- Matthijs Spaan – IJCAI'09 Tutorial on “Decision-Theoretic Planning for Multi-Agent Systems: New Directions and Opportunities”, with Shlomo Zilberstein and Christopher Amato
- Matthijs Spaan gave a seminar on “Decision-theoretic Planning under Uncertainty for Active Cooperative Perception” at Linköping University, Sweden, Oct 2009, and Örebro University, Sweden, Nov 2009.
- Pedro Lima is a co-supervisor of PhD student José Nuno Pereira with Alcherio Martinoli at EPFL, Switzerland, under the IST-EPFL Dual Degree program
- ISLab researchers were members of the editorial board of the following journals:

Group Productivity

- o Journal of Advanced Robotic Systems, published by ARS Publishing, Vienna (Pedro Lima)
- o Portuguese Magazine Robótica (Pedro Lima)
- ISLab researchers were reviewers of the following journals:
 - o IEEE Transactions on Robotics
 - o Elsevier Journal of Robotics and Autonomous Systems
 - o Journal of Artificial Intelligence
 - o Artificial Intelligence
 - o Autonomous Agents and Multi-Agent Systems
 - o IEEE Systems, Man and Cybernetics - Part B
- Pedro Lima was co-supervisor of PhD student Valdinei Silva, with Anna Costa at Universidade Politécnica de São Paulo, Brasil , in co-tutela
- Pedro Lima is a Trustee of the RoboCup Federation
- Pedro Lima was awarded a Catedra de Excelencia (6 months) by the Board of Governors of the U. Carlos III de Madrid
- Pedro Lima was member of the PhD thesis committee of Antidio Viguria, U. Seville, Sep 2009
- Matthijs Spaan was member of the Licenciante's thesis committee of Per Skoglar, "Planning Methods for Aerial Exploration and Ground Target Tracking", Linkoping University, Oct 2009.
- Matthijs Spaan was guest editor of Special issue on "Signal Processing Advances in Robots and Autonomy", EURASIP Journal on Advances in Signal Processing (2009)

Future Research

Objectives

ISR's ISLab and MRLab have a past experience of collaboration in research projects, and graduate students supervision. Research staff in both labs share common scientific interests, and tackle complementary aspects in the area of intelligent mobile robots. The two groups will merge into a single one, the IRSLab (Intelligent Robots and Systems Lab), starting 2010, proceeding with the effort already started in 2009, with the goal of fostering their collaboration and increasing the critical mass. The Future Research herein presented corresponds to the objectives of this new research group.

The new IRSLab will reinforce the research focus on some of the topics currently studied by ISLab and MRLab:

- i) the development of decentralized sequential decision making methods based on POMDP models (worldwide cited work, with considerable number of publications already in 2008);
- ii) using DES for multi-robot plan representation, analysis and synthesis, namely Petri nets based task modeling and temporal logic based multi-robot task specifications;
- iii) active cooperative perception and cooperative navigation in multi-robot teams using probabilistic approaches, where we expect to introduce novel methods and demonstrate results in unstructured scenarios;
- iv) systems integration, middleware and robot architecture for networked robot systems;
- v) exploring models of social behavior in human societies, inspired on semiotics, to devise alternative, human-like, strategies for interaction among robots and between humans and robots.

We are also exploring multidisciplinary, thought-provocative research topics, which have demonstrated potential for introducing breakthrough concepts in areas such as coordination of robot collectives based on concepts borrowed from the social and natural sciences, namely Economy and Biology. In the upcoming 3 years, it is our goal to strengthen those areas by increasing the collaboration with experts in related fields, and by increasing our critical mass in fields lying in the intersection of the contributing disciplines through recruitment of post-docs. Major ideas in these directions concern:

- exploiting the concept of institutional economy to further develop our awarded Institutional Robotics concept, namely its potential for interaction between robot collectives and humans;
- exploiting the immune system ability to detect anomalous situations and to trigger adequate responses, replicating its operation principles in teams of several robots with a large number of virtual sensors that can be reproduced, mutated or eliminated;
- addressing the problem of how a single robot can cope with an unstructured, unpredictable, and dynamic environment, by using bio-inspired cognitive architectures, such as ego-centered spatial representations of the environment, and motivational systems aiming at the sociability of the robot.

Regarding applications, we will continue extending our work in search and rescue to field robotics activities and applications, notwithstanding their relevance for public policies, and potential for innovative results on unstructured environments blending sound theory and technological developments. In addition, generic robotics applications, namely those including networked robot systems, will extend the contributions to the area of integration of complex systems.

The involvement in ITER Remote Handling activities will continue, extending the past contributions of the group, among them the design of the current reference model for ITER cask transportation systems.

Funding, source, dates

Future Research

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

Activities related to the development of an Air Transfer System prototype and Cask Transfer System Virtual Mockup - EURATOM F4E-2008-GRT-016 (MS-RH), Mar/2009-Jun/2010 [together with IRS' MRLab]

PCMMC: Perception-Driven Coordinated Multi-Robot Motion Control, FCT PTDC/EEA-CRO/100692/2008, Jan. 2010 - Dec. 2012 (with INESC-Porto, ISEP/IPP, ISLab/ISR/IST Coordinates)

BioInstBots: From Bio-Inspired to Institutional-Inspired Collective Robotics, FCT PTDC/EEA-CRO/104658/2008, Feb. 2010 - Jan. 2013 (with IGC/FCG, ISLab/ISR/IST Coordinates)

Group Description	
Title of Research Group:	(RG-LVT-50009-3508) VisLab - Computer and Robot Vision Laboratory
Principal Investigator:	Jose Alberto Rosado Santos Victor
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
HANDLE: Developmental pathway towards autonomy and dexterity in robot in-hand manipulation, ICT –231640– HANDLE, Feb 2009-Jan 2013.	
URUS - Ubiquitous Networking Robotics in Urban Settings, FP6-EU-IST-045062, Dec06– Nov09 [ISLab and MRL]	
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–Feb09.	
ROBOSOM: Robotic Sense of Movement, ICT- 248366-ROBOSOM, Dec 2009-Nov 2012.	
BIOLOOK: Biomimetic Oculomotor Control for Humanoid Robots, FCT - PTDC/EEA-ACR/71032/2006, Oct.2007-Sept.2010.	
MMCACC: Advanced Monte Carlo Algorithms for Computational Control, FCT - PTDC/EEA-ACR/ 70174/2006, Sep.2007–Aug 2010	
DCCAL: Discrete Cameras Calibration using Properties of Natural Scenes, FCT - PTDC/EEA-CRO/105413/2008, Jan 2010–Dec 2012.	

Objectives & Achievements	
Objectives	
<p>One of the key objectives of the VisLab is to conduct research in computer and robot vision aiming at (i) the development of new methodologies and tools for computer and robot vision and the (ii) demonstration of such methodologies in challenging applications.</p> <p>We can learn from biological systems how vision is an extremely powerful sensing modality to perceive the surrounding world (colour, texture, motion, shape, contrast, etc.) and act accordingly, offering large spatial resolution and reasonable temporal dynamics.</p> <p>Our research is organized in two main lines:</p> <ul style="list-style-type: none"> • Vision Based Control and Navigation • 3D Reconstruction, Motion Analysis and Surveillance <p>a) Vision Based Control and Navigation</p> <p>We address the problem of understanding how to use visual information to control an artificial system (robot) in order to perform a given task. Our research is often inspired on biological systems and aims at designing more flexible and robust artificial vision systems and to improve the understanding of biology. Thanks to massive developments in computing power we can now employ powerful learning techniques in the context of vision and robotic problems. The following topics are currently addressed:</p> <ul style="list-style-type: none"> - Design of visual geometries and camera networks - Vision based control, active vision and navigation - Feature learning and object recognition - Learning and cognition for (humanoid) robots <p>b) 3D Reconstruction, Motion Analysis and surveillance</p> <p>Vision allows us to retrieve information about the scene structure (geometry) or camera motion from video sequences. Amongst other topics, we are currently investigating the following problems:</p> <ul style="list-style-type: none"> - Video surveillance systems able to learn and understand patterns of human activity - Calibration of camera networks and nonconventional camera systems - Model based tracking and object recognition - Gesture analysis and recognition 	

Main Achievements	
<p>The work at VisLab is characterized both by the development of new methodologies for computer and robot vision as well as by addressing several applications with societal impact. The approach followed is strongly multidisciplinary with close links to biology, neuroscience or psychology. The lab has been involved in large-scale, ambitious projects with international partners (e.g. EU). As before, the group has hosted several international post-doc, doctoral or visiting students during this year.</p>	

Objectives & Achievements

Some of the main achievements are listed below:

Humanoid robotic platforms - As a result of the RobotCub project, we host an iCub humanoid robotic platform. The iCub is the most sophisticated humanoid robot currently available in several research laboratories worldwide as part of an open-source community interested in cognitive system. We have continued the development of another mobile platform (Vizzy) combining a humanoid torso and a mobile base.

Cognitive systems and vision - We have developed methods for learning sensorimotor coordination with complex humanoid platforms. Such methods are the basis for an affordance based architecture whereby an artificial system acquires knowledge about the world by experiencing the interaction with objects or other humans or robots. This method follows closely findings in developmental psychology and neuroscience.

Learning by demonstration - We have developed unified models for different imitative or social behaviours that explains different observations in experimental psychology both for humans and human infants. Such methods may provide a basis for a unified mechanism explaining different behavioural patterns as well for building imitative behaviours in robots

Human activity analysis - We have continued the development of computer vision methods able to provide an interpretation of the observed scenes. We developed learning approaches for recognizing human activity from video in different scenarios, in particular for surveillance or human robot interface.

Feature selection and object recognition - We have developed models for feature detection and selection based on Gabor filters, with responses similar to the human visual system. We further adopted boosting techniques to improve the recognition rates as well as for feature selection.

Camera design and camera networks - We developed methods for the calibration of novel camera geometries and networks of cameras from extended observation of video streams.

Participation in EU Projects- In addition to key contributions to our major EU Projects (Robotcub, Contact , Urus and Handle), we have won two other EU Project proposals (Robosom and First-MM) on the topics of robotic sense of movement and mobile manipulation. The Robosom project was ranked first amongst all projects submitted to the IST-Call 4 on cognitive projects (~120 projects)

International Partnerships - We have also actively participated in the IST-EPFL Joint PhD Initiative with students involved in the joint doctoral studies between IST and EPFL as well as in the CMU-Pt dual doctoral program.

Group Productivity

Publications in peer review Journals

- A Bayesian Exploration-Exploitation Approach for Optimal Online Sensing and Planning with a Visually Guided Mobile Robot, Ruben Martinez-Cantin, Nando de Freitas, Eric Brochu, Jose Castellanos and Arnaud Doucet. Autonomous Robots - Special Issue on Robot Learning, Part B, 27(3):93-103, 2009.

- Tracking objects with generic calibrated sensors: an algorithm based on color and 3D shape features, M. Taiana, J. Santos, J. Gaspar, J. Nascimento, A. Bernardino, P. Lima, Robotics and Autonomous Systems, in press.

- A Computational Model of Social-Learning Mechanisms, Manuel Lopes, Francisco S. Melo, Ben Kenward and Jose Santos-Victor. Adaptive Behaviour, 17(6), pp467-483, 2009.

- Abstraction Levels for Robotic Imitation: Overview and Computational Approaches, Manuel Lopes, Luis Montesano, Francisco Melo and José Santos-Victor. in Olivier Sigaud & Jan Peters (eds), From motor to interaction learning in robots, Springer Verlag, 2009.

Other publications International

- Waving detection using the local temporal consistency of flow-based features for real-time applications, P. Moreno, A. Bernardino, J. Santos-Victor. Proc. of ICIAR2009 - 6th International Conference on Image Analysis and Recognition, Halifax, Canada, June 2009.

- Optical flow based detection in mixed human robot environments, D. Figueira, P. Moreno, A. Bernardino, J. Gaspar, J. Santos-Victor, Proc. of ISVC 2009 - 5th International Symposium on Visual Computing, 2009.

- Calibrating an Outdoor Distributed Camera Network using Laser Range Finder Data, Agustin Ortega, Bruno Dias, Ernesto Teniente, Alexandre Bernardino, José Gaspar and Juan Andrade-Cetto, IEEE/RSJ International Conference on Intelligent Robotic Systems, St. Louis, USA, October 2009.

- ISROBOTNET: A Testbed for Sensor and Robot Network Systems, Marco Barbosa, Alexandre Bernardino, Dario Figueira, José Gaspar, Nelson Gonçalves, Pedro U. Lima, Plinio Moreno, Abdolkarim Pahlani, José Santos-Victor, Matthijs T. J. Spaan, João Sequeira, IEEE/RSJ International Conference on Intelligent Robotic Systems, St. Louis, USA, October 2009.

- Multimodal Word Learning from Infant Directed Speech, Jonas Hörnstein, L. Gustavsson, F. Lacerda, José Santos-Victor, IEEE/RSJ International Conference on Intelligent Robotic Systems, St. Louis, USA, October 2009.

- Avoiding Moving Obstacles: The Forbidden Velocity Map, Bruno Damas, José Santos-Victor, IEEE/RSJ International Conference on Intelligent Robotic Systems, St. Louis, USA, October 2009.

- Predictive Tracking across Occlusions on the iCub robot, E. Falotico, M. Taiana, D. Zambrano, A. Bernardino, J. Santos-Victor, C. Laschi, P. Dario. 9th IEEE-RAS International Conference on Humanoid Robots, Paris, December 2009.

- Smooth Foveal Vision with Gaussian Receptive Fields., D. Pamplona, A. Bernardino. 9th IEEE-RAS International Conference on Humanoid Robots, Paris, December 2009.

- Active Learning for Reward Estimation in Inverse Reinforcement Learning, Manuel Lopes, Francisco Melo and Luis Montesano. European

Group Productivity

Conference on Machine Learning (ECML/PKDD) Bled, Slovenia, 2009.

- Evolving Predictive Visual Motion Detectors, J. Ruesch, A. Bernardino. ICDL - IEEE International Conference on Development and Learning, Shanghai, China, 2009.
- Biomimetic Eye-Neck Coordination. Manuel Lopes, Alexandre Bernardino, José Santos-Victor, Claes von Hofsten, Kerstin Rosander. ICDL - IEEE International Conference on Development and Learning, Shanghai, China, 2009.
- Learning grasping affordances from local visual descriptors, Luis Montesano and Manuel Lopes. ICDL, IEEE International Conference on Development and Learning, Shanghai, China, 2009.
- From Pixels to Objects: Enabling a spatial model for humanoid social robots, Dario Figueira, Manuel Lopes, Rodrigo Ventura, Jonas Ruesch. ICRA 2009 - IEEE Intl. Conf. on Robotics and Automation, Kobe, Japan, 2009.
- Affordance based Word-To-Meaning Association, V. Kunic, G. Salvi, A. Bernardino, L. Montesano, J. Santos-Victor. ICRA 2009 - IEEE Intl. Conf. on Robotics and Automation, Kobe, Japan, 2009.
- Active Body Schema Learning, Ruben Martinez-Cantin, Manuel Lopes and Luis Montesano. Robotics: Science and Systems, Workshop on Regression in Robotics, 2009.
- A Computational Model of Object Affordances, L. Montesano, M. Lopes, F. Melo, A. Bernardino and J. Santos-Victor. Advances in Cognitive Systems, IET, 2009.

Other publications National

- Bootstrapping Visual Memories for a Humanoid Robot, G. Saponaro, A. Bernardino, In 15th Portuguese Conference on Pattern Recognition (RecPad 2009). Aveiro, Portugal, October 2009.
- Towards Fully Automated Learning of Grasping Affordances, Christian Wressnegger, Ashish Jain, Misel Batmendijs, Manuel Lopes, Luis Montesano, Alexandre Bernardino and Jose Santos-Victor, In 15th Portuguese Conference on Pattern Recognition (RecPad 2009). Aveiro, Portugal, October 2009.
- Assessing Control Modalities Designed for Pan-Tilt Surveillance Cameras, Diogo Vicente, Jacinto C. Nascimento, José Gaspar, In 15th Portuguese Conference on Pattern Recognition (RecPad 2009). Aveiro, Portugal, October 2009.

Master and Ph.D. thesis completed

- Nuno Moutinho "Localização e Mapeamento Visual em Simultâneo: Detecção de Zonas de Aterragem", M.Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, November 2009.
- Nuno Miguel Pinto Leite, "Calibração de uma Rede de Câmaras baseada em Odometria Visual", M.Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, November 2009.
- Diogo André Pires Vicente, "Event Detection with Pan-Tilt Cameras", M.Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, November 2009.
- Ricardo Jorge Baptista Carona, "Controlo Visual de Robots Tipo Uniciclo", M.Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, November 2009.
- Giovanni Saponaro, "Object Manipulation from Simplified Visual Cues", MSc. Thesis in Computer Engineering (Artificial Intelligence Systems), Sapienza University of Rome, Italy, March 2009.

Patents/prototypes

- iCub humanoid platform: this humanoid platform was developed within the RobotCub project and, with 54degrees of freedom, it is the most sophisticated humanoid platform worldwide. By the summer of 2010, there will be 20 copies of the iCub in different labs around the world, the largest population of conspecific humanoid robots available worldwide.
- Baltazar Humanoid Torso: composed of a high-speed 4 degrees of freedom binocular head, an articulated arm and hand, for research in learning by imitation. This robot was developed at VisLab since 2001 and was one of the most versatile humanoid robots in Portugal.
- Vizzy –humanoid platform mounted on a Segway mobile base. Construction is planned to be finished in 2010. This platform was developed within the lab and combines the flexibility and robustness of Baltazar with mobility. Some parts of the mechanical design were inspired after our design for the iCub.
- Two robotic heads designed for the iCub, each with 6 degrees of freedom, an inertial sensor, audio and ability to perform facial expressions
- TRC LabMate mobile platform, equipped different sorts of cameras, including panoramic ones if curved mirrors.
- One Pioneer mobile platform equipped with a Katana manipulator used for experiments in navigation, SLAM or mobile manipulation.
- Two Nomad Superscout mobile platforms, equipped with vision and an on-board computer.
- One Tobii system for gaze tracking
- One data glove and magnetic tracker
- The ISobotNet is a testbed for Networked Robot Systems developed by VisLab together with ISLab and MRLab, composed of an indoor area of around 160 m2 with 10 webcams placed at the ceiling such that some of the fields of view do not overlap. Besides the camera sensors, four

Group Productivity

Pioneer AT and one ATRV-Jr robots are available. Each of the robots is equipped with sonars, onboard cameras, laser range finder and is Wi-Fi connected to the network.

Organization of conferences

Vislab members organized the following conferences / workshops / summer schols:

- "RLSS09: Robot Learning Summer School", Mon 20 to Fri 24 July, 2009, Venue: Instituto Superior Técnico, Lisboa, Portugal, <http://vislab.isr.ist.utl.pt/RLSS09/>

- "Adaptive Sensing, Active Learning, and Experimental Design", held with NIPS 2009, organized by Rui Castro - Columbia University, Nando de Freitas - UBC, Ruben Martinez-Cantin, IST/ISR, Dec.11, 2009.

<http://nips.cc/Conferences/2009/Program/event.php?ID=1501>

VisLab members were involved in the Program Committee of the following conferences:

- Robotics Science and Systems (RSS)
- Emerging Technologies and Factory Automation (ETFA)
- International Conference on Computer Vision Systems (ICVS)
- International Conference on Image Analysis and Recognition (ICIAR)
- IEEE Intl. Conference on Robotics and Automation, ICRA.
- IEEE Computer Society Conf. Computer Vision and Pattern Recognition, CVPR.
- IEEE Intl. Conf. on Intelligent Robots and Systems, IROS.

Industry contract research

- Collaborative project with the company Ydreams

Internationalization

The group consists of a multinational team with less than 50% of the members with Portuguese nationality and currently comprising 8 different nationalities. Most the core activities are carried out in the context of large international projects.

EU PROJECTS AND PARTNERSHIPS

- EU Proj. ROBOTCUB
- EU Proj. URUS
- EU Proj. CONTACT
- EU Proj HANDLE:
- IST-EPFL Joint Doctoral Initiative
- CMU-Portugal Joint Doctoral Initiative

NATIONAL PROJECTS WITH INTERNATIONAL PARTNERS

- FCT Proj. BIOLOOK – Uppsala Univ.
- FCT Proj. MCMCAC – Univ. of Vancouver.

PARTICIPATION IN THESES COMMITTEES ABROAD

- A. Skoglund, "Programming by Demonstration of Robot Manipulators", Ph.D thesis, Orebro Univ., Jun 2009.
- Ricardo Vazquez Martin, "OnLine Environment Segmentation based on Spectral Mapping (LESS-Mapping)", Ph.D. Thesis, Malaga Univ, Oct 2009.
- Diego Pardo, "Learning rest-to-rest motor coordination in articulated mobile robots", Ph.D. Thesis, UPC, Spain, Oct. 2009.
- Ahmed Al-Tunaiji, "2D Binaural Sound Localization", M.Sc. Thesis, Khalifa University of Science, Technology & Research (KUSTAR), Abu Dhabi, UAE, Jun 2009
- Rasha Abdulrahman Abdulla, "Selective Visual Attention for Urban Search And Rescue (USAR) Systems", M.Sc. Thesis, Khalifa Univ. Science, Technology, & Research (KUSTAR), Abu Dhabi, UAE, Jun 2009
- F. Chersi, Learning through imitation: a biological approach to robotics, Ph.D. Thesis, supervised by Prof. E. Bicho, Prof. W. Erlhagen and Prof. L. Fogassi, Minho Univ., Portugal, 2009.

SUPERVISION OF INTERNATIONAL STUDENTS

- Afshin Dehghan, BSc student, Univ. of Tehran, Iran

Group Productivity

- Ashish Jain, BE student, Manipal Inst. of Technology, India
- Misel Batmendijn (IAESTE), BSc student, Tech. University of Kosice, Slovakia
- Nicolas Greggio, PhD student, Scuola Superiore Sant'Anna, Italy
- Giovanni Saponaro, MSc student, Univ. di Roma La Sapienza, Italy

MEMBERSHIP EDITORIAL BOARDS (AND SPECIAL ISSUES)

IEEE Trans. Autonomous Mental Development, special issue "Active learning and intrinsically motivated exploration in robots" - <http://flowers.inria.fr/tamd-activeLearningIntrinsicMotivation.htm>

REVIEWERS FOR INTERNATIONAL JOURNALS

- Autonomous Robots
- IEEE Transactions:
 - o Biomed Eng.
 - o Circuits and Systems for Video Technology
 - o Image Proc.
 - o Neural Systems & Rehabilitation Engineering
 - o PAMI
 - o Robotics
 - o System Man and Cybernetics
- Intl. J. of Humanoid Robotics
- J. of Robotics and Autonomous Systems
- J. of Intelligent and Robotic Systems

Government/Organization contract research

- José Santos-Victor: IST Vice-President for International Affairs
- José Santos-Victor; IST Director for the IST-EPFL Joint Doctoral Program
- José Santos-Victor, National delegate to the European Space Agency, Mars Exploration Program (AURORA).

Future Research

Objectives

The goals for 2010 consist in the developing the main research lines of the Lab.

We plan to establish the lab as a training centre concerning the iCub platform. The idea is to allow researchers from other labs (national and international) to have access to this experimental platform for carrying our research studies.

We will pursue an aggressive policy of participation in EU Projects. While this results from the international reputation of the group, it contributes to the international visibility and allows us to tackle ambitious projects in multidisciplinary consortia.

We will develop new workshops in 2010, mainly concerning the key research areas in the lab and the main research projects currently under execution.

In 2010 we will have the kick off of new EU-Projects, Robosom and First-MM that should involve considerable effort of the group members.

Finally, we will need to hire more researchers since the new platforms and the range of research initiatives currently undertaken in the lab call for enlarging the research team with new people and competences. This is specially critical for 2010 because some of the lab's former members have been offered new permanent positions internationally.

Funding, source, dates

HANDLE: Developmental pathway towards autonomy and dexterity in robot in-hand manipulation, ICT –231640– HANDLE, Feb 2009-Jan 2013.

ROBOSOM: Robotic Sense of Movement, ICT- 248366-ROBOSOM, Dec 2009-Nov 2012.

First-MM: Flexible Skill Acquisition and Intuitive Robot Tasking for Mobile Manipulation in the Real World ICT-248258-First-MM, Feb 2010-Jul 2013

BIOLOOK: Biomimetic Oculomotor Control for Humanoid Robots, FCT - PTDC/EEA-ACR/71032/2006, Oct.2007-Sept.2010.

DCCAL: Discrete Cameras Calibration using Properties of Natural Scenes, FCT - PTDC/EEA-CRO/105413/2008, Jan 2010–Dec 2012.

Group Description	
Title of Research Group:	(RG-LVT-50009-3583) Laboratory for Energy and Environmental Studies at IN+ Center for Innovation, Technology and Policy Research
Principal Investigator:	Paulo Manuel Cadete Ferrao
Main Scientific Domain:	Engenharia Mecânica
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
<p>Agência Portuguesa do Ambiente, Contract N.º 76/2008, 2008/2009</p> <p>Agência Portuguesa do Ambiente, Contract N.º 164/2008, 2008/2010</p> <p>Agência Portuguesa do Ambiente, Contract N.º 125/2009, 2009/2011</p> <p>Fundação para a Ciência e a Tecnologia, Contract N.º PTDC/70767/2006, 2007/2010</p> <p>Fundação para a Ciência e a Tecnologia, Contract N.º PTDC/AMB/67241/2006, 2007/2010</p> <p>Fundação para a Ciência e a Tecnologia, Contract N.º MIT-PT/SES/0008/2006, 2007/2011</p> <p>Fundação para a Ciência e a Tecnologia, Contract N.º MIT-PT/AP/0015/2006, 2006/2011</p> <p>Fundação para a Ciência e a Tecnologia, Contract N.º MIT-Pt/SES-SUES/0037/2008, 2009/2012</p> <p>Fundação para a Ciência e a Tecnologia; Acordo MIT-Coordenação, 2008, 2008/2011</p> <p>EDP - Electricidade de Portugal, SA., Contract W/N, 2009/2011</p> <p>REN, FCT, Valorpneu; Sogilub, AMB3E; Conferência ISIE 2009, 2009 2009/2009 (...)</p>	

Objectives & Achievements	
Objectives	
<p>The objective is to undertake multidisciplinary research aiming at developing and evaluating emerging and alternative complex engineering systems promoting sustainability, namely in terms of the needs to secure socio-economic development and the quality of the environment, creating a more prosperous and sustainable society. Enabling technologies will be developed and assessed under a systems view, comprising the use and environmental implications of materials, energy, and products in modern societies. To achieve these objectives, research and development activities include the analysis of advanced systems, but also the analysis of the global carbon bio-geochemical cycle and of material flows in the economy, including product and material life cycle management through reuse, remanufacturing, and recycling.</p> <p>Main research areas include:</p> <ul style="list-style-type: none"> - Development of fundamental sustainability theory, linking thermodynamics, ecology and economics. - Environmental modelling- Carbon cycle - Eco-design for sustainability in industrial, domestic and agricultural applications - Total life-cycle energy chain and environmental impact assessment - Develop new models for Urban climate - Economic tools in environmental and sustainability assessment - Flows of materials in the economy from raw-materials extraction to final integration in the natural environment - Techno-economic assessment, technological change and systems integration. 	

Main Achievements	
<p>The activities developed within this topic were multidisciplinary, linking basic and applied research to technology development, and focused on the issues of sustainability, namely in terms of the needs to secure the quality of the environment, together with the management of energy resources and economic development. In this context, the Laboratory of Environmental Systems has been able to:</p> <ul style="list-style-type: none"> - Develop major experiments that contribute to demonstrate the feasibility of including natural fibers in composites for major product components, such as the automobile. - Support entrepreneurial initiatives in Industrial Ecology in Portugal, such as the design of a variety of new models to promote industrial symbiosis. - Develop new holistic models to promote a better understanding of urban regions metabolism to facilitate the penetration of renewable energies. - Develop new methods, practices and tools to increase the efficiency of energy systems 	

Group Productivity	
Publications in peer review Journals	

Group Productivity

- S. Luz, A. Caldeira-Pires and P. Ferrão. (2009) "Sugarcane bagasse fibers instead talc as reinforcement in polypropylene composites: An Ecodesign strategy for automotive components". Resources, Conservation and Recycling.
- S. Niza, L. Rosado and P. Ferrão. (2009) "Urban Metabolism: Methodological advances in Urban Material Flow Accounting based on the Lisbon case study". Journal of Industrial Ecology, 13 (3) pp. 384-405.
- M J.N.O. Panão, H. J. P. Gonçalves and P. Ferrão. (2009) "Numerical analysis of the street canyon thermal conductance to improve urban design and climate". Building and Environment, 44, (1), pp. 177-187.
- P. Ferrão and J. Nhambiu. (2009) "A comparison between conventional LCA and Hybrid EIO-LCA: Analyzing crystal giftware contribution to global warming potential". Handbook of Input-Output Economics in Industrial Ecology, pp. 219- 230. Edited by Sangwon Suh. Springer. ISBN 978-1-4020-4083-2.
- C. Alves, P. Ferrão, M. Freitas, A. J. Silva, S. M. Luz, D. E. Alves. (2009) "Sustainable Design Procedure: the role of composite materials to combine mechanical and environmental features for agricultural machines". Materials and Design, 30, (10), pp. 4060-4068.
- DOI: 10.1016/j.matdes.2009.05.015.
- A. L. Leão, P. Ferrão and S. F. Souza. (2009) "State of the art for extrusion and injection molding FPC: natural Fibre Plastics Composites in Brazil" Int. J. Materials and Product Technology, 36, (1-4), pp. 134-154.
- F. Sim Sim, D. Livengood, C. S. Ioakimidis, R. Larson. (2009) "Responsive Demand in Isolated Energy Systems" WIT Transactions on the Ecology and the Environment (ISSN:1743-3541), International Journal of Sustainable Development and Planning.
- J. Borges, C. S. Ioakimidis, P. Ferrão. (2009) "Fast charging stations for Electric Drive Vehicles infrastructure", WIT Transactions on the Ecology and the Environment (ISSN:1743-3541), International Journal of Sustainable Development and Planning.
- Böttcher, T., L. Huber, L. Corre, J. Leitner, D. McCarthy, R. Nilsson, C. Teixeira, S. Araujo, R. Wilson, F. Adjali, M. Altenburg, G. Briani, P. Buchas, A. Postollec, T. Meier (2009). The HADES mission concept – astrobiological survey of Jupiter's icy moon Europa. International Journal of Astrobiology 8 (4) : 321–329, Cambridge University Press.
- Mota, R., T. Domingos, V. Martins (2009). Analysis of green net national income and genuine saving: Portugal 1991-2005, Ecological Economics (01.09.09: accepted subject to major revisions).
- Rodrigues, A., A. Balmford, P. Carey, V. Kapos, A. Manica, J. Scharlemann, R. Green (2009). Capturing the Many Dimensions of Threat: Comment on Salafsky et al., Conservation Biology, Volume 23, No. 2, 482–487.
- Rodrigues, A., R. Ewers, L. Parry, C. Souza, A. Veríssimo, A. Balmford (2009). Boom-and-Bust Development Patterns Across the Amazon Deforestation Frontier. Science 324, 1435 (2009).
- Sousa, T., G. Marques, T. Domingos (2009). Comment on "Energy Uptake and Allocation During Ontogeny". Science 325, 1206-b (2009).
- Vieira, R., T. Domingos, P. Canaveira, A. Simões (2009). Aggregation in LCA: Comparison of EcoIndicator95, Emergy, Ecological Footprint, Primary Energy Analysis and Economic Evaluation. Ecological Economics (considered with potential; in revision).

Other publications International

- S. Connors, E. Spang, C. Silva, C. S. Ioakimidis. (2009) Poster "Designing Pathways for a Sustainable World: At Scale, in Time, and for All", The Alliance for Global Sustainability (AGS) Annual Meeting 2009, Zurich, Switzerland, January 26-29, 2009.
- P. Kadurek, C. S. Ioakimidis and P. Ferrão. (2009) Oral Presentation "Electric Vehicles and their Impact to the Electric Grid in S. Miguel", Proceedings of International Conference on Power Engineering, Energy and Electrical Drives, (Paper 147), p. 49-54, Lisbon, Portugal March 18-20, 2009.
- P. Kadurek and C. S. Ioakimidis. (2009) Poster on "Electric Vehicles as a support for the electricity grid of São Miguel" on the 2nd Transatlantic Conference on Renewable Energy, São Miguel, Açores, Portugal, April 2-4, 2009.
- F. Sim-Sim, G. Mendes, R. Bernardo and C. S. Ioakimidis. (2009) Poster on "Conceptual Planning, Operation & Control of Intelligent μ Grids: Case implementation in the Azores Islands" 'on the 2nd Transatlantic Conference on Renewable Energy, São Miguel, Açores, Portugal, April 2-4, 2009.
- P. Kadurek, A. Pina, C. S. Ioakimidis and P. Ferrão. (2009) "Presentation 'São Miguel Island as a case study on a possible usage of Electric vehicle to store energy'", Proceedings of The 24th International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exhibition (EVS24 Towards Zero Emission), Stavanger, Norway, May 13-16, 2009.
- C. S. Ioakimidis, M. Águas, C. Silva and P. Ferrão. (2009), "Innovation days 2009– 4 as Jornadas de Inovação" Video Presentation, FIL, Lisbon, June 18-20, 2009.
- F. Amorim, A. Pina, C. S. Ioakimidis, C. Silva and P. Ferrão. (2009) Presentation "'Resource Management and Integration of a Sea Water Pumped-Storage System in the island of São Miguel", The 5th International Sustainable Industrial Ecology (ISIE2009), Lisbon, Portugal, June 21-24, 2009.
- C. S. Ioakimidis, A. Pina, C. Silva and P. Ferrão. (2009) Poster "The use of Biomass as an energy source in the energy mixture of a remote island and the sustainable resource management of the energy system" The 5th International Sustainable Industrial Ecology (ISIE2009), Lisbon, Portugal, June 21-24, 2009.
- C. Silva, C. S. Ioakimidis and P. Ferrão. (2009) Presentation "Green Islands: An Integrated socio-techno-economic framework towards the implementation of a sustainable energy system in the island of São Miguel Azores", The 5th International Sustainable Industrial Ecology (ISIE2009), Lisbon, Portugal, June 21-24, 2009.
- H. Gerbelova, (2009) "Carbon Capture and Storage Technology Implementation into the Portuguese Energy System", 2nd Best Poster Award, Proceedings 1st Annual Conference, Engineering for Better Jobs, Lisbon, 7th July, 2009.
- S. Casimiro. (2009) "Planning the Transfer of Early Stage Technologies to the Portuguese Energy System for Base-Load", Poster, Proceedings 1st Annual Conference, Engineering for Better Jobs, Lisbon, 7th July, 2009.
- G. Mendes. (2009) "Optimal configuration of a microgrid in an urban residential area in São Miguel, Azores", Poster, Proceedings 1st Annual Conference, Engineering for Better Jobs, Lisbon, 7th July, 2009.

Group Productivity

- J. Borges. (2009) "Electric Vehicles Infrastructure - Fast Charging Stations", Poster, Proceedings 1st Annual Conference, Engineering for Better Jobs, Lisbon, 7th July, 2009.
- J. Lucas. (2009) "Study the biomass potential in Azores to produce an alternative fuel for aviation", Poster, Proceedings 1st Annual Conference, Engineering for Better Jobs, Lisbon, 7th July, 2009.
- R. Bernardo. (2009) "Dealing with uncertainty in the operation, control and planning stages of μ Grids", Proceedings 1st Annual Conference, Engineering for Better Jobs, Lisbon, 7th July, 2009.
- C. S. Ioakimidis. (2009) Oral Presentation on the MIT-Portugal Workshop on the SES PhD Program Research Integration, University of Coimbra, Coimbra, Portugal, October 9-11, 2009
- C. S. Ioakimidis, C. Silva, P. Ferrão, S. Connors, E. Spang. (2009) White Paper on Preparation "Green Islands: Design and Implementation of a Sustainable Energy System of São Miguel and Flores: Part II – The Green Islands Research Landscape", 2009.
- C. S. Ioakimidis, H. Gerbelova, S. Casimiro, M. Melo, L. Gonçalves and P. Ferrão. (2009) White Paper on "Towards Pathways for the implementation of CCS in Portugal", Working report, (2009).
- Pinto, R. C., J. Patrício, J. Neto, T. Domingos, A. Baeta, Z. Teixeira, J. C. Marques (2009). Water uses and ecological costs evaluation: a DPSIR approach on the Mondego estuary, ECSA 45th meeting, Dublin, 30 August-04 September 2009, at <http://www.hull.ac.uk/iecs/ecsa/Documents/Emden%20Meeting/18%20Victor%20de%20Jonge%20&%20Rute%20Pinto%20ECSA%20Emden%202009.pdf>.
- Rodrigues, A., Pita, G., Mateus, A. Santos Pereira, J. (2009). Recovering of carbon fixation in a eucalyptus site after felling EGU General Assembly 2009, Vienna, 19-24 April 2009.
- Marques, A., R. Teixeira, A. Lorena, V. del Pino, Y. del Valle-Incán, J. Navalho, T. Domingos (2009). Sustainability Assessment of Traditional Solar Salt, Proceedings of the 2nd International Conference on the Ecological Importance of Solar Saltworks (CEISSA 2009), Merida, Yucatan, Mexico, 26 – 29 March 2009, In CEISSA2009: 88-97, (Sep 2009) . http://www.srcosmos.gr/srcosmos/generic_pagelet.aspx?pagelet=Article%20summary&pub_id=12063"
- Marques, G.M., A. Lorena, J. Magalhães, T. Sousa, S. A. L. M. Kooijman, T. Domingos (2009). Life Engine - Construction of a biological engine for videogames, ECAL 2009 - 10th European Conference on Artificial Life, Budapest, 13-16 September.
- Gonçalves, A., A. Serrenho, T. Domingos (2009), Economic development in cities: Stylized facts, European Colloquium Quantitative Theoretical Geography, 4-8 September 2009, Maynooth, Ireland
- Mota, R., T. Domingos, V. Martins (2009). Welfare measures and sustainability for Portugal, 1992 – 2004, 17th Annual Conference of the European Association of Environmental and Resource Economists, Amsterdam, 24-27 June 2009.
- Pereira, H., T. Domingos, L. Vicente, V. Proença (eds.) (2009). Ecosistemas e Bem-estar Humano. Livraria Escolar Editora, Lisboa.
- Aguiar, C., O. Rodrigues, J. Azevedo, T. Domingos (2009). Montanha (Cap. 09), In H. Pereira, T. Domingos, L. Vicente, L. & Proença, V. (eds.), Ecosistemas e Bem-estar Humano: Avaliação para Portugal do Millennium Ecosystem Assessment.
- Pereira, H., T. Domingos, V. Proença, L. Vicente, P. Rodrigues (2009), A Avaliação Sub-Global para Portugal (Cap. 02) In H. Pereira, T. Domingos, L. Vicente, L. & Proença, V. (eds.), Ecosistemas e Bem-estar Humano: Avaliação para Portugal do Millennium Ecosystem Assessment.
- Pereira, H., R. Mota, M. Ferreira, I. Gomes (2009), Cenários Socioecológicos para Portugal (Cap. 04), In H. Pereira, T. Domingos, L. Vicente, L. & Proença, V. (eds.), Ecosistemas e Bem-estar Humano: Avaliação para Portugal do Millennium Ecosystem Assessment.
- Rosas, C., R. Teixeira, A. Mendes, T. Valada, E. Sequeira, C. Teixeira, T. Domingos (2009). Agricultura (Cap 07).In H. Pereira, T. Domingos, L. Vicente, L. & Proença, V. (eds.), Ecosistemas e Bem-estar Humano: Avaliação para Portugal do Millennium Ecosystem Assessment.

Other publications National

- P. Ferrão. (2009) Ecologia Industrial: princípios e ferramentas" Coleção Ensino da Ciência e Tecnologia. IST-PRESS (422 páginas, 2000 exemplares). ISBN 978-972-8469-75-5.
- P. Ferrão, I. Costa. (2009) "Simbioses Industriais: Redes de Colaboração em Gestão de Recursos. Indústria e Ambiente, 55;
- P. Ferrão, M. Heitor (2009) "10 years of Innovation, Technology and Policy Research, IN+ 1998-2008", Publicação: IN+.

Master and Ph.D. thesis completed

- Afonso, A. (2009) "Ensaio de colectores solares térmicos pelo método quasi-dinâmico", Dissertação para obtenção de grau de Mestre em Engenharia Mecânica, IST, Lisboa.
- Severino, A. (2009) "Evaluation of the Waste from Electric and Electronic Equipment Managment in Portugal", Dissertação para obtenção de grau de Mestre em Engenharia de Concepção, IST, Lisboa.
- Ramalho, R. (2009) "Environmental Assessment of Power Systems: Integrating Life Cycle Assessment and Operational Requirements", Dissertação para obtenção de grau de Mestre em Engenharia do Ambiente, IST, Lisboa.
- Silva, Luís (2009) "Engineering Design: A importância da Inovação e do Desenvolvimento Integrado do produto num Cenário de Mobilidade Sustentável: Caso de Estudo da Bicicleta com Pilha de Combustível, baseado num Cluster como Cenário de Desenvolvimento Industrial", Dissertação para obtenção de grau de Mestre em Engenharia de Concepção , IST, Lisboa.
- Santos, P (2009) "Perfis de Desempenho do Design, da Engenharia e do Marketing no Desenvolvimento de Produto, Dissertação para obtenção de grau de Mestre em Engenharia de Concepção , IST, Lisboa.
- Rodrigues, M. J. (2009) "Building integrated photovoltaics (BiPV) technology diffusion into Portuguese urban áreas", Dissertação para obtenção de grau de Doutor em Engenharia Mecânica, IST, Lisboa.
- Lopes, C., 2009. Desenvolvimento de uma norma para certificação ambiental integrada de organizações e produtos no sector agro-florestal, Tese de Mestrado em Engenharia do Ambiente, IST, Lisboa.

Group Productivity

Quiroga, H. (2009). Validação dos fluxos atmosféricos de carbono por detecção remota. Dissertação para a obtenção do Grau de Mestre em Engenharia do Ambiente, IST, Lisboa.

Saião, M. (2009). Implementação de uma Central a Biomassa - Análise de Sustentabilidade Ambiental e Económica, Dissertação para obtenção do grau de Mestre em Engenharia do Ambiente, IST, Lisboa.

Organization of conferences

5th International Conference of the International Society for Industrial Ecology "Transition Toward Sustainability", Fundação Calouste Gulbenkian, 21 a 24 de Junho de 2009, 2009. <http://www.isie2009.com>

1st MIT Annual Conference "Engineering for Better Jobs", Centro Cultural de Belém, 7 de Julho de 2009, 2009. <http://www.mitportugal.org/conference09>

Industry contract research

Consulting services for the compensation of environmental impacts of printing and sending electricity invoices – contract with EDP – Energias de Portugal, S. A. (2009-2011).

Consulting services for the evaluation, reporting, reduction and compensation of emissions of greenhouse gases – contract with Chamartin Imobiliária and Sustentare, consultoria de sustentabilidade, Lda. (2008-2009).

Consulting services for the evaluation of sustainability of marine salt production - contract with Necton, S. A. (2008-2009).

Consulting services for the compensation of greenhouse gas emissions - contract with Ecoprogresso, S. A.

Internationalization

Participation in the European Research Group AquaDEB (www.ifremer.fr/aquadeb).

Government/Organization contract research

Services of continuous evaluation of the Rural Development Program for Continental Portugal – year of 2008 (Ministry of Agriculture).

Services of confirmation of the adequacy and accuracy of the calculations of proposed payments for the Territorial Integrated Intervention of Monchique, in the framework of the Rural Development Program for Continental Portugal (Ministry of Agriculture).

Future Research

Objectives

The future research activities will maintain the global objective of undertaking multidisciplinary research aiming at developing and evaluating emerging and alternative complex systems promoting sustainability, strengthening five major areas:

- 1) Fundamental Sustainability Theory
- 2) Industrial Ecology
- 3) Sustainable Energy Systems
- 4) Sustainable Agricultural Systems
- 5) Carbon Sinks in Natural Systems
- 6) Urban metabolism

The main objectives for the future development of these areas are as follows:

1) FUNDAMENTAL SUSTAINABILITY THEORY

Work on the development of the fundamental theoretical tools for sustainability will continue, thermodynamics (Gibbs-Tisza-Callen formalism, finite-time thermodynamics and non-equilibrium thermodynamics), ecology (based on DEB – Dynamic Energy and Mass Budgets theory) and economics (standard neo-classical microeconomics and behavioural economics).

Industrial Ecology will be developed to promote a holistic view of engineering systems which requires the development of a set of tools to bridge different scales, from site or product specific analysis to the whole economy and from the economic to the socio-environmental dimension, thus resulting in a multi-disciplinary set of analytical tools, the "Industrial ecology toolbox", whose development and extension will be a continuous goal for the future. These tools will be used to design and promote new policy instruments that may contribute to improve the environmental performance of products and services through their life-cycles, as well as more efficient Economic Metabolisms at different scales.

3) SUSTAINABLE ENERGY SYSTEMS

The future activities in this scientific domain are intended to promote leadership in sustainable energy systems, by promoting high level international scientific and industrial partnerships, with emphasis on:- Energy Planning Including Economics

This research area will build upon energy and environment values and economic domains, at the level of energy systems analysis and design. This will be based on a strong modelling framework capacity, including the analysis of the dynamics of energy demand (behavioural economics theory) and of local and regional renewable energy resources.

Future Research

4) SUSTAINABLE AGRICULTURAL SYSTEMS

Work on this area will continue the development of sustainability assessment in agriculture, and its application to public policy and farmer counselling.

5) CARBON SINKS IN NATURAL SYSTEMS

Work on carbon sinks in natural system will continue, analysing carbon dynamics in forests and grassland. This will be based on experimental work using carbon flux measurements (eddy-covariance) and direct measurements of carbon pools, and modelling work, using conventional models and DEB-based models.

6) Urban metabolism

Development of a spatially comprehensive and temporally broad physical accounting of resource consumption of urban centres, emphasising energy consumption in buildings and new and innovative solutions to promote the concept of "Sustainable Buildings".

Funding, source, dates

Fundação para a Ciência e a Tecnologia, Contract N.º PTDC/SEN-ENR/103044/2008, 2010/2014

Fundação para a Ciência e a Tecnologia, Contract N.º PTDC/SEN-ENR/108440/2008, 2010/2013

Algarve Energy Park, Contract Nº W/N, 2010, 2010/2010

Group Description	
Title of Research Group:	(RG-LVT-50009-3584) Laboratory of Thermofluids, Combustion and Energy Systems, at IN+ Center for Innovation, Technology and Policy Research
Principal Investigator:	Antonio Luis Nobre Moreira
Main Scientific Domain:	Engenharia Mecânica
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
	“15th International Symposium on Applications of Laser Techniques to Fluid Mechanics”, Projecto de financiamento próprio, Instituto Superior Técnico, 2009-2010.
	“Advanced Intermittent Spray Cooling Systems”, Projecto PTDC/EME-MFE/69459/2006, Instituto Superior Técnico, 2007-2010.

Objectives & Achievements	
Objectives	
	<p>The core goal of fundamental research is the innovation of new engineering concepts and is addressed as a driving force for new technologies. Fundamental research builds the scientific knowledge necessary to give function a sustainable and human-oriented form, thus harmonizing technology with the environment, at the same time that application studies chase the functionality of advanced technologies and their results (products and services) from a user perspective. In this context, research at the Laboratory of Thermofluids, Combustion and Energy Systems Design is aimed at improving knowledge in advanced fields of strategic technologies with emphasis on principles of thermodynamic transport phenomena. The final goal is to bring together multidisciplinary knowledge to develop new procedures and technologies, as well as to carry out research to gain the fundamental knowledge needed to solve new problems in the topic of system conversion energy.</p> <p>The work essential covers the system optimization of input/output of energy and pollutant, ranging from large scale units to micro-systems with special emphasis on lean burning processes (for NO_x control), ignition and instabilities aspects of flames, fundamentals of fluid atomization, enhanced heat transfer processes, and experimental and physical modelling of forest fire phenomena, covering interdisciplinary scientific fields, such as Thermal-fluid-dynamics, Combustion and Advanced Techniques for Flow Measurements, Control Engineering, Materials Engineering, Transport and Thermophysical Properties of Materials, Electronics and Microsystems.</p> <p>The activities are organized on the basis of projects which provide the necessary external funding, namely from national and international funding agencies and/or private companies from which research areas emerge.</p>

Main Achievements	
	<p>The work essential covered the system optimization of input/output of energy and pollutant, ranging from large scale units to more recently micro-systems with special emphasis on lean burning processes (for NO_x control), ignition and instabilities aspects of flames In general the main achievements can be resumed as</p> <ul style="list-style-type: none"> -International collaborative research – e.g. University of Lulea-Sweden, Institute of Physics and Mathematics-Russia, UCambridge, and a large consortium (over 50 institutions) -Organization of a thematic workshop -International collaboration at the student graduation level (Graduation-University of Lulea-sweden) -Research contracts with Industry on the special topics of Low NO_x burner, flame ignition process and flame noise analysis (2008/...)

Group Productivity	
Publications in peer review Journals	
	“Development of an empirical correlation to predict secondary atomization of impacting boiling droplets”, 2009. A. S. Moita and A. L. N. Moreira, Experiments in Fluids, Volume 47, Numbers 4-5, pp. 755-768.
	“Heat transfer correlation for intermittent spray impingement: a dynamic approach”, M. R. O. Panão and A.L.N. Moreira. International Journal of Thermal Sciences, Volume 48, Issue 10, October 2009, Pages 1853-1862.
	“Simultaneous PDA and wall heat flux measurements to develop a dynamic heat transfer correlation for fuel-spray impingement in port-fuel systems”, M. R. O. Panão, D.F. Durão and A. L. N. Moreira, 2009. International Review of Mechanical Engineering, Praise Worthy Prize, , vol. 3 (1).
	“Intermittent spray cooling: a new technology for controlling surface temperature”, M. R. O. Panão and A. L. N. Moreira. International Journal of Heat and Fluid Flow , 30 (2009) 117-130.

Other publications International	

Group Productivity

"Thermal-fluid assessment of multijet atomization for spray cooling applications", M. R. O. Panão, A. L. N. Moreira and D. F. G. Durão. 5th Conference on Sustainable Development of Energy, Water and Environment Systems, September 29 - October 3 2009, Dubrovnik, Croatia.

"Multijet spray characteristics for spray cooling", M. R. O. Panão, J. L. C. V. Rosa and A. L. N. Moreira, to be presented at the 11th International Conference on Liquid Atomization and Spray Systems, July 26-30 2009, Vail Colorado, USA.

"Evaluation of the cooling performance of individual droplets impinging onto heated targets", A. S. Moita, M. Morais, A. Spina and , A. L. N. Moreira, to be presented at the 11th International Conference on Liquid Atomization and Spray Systems, July 26-30 2009, Vail Colorado, USA.

Ventura, João, A Segurança e Higiene Ocupacionais no Combate aos Incêndios Florestais, SHO2009 - International Symposium on Occupational Safety and Hygiene, Portuguese Society of Occupational Safety and Hygiene (publ.), Guimarães, 2009, (ISBN 978-972-99504-5-2), pp. 409-412

Other publications National

Ferreira, I., J. Ventura, J. Coelho e M. Funenga, Gestão do Risco Industrial numa Central Termoelectrica de Ciclo Combinado, Riscos Industriais e Emergentes, C. Guedes Soares, C. Jacinto, A.P. Teixeira, P. Antão (Eds), Edições Salamandra, Lisboa, 2009, (ISBN 978-972-689-233-5), pp. 323-336.

Vasconcelos, J.C.G. e J. Ventura, Aplicação de uma Metodologia de Caracterização e Ordenação de Medidas de Segurança contra Incêndio a um Edifício Multifamiliar de Muito Grande Altura, Riscos Industriais e Emergentes, C. Guedes Soares, C. Jacinto, A.P. Teixeira, P. Antão (Eds), Edições Salamandra, Lisboa, 2009, (ISBN 978-972-689-233-5), pp. 675-692.

J.F.R. Fonseca Pereira J F R, and Mendes-Lopes J M C: "Desenvolvimento experimental e numérico de um sistema de admissão de geometria variável para motores de veículos automóveis", III Conferência Nacional em Mecânica dos Fluidos, Termodinâmica e Energia, Bragança, 2009

Mendes-Lopes J M C: "Motores de combustão interna – alguns princípios de funcionamento e desafios a vencer", in "Uma vida pela modernização dos Caminhos de Ferro Portugueses – homenagem a Francisco de Almeida e Castro", ed. Manuel Seabra Pereira, IST PRESS, Junho 2009

Master and Ph.D. thesis completed

- Análise termodinâmica de gotas multicomponentes incidentes em superfícies aquecidas, Ana Sofia Moita, Instituto Superior Técnico, DEM

- Experimental and Analytical Flame Transfer Functions of Multi-Perforated Plate Burners, Ivo Leitao, MeMec, IST

- EVALUATION OF THE EFFECTS OF THE "+100" JP-8 THERMAL STABILITY ENHANCER'S ON COMBUSTION REACTIONS AND CARBON DEPOSITS BELOW 290°C.", João Caetano, MAero, IST

- FLAME IGNITION – AN EXPERIMENTAL APPROACH IN SIMPLE SYSTEMS, Hugo Ramos, Memec, IST

- Experimental Study of Ignition in a Pilot Flame System, Ricardo Rato, MeMec, IST

- Vasconcelos, João, Método para estabelecimento de medidas de segurança contra incêndio, ordenadas em função da razão eficácia/custo, Master thesis on Environment, Health and Safety, Universidade dos Açores (supervisor: João Ventura)

Patents/propotypes

- Patent process pending N° 104185, "Método para a estimação do comportamento de espécies quimiluminiscentes em espectros de luz de chamas" Ferro, F. And Fernandes, E.C.

- Pedido de patente internacional: "Variable Geometry Air Intake System For Internal Combustion Engines" (submissão nº 30023, pedido nº PCT/IB2009/055641)

Organization of conferences

Workshop on Experimental Techniques for Combustion Diagnostics, Lisbon 21-24 April, 2009, Aether (MRTN-CT-2006-035713)

Industry contract research

- "Ignition", Research contract with Bosch- Thermotecnia, 2009

- "Low Nox" Research Contract with Bosch Thermotecnia, 2009

Internationalization

- "Aether" Aero-acoustical and thermo-acoustical coupling in energy processes", Marie Curie Program MRTN-CT-2006-035713

- Invited Keynote: "Combustion Instabilities with non-confined flames" ETC Seminar, Pitea/Sweden-2009

- Research on Thermoacoustic of Burning Biomass with University of Lulea-Sweden and Center ETC-Pitea/Sweden

Future Research

Objectives

- To address new cooling and surface micromachining technologies to tackle the challenge of dynamic power demands and achieve efficient thermal management with less energy, thereby paving the way for the next-generation of energy storage systems and intelligent power electronic devices.

The workplan foresees to drive technologic advances based on solutions to deal with the interdisciplinary issues raised by thermal management,

Future Research

including materials, manufacturing and packaging technologies. Namely, utilizing cutting-edge experimental and theoretical techniques, the group envisages a long-term fundamental and applied research in emerging areas of knowledge, including two-phase heat transfer at micro-scale, nano-structured surfaces, novel and innovative methods of advanced thermal management.

- Continued research on the thermodynamic transport phenomena, with special emphasis on thermoacoustic oscillations, of lean flames for low pollutant emission technology, and heat transfer phenomena should now be directed towards the micro systems of distributed energy systems (mini-micro flames and combustion chambers with application for example in fuel cells). The transfer of knowledge into these Microsystems is not a linear process, since fluid mechanic processes are changed, boundary conditions becomes of the same order of magnitude of the process itself and the size of the systems required a special adaptation of the laboratory non-intrusive techniques (specially based on light emission and sound waves) need to be made. The objective is to improve fundamental knowledge and establish/reinforce international collaborative work in these new areas while contributing to the Industry in these topics. In addition the topic of biomass combustion will continue to be addressed with a collaborative research with the Technical University of Luella/Sweden.

Funding, source, dates

" Desenvolvimento da técnica de quimiluminiscência para a detecção directa da composição de misturas de combustíveis em chamas laminares.

FCT- PDTC/EME/-MFE/68830/2006

"Chamas incidentes-modelação matemática e experimental do seu comportamento instável"

FCT-PDTC/EME-NFE/68829/2006

"Aether" Aero-acoustical and thermo-acoustical coupling in energy processes", Marie Curie Program MRTN-CT-2006-035713

- PTDC-EME-MFE_114264_2009, "Influence of biofuel composition and moisture air on spark ignition success of lean reactive mixtures", submitted

An innovative approach of integrated wildland fire management regulating the wildfire problem by the wise use of fire: solving the Fire Paradox - FP6-018505 (2006-2010)

"Ignition", Research contract with Bosch- Thermotecnica, 2009

"Low Nox" Research Contract with Bosch Thermotecnica, 2009

"Fundamental Studies on MULTIJET Spray Technology", Projecto PTDC/EME-MFE/099040/2008

Instituto Superior Técnico, 2010-2013.

"24th Annual Conference on Liquid Atomization and Spray Systems", Projecto de financiamento próprio, Instituto Superior Técnico, 2010-2011.

iTherM "Intelligent Thermal Management for efficient power electronics in electrical machines integration", Projecto STREP submetido ao FP7.

Group Description	
Title of Research Group:	(RG-LVT-50009-3585) Laboratory of Technology Policy and Management of Technology, at IN+ Center for Innovation, Technology and Policy Research
Principal Investigator:	Rui Miguel Loureiro Nobre Baptista
Main Scientific Domain:	Economia e Gestão
Group Host Institution:	Instituto Superior Técnico - Universidade Técnica de Lisboa

Funding, source, dates	
Funding, source, dates	
	<p>"CORPORATE R&D PRODUCTIVITY", 151460-2009 AO8-PT; EUROPEAN COMMISSION, 29/09/2009</p> <p>"CAPITAL HUMANO, CARREIRAS EMPREENDEDORAS E NOVAS EMPRESAS DE BASE TECNOLÓGICA", CMU-PT/ETECH/0036/2008; FCT, 01/04/2009</p> <p>"IECER – 2009" – FCT, 01/06/2008</p> <p>Universidades e Criação de Empresas", PTDC/ESC/71125/2006; FCT, 01/01/08</p> <p>"Diversificação", PTDC/GES/71174/2006; FCT, 01/09/07</p> <p>"Mudança Tecnológica e Inovação", CMU-PT/0014/2007; FCT, 01/07/07</p> <p>"Planos de Negócios IAPMEI"; IAPMEI, 07/11/06</p>

Objectives & Achievements	
Objectives	
	<p>The main objectives of the "Technology Policy and Management of Technology" Laboratory are:</p> <ul style="list-style-type: none"> - To develop and use advanced research methodologies for the analysis of techno-economic systems; - To promote the exchange of knowledge in advanced technologies and the management of technology and innovation for the optimization of industrial processes, as a way to promote competitive advantages at the corporate level; - To derive science and technology policies, and innovation and entrepreneurship strategies leading to socio-economic development. <p>The emphasis on innovation and entrepreneurship draws on recent conceptual approaches to economic growth in which the accumulation of knowledge and entrepreneurial activity are the fundamental driving forces behind growth. This fact is reflected in the trend in developed economies towards an increasing investment in advanced technology and the development of entrepreneurial capabilities. Concepts such as learning ability, creativity, and entrepreneurial human capital gain greater importance as guiding principles for the conduct of individuals, institutions, nations and regions. The research carried out focuses on a variety of issues surrounding the creation and diffusion of knowledge as well as of human capital capable of learning and developing commercial applications for that knowledge. These issues include:</p> <ul style="list-style-type: none"> - Systems and Policies for Knowledge Creation, Diffusion and Usage; - Higher Education Policy and Management; - The Learning Economy; - Technology and Economic Inequality; - The impact of Entrepreneurship on Regional and National Economic Development; - Innovation and Firm Productivity; - Technology Management and Collaborative Innovation; - Education, Human Capital and Entrepreneurship; - Globalization, Diversification and Technology Capacity in the Auto Parts Sector; - Mobilizing Information and Communication Technologies: Implications for Regional Development.

Main Achievements	
	<p>The development of competencies in the areas of entrepreneurship, and science, technology and innovation policy has been carried out successfully according to the following main lines of development:</p> <ol style="list-style-type: none"> i) The promotion of master degree programs in "Engineering Policy and Management of Technology" (from 1998) and in "Engineering Design" (from 2002), with the aims of training young engineering graduates in new areas of education, and promote new links with Portuguese companies; ii) The promotion of a new Ph.D. program in technological change and entrepreneurship (from 2007), developed jointly with Carnegie Mellon University (and leading to a dual degree by IST and CMU), with the aim of providing advanced training to young researchers, and developing international research projects

Objectives & Achievements

involving students and faculty across the Atlantic;

iii) Active participation by faculty and research students in international conferences and workshops, and the organization of the International Conferences on Technology Policy and Innovation, which were launched in July 1997 and are carried out in close collaboration with a number of leading research groups

worldwide.

iv) Activities promoting technology-based entrepreneurship through extra-mural programs of entrepreneurship education and new venture development, such as the VECTORE program, which has led to several technology-based start-ups.

The Laboratory has obtained funding for the development of research projects in a variety of fields related with its main objectives, including:

- Technological change and economic development;
- Education and Entrepreneurial Human Capital;
- Higher Education Policies;
- Universities and Technology-based Entrepreneurship;
- Innovation and Firm Productivity;
- Diversification and Entrepreneurial Entry by Small Firms.

Group Productivity

Publications in peer review Journals

Amaral, A.M., Baptista, R. e F. Lima (2009). "Serial Entrepreneurship: Impact of Human Capital on Time to Re-entry", *Small Business Economics*, Springer. Publicado Online, Setembro de 2009, DOI 10.1007/s11187-009-9232-4.

Baptista, R. e J. Mendonça (2009), "Proximity to Knowledge Sources and the Location of Knowledge Based Start-ups", *Annals of Regional Science*, Springer. Publicado Online, Fevereiro de 2009, DOI 10.1007/s00168-009-0289-4.

Baptista, R. e M. Karaöz (2009). "Turbulence in Growing and Declining Industries", *Small Business Economics*, Springer. Publicado Online, Agosto de 2009, DOI 10.1007/s11187-009-9226-2.

Maças Nunes, P.; Z. Serrasqueiro; and J. Leitão (2009). 'Companies Growth and Labor Productivity in SMEs: Empirical Evidence', *Actual Problems of Economics*: 92: 229-240 (indexed in ISI).

Other publications International

Amaral, A.M., Baptista, R. e F. Lima (2009), "Becoming an Ex-entrepreneur: the Sell-out or Dissolution Decision", em *Entrepreneurship and Growth in Local, Regional and National Economies*, David Smallbone, Hans Landström and Dylan Jones-Evans (eds.), Edward Elgar.

Baptista, R. e J. Leitão, Eds. (2009), *Public Policies for Fostering Entrepreneurship: Perspective*, Series: International Studies in Entrepreneurship, Vol. 22 Julho de 2009, ISBN: 978-1-4419-0248-1 Springer

Leitão, J. & R. Baptista (Eds.) (2009). *Public Policies for Fostering Entrepreneurship: A European Perspective*, Series: International Studies in Entrepreneurship, Vol. 22, Springer, July 2009, US. ISBN: 978-1-4419-0248-1.

Leitão, J. & J. Ferreira (2009). 'Entrepreneurship and ICT: A Comparative Analysis between Germany and Portugal', *International Journal of Entrepreneurship and Small Business*, 7(3): 324-346 (indexed in Scopus).

Leitão, J. & M. Franco (2009). 'Individual Entrepreneurship Capacity: A Human and Organizational Capital Approach', *International Journal of Entrepreneurship and Small Business*, Forthcoming (indexed in Scopus).

Leitão, J. & R. Baptista (2009). 'Inward FDI and ICT: Are They a Joint Technological Driver of Entrepreneurship?', *International Journal of Technology Transfer and Commercialization*, Forthcoming (indexed in ABI/Inform).

Mendonça, J., Baptista, R. e F. Lima (2009), "Creation of Higher Education Institutions and Firm Entry: a Policy Evaluation", em *Entrepreneurship and Growth in Local, Regional and National Economies*, David Smallbone, Hans Landström and Dylan Jones-Evans (eds.), Edward Elgar.

Preto, M.T., Baptista, R. e F. Lima (2009), *Switching from Paid Employment to Entrepreneurship: the Effect on Individuals' Earnings*", em *Entrepreneurship and Growth in Local, Regional and National Economies*, David Smallbone, Hans Landström and Dylan Jones-Evans (eds.), Edward Elgar.

Silva, M & J. Leitão (2009). 'Cooperation in Innovation Practices among Firms in Portugal: Do External Partners Stimulate Innovative Advances', *International Journal of Entrepreneurship and Small Business*, 7(4): 391-403 (indexed in Scopus).

Other publications National

Caetano, D. & J. Leitão (2009). 'Responsabilidade Social Corporativa dos Clubes de Futebol Espanhóis de Referência Internacional'. In Almeida, F.; A. Guimarães; M. Franco; e J. Leitão (Eds.), *Governança Estratégica: Fundamentos e Aplicações: Uma Visão Supraempresarial*, São Paulo, Brasil.

Rodrigues, F.; V. Souza; e J. Leitão (2009). 'Coopetição Estratégica de Marcas Globais: O Caso da Nike+iPod Sport Kit'. In Almeida, F.; A. Guimarães; M. Franco; e J. Leitão (Eds.), *Governança Estratégica: Fundamentos e Aplicações: Uma Visão Supraempresarial*, São Paulo, Brasil.

*Silva, M. & J. Leitão (2009). 'The role of University's networks in reinforcing the entrepreneurial innovation capability of Industrial SMEs', In Leitão, J. and R. Baptista (Eds.), *Public Policies for Fostering Entrepreneurship: A European Perspective*, Springer, Chapter 8: 151-161. ISBN: 978-1-4419-0248-1.

Master and Ph.D. thesis completed

Group Productivity

Daniela Santos (2009). "Human Capital of entrepreneurial teams in High-tech firms" Ms. Thesis, Universidade Técnica de Lisboa – Instituto Superior Técnico.

Joana Mendonça (2009). "The Impact of Knowledge Creation and Accessibility on Entrepreneurial Activities" PhD. Thesis, Universidade Técnica de Lisboa – Instituto Superior Técnico.

Miguel Torres Preto (2009). "Essays on the Impact of Entrepreneurship on Careers and Earnings" PhD. Thesis, Universidade Técnica de Lisboa – Instituto Superior Técnico.

Organization of conferences

VI IECER – Interdisciplinary European Conference on Entrepreneurship Research (<http://www.iecer.org/index.html>), Instituto Superior Técnico, 4-6 de Março, 2009.

Internationalization

[Collaborative publication, Research, Graduate Training Networks or other forms of participation of the Research Group at the international level.]

Future Research

Objectives

The Laboratory of Technology Policy and Management of Technology at IN+ plans to pursue the development of the main research lines it has established and solidified over the last few years. In particular, two principal lines of development are to be pursued:

i) The development of research in entrepreneurship, technological change and higher education, leading to new insights for practitioners and policy makers in science, technology, industry and higher education, and aiming to contribute to economic development, competitiveness and employment growth.

ii) The development of activities promoting technology commercialization and technology-based entrepreneurship in a university environment, through entrepreneurship and technology transfer training, and new venture development.

Concerning the first line of development, research in a variety of topics, using diverse methodologies, is to be pursued. Some of the topics to be addressed are the continuation of already successful research streams, while other represent new challenges:

- Systems and Policies for Knowledge Creation, Diffusion and Usage;
- Higher Education Policy and Management;
- The Learning Economy;
- The impact of Entrepreneurship on Regional and National Economic Development;
- Innovation and Firm Productivity;
- Technology Management and Collaborative Innovation;
- Education, Human Capital and Entrepreneurship;
- Spin-offs and the Pre-history of Entrepreneurs: analysis of specific forms of entrepreneurial human capital;
- The Post-history of Entrepreneurs: entrepreneurial experience and the internal labor markets of the firm;
- Universities and New Firm Creation: geographical proximity and technology-based entrepreneurship;
- Entrepreneurial Exit and Habitual Entrepreneurship.

Concerning the second line of development, the VECTORE program will remain a cornerstone of entrepreneurship training and new venture development in Lisbon, and new programs will be developed focusing on specific technologies in energy, the environment, ICTs, and bio-engineering.

Funding, source, dates

"GRUPO MINORITÁRIOS NO EMPREENDEDORISMO", PTDC/EGE-ECO/101493/2008; FCT, 01/02/2010

"TRANSFORMAÇÃO EM REDES ACADÉMICAS, ENSINO SUPERIOR E SOCIEDADE DO CONHECIMENTO", EUROHESC/0002/2008; FCT, 01/01/2010

"CORPORATE R&D PRODUCTIVITY", 151460-2009 AO8-PT; EUROPEAN COMMISSION, 29/09/2009

"CAPITAL HUMANO, CARREIRAS EMPREENDEDORAS E NOVAS EMPRESAS DE BASE TECNOLÓGICA", CMU-PT/ETECH/0036/2008; FCT, 01/04/2009

Universidades e Criação de Empresas", PTDC/ESC/71125/2006; FCT, 01/01/08

"Diversificação", PTDC/GES/71174/2006; FCT, 01/09/07

"Mudança Tecnológica e Inovação", CMU-PT/0014/2007; FCT, 01/07/07

Group Description	
Title of Research Group:	(RG-LVT-50009-3589) Centre of Mineral Resources, Mineralogy and Crystallography of the Faculty of Science of Lisbon University (CREMINER)
Principal Investigator:	Fernando José Arraiano de Sousa Barriga
Main Scientific Domain:	Ciências da Terra e do Espaço
Group Host Institution:	Fundação da Faculdade de Ciências - Faculdade de Ciências da Universidade de Lisboa

Funding, source, dates	
Funding, source, dates	
The main sources of funding for the RG (2009) have been provided by FCT, as i) Pluriannual and Programatic funding ii) 2009 - research projects FCT, Contracts with industry, extremely significant as achievements, were another source of funding.	

Objectives & Achievements	
Objectives	
<p>Given the continuing extremely high demand for natural resources, largely related to expansion of “sleeping giants” economies, Creminer continues devoted to research and development in Earth and Space Sciences related to geochemical systems and to the genesis, evolution and use of crustal resources, from land and the ocean floors, with emphasis in fluid-rock interaction processes and Mineralogy and Crystallography and their applications, including environmental management.</p> <p>Creminer is starting a new, large research effort in uranium deposits, related not only to the strategic character of this energy resource but also to the uranium mining impacts.</p> <p>Studying the sea floor continues dominant in Creminer. Among the infrastructures under the responsibility of Creminer there are the Stable Isotope Laboratory, AmbiTerra, and the Mobile Lab. We are progressively gaining access to ships equipped for earth science research, with multi-beam bathymetry, multi-channel seismics and specialised vehicles and samplers such as AUVs, ROV's and TV Grabs. Scientific subjects to be developed by Creminer in the next few years include i) Geology of the Deep Biosphere; ii) The Carbon Cycle and CO₂ Sequestration; iii) Geoarchaeology; iv) Uranium exploration and environmental issues. Our expertise in soil science and our ability to analyse low temperature rocks and soils for nutrients and pollutants shall contribute to find essential links between the deep biosphere and rock evolution, from soft sediments to hard rock. We are applying this expertise to studies in the Azores Sea and in the Arctic near 74°N. The Carbon Cycle and CO₂ Sequestration is self explanatory on the inevitability of widespread use of fossil fuels for decades to come. An efficient CO₂ sequestration will imply the confinement of CO₂ produced in large industrial facilities, the refinement of sequestration models and the identification of suitable geological formations in order to avoid an unbearable environmental cost.</p>	

Main Achievements	
<p>The group has achieved internationally recognized success with its studies on i) ore-forming processes on land; ii) submarine hydrothermal resources and the deep biosphere, and iii) experimental and geochemical modelling of low-temperature processes related with environmental impacts due to heavy metal contamination in landfills and old mining areas. The main components of these studies are mineralogy and geochemistry, including isotopic geochemistry. Combination of i) and ii) led to original proposals for the exploration for submarine massive sulphide deposits, ready to be tested in actual exploration campaigns.</p> <p>Creminer led the Portuguese part of a new consortium with Brazil, for environmental studies, Rede Luso-Brasileira de Remediação e Reabilitação de Ambientes Degradados (READE), created in 2009.</p> <p>Geoarchaeology and public outreach efforts have strengthened further. The latter in particular deserves much credit, largely related to the Centro Ciência Viva Mina de Ciência (Mine of Science Live Science Centre, part of the national network of science centres) already acclaimed as a landmark of capacity for the original production of scientific contents in hands-on exhibits.</p> <p>Concerning the new experimental facilities, the Stable Isotope lab is now installed, and AmbiTerra gained expertise and general recognition as a top quality laboratory for soils and sediments. These labs are beginning to perform analyses not only for Creminer's research but also in the framework of external contracts for applied studies and surveys.</p>	

Group Productivity	
Publications in peer review Journals	
<ul style="list-style-type: none"> •Rosa D., Finch, A., Andersen T., e Inverno C., 2009, “U-Pb geochronology and Hf isotope ratios of magmatic zircons from the Iberian Pyrite Belt”, <i>Mineralogy & Petrology</i>, 95, 47-69. •Reiser F., Rodrigues C, Rosa D., 2009, “High-technology elements for thin-film photovoltaic applications: A demand-supply outlook on the basis of current energy and PV market growths scenarios”, <i>Proceedings of the 5th Thin-film Photovoltaics User Forum, Würzburg, Alemanha.</i> •Reiser F, Rosa D, Pinto A, Carvalho J, Matos J, Guimarães F, Alves L e Oliveira D, 2009, “Preliminary mineralogical results on tin- and germanium-rich chalcopyrite from the Barrigão Remobilised Vein Deposit, Iberian Pyrite Belt, Portugal”, <i>Annual Meeting of the German Mineralogical Society, Halle/Germany, September 13-17. Abstract, Hallesches Jahrbuch für Geowissenschaften 31, p. 201.</i> 	

Group Productivity

- Ribeiro A., Munhá J., Fonseca P.E., Araújo A., Pedro J.C., Mateus A., Tassinari C., Machado G., Jesus A. (2010). Variscan Ophiolite Belts in the Ossa-Morena Zone (Southwest Iberia): geological characterization and geodynamic significance. *Gondwana Research* 17, 408-421
 - FONSECA, R., BARRIGA, F.J.A.S., CONCEIÇÃO, P. (2009) – Clay minerals in sediments of Portuguese reservoirs and their significance as weathering products from over-eroded soils. Comparative study of the Maranhão, Monte Novo and Divor Reservoirs (South Portugal). *International Journal of Earth Sciences*, DOI: 10.1007/s00531-009-0488-3
 - THEODORO, S.H.; LEONARDOS, O.H.; ROCHA, E. ; MACEDO, I.; FONSECA, R. (in press) - Geochemistry of sediments, soil remineralization and agroforestry in Amazon: the way toward the reintegration of the natural sciences. *Scielo, Revista da Academia Brasileira de Ciências*. RJ
 - Azevêdo, T. M. and Gonçalves, M.A. (2009). Geochemistry of core sediments from the Middle Tagus alluvial plain (Portugal) since the last glacial: using background determination methods to outline environmental changes. *Environmental Earth Sciences*, DOI: 10.1007/s12665-009-0016-6.
 - Kriaa, A., Hamdi, N., Gonçalves, M.A. and Srasra, E. (2009). Acid-base Properties of Tunisian Glauconite in Aqueous Suspensions. *International Journal of Electrochemical Science*, 4: 535-550.
 - Figueiras, J., Gonçalves, M.A., Mateus, A., Marques, F. O., Monteiro Santos, F. e Mota, R. (2009). Initial stages of pollutants dispersion around municipal waste disposal facilities; a case study in northern Portugal. *International Journal of Environment and Waste Management*, 4 (3/4): 341-365.
 - Dias, Á. S., Früh-Green, G. L., Bernasconi, S. M., Barriga, F. J. A. S. and Seahma and Charles Darwin 167 cruise teams (accepted) Geochemistry and stable isotope constraints on high temperature activity from sediment cores of the Saldanha hydrothermal field. *Marine Geology*
 - Dias, Á. S., Mills, R. A., Ribeiro da Costa, I., Costa, R., Taylor R. N., Cooper, M. J. and Barriga, F. J. A. S. (accepted) Tracing fluid-rock reaction and hydrothermal circulation at the Saldanha hydrothermal field. *Chemical Geology*
 - Searle R., B. Murton and the JC24 Shipboard Scientific Party (Kay Achenbach, P.L. Ferreira , Tim LeBas, Chris Mallows, Kirsty Morris, Nicole Schroth, Maurice Tivey , Peter van Calsteren , Chris Waters and Isobel Yeo) (2009). Structure and development of the axial volcanic ridge: cruise JC24 to the Mid-Atlantic Ridge, 45°N. *InterRidge News*, vol. 17, 11-15
 - R.C. Searle, B. J. Murton, K. Achenbach, T. LeBas, M. Tivey, I. Yeo, M. Cormier, J. Carlut, P. Ferreira, C. Mallows, K. Morris, N. Shroth, P. van Calsteren, C. Waters Structure of an Axial Volcanic Ridge: Mid-Atlantic Ridge, 45°N. *Submetido à Earth and Planetary Science Letters*.
 - Neiva, A.M., Williams, I.S., Ramos J.M., Gomes, M.E., Silva , M.M.V.G., Antunes, I.M.H.R., (2009) Geochemical and isotopic constraints on the petrogenesis of early Ordovician granodiorite and Variscan two mica granites from Gouveia area central Portugal *Lithos* 11, págs 186 a 202.
- Marques AFA, Scott SD, Gorton M, Barriga, FJAS, Fouquet, Y. Pre-eruption history of enriched MORB basalts from the Lucky Strike and Menez Gwen areas, Mid-Atlantic Ridge (37°50'N). *Lithos* 112(1-2):18-38 (A volume in tribute to Roger Hekinian) 10.1016/j.lithos. 2009.05.026
- InterRidge, 2009. Working Group on Seafloor Mineralization Meeting Report,
http://www.interridge.org/files/interridge/SMWG_meeting_report_2009_final_rev.pdf in press (includes Fernando JAS Barriga)
- Relvas, JMRS, Povoas, L, Costa, T, Matos, J, Varela, T, Lopes, C, Barriga, FJAS, 2009. Project "Underground Visit to the Lousal Mine": rehabilitation of a closed mine in the Iberian Pyrite Belt towards sustainable development and preservation of mining heritage. *PROGEO Special Volume* (in press).

Other publications International

- FONSECA, R., BARRIGA, F.J.A.S., CANÁRIO, T., THEODORO, S. (2009) – Mineralogy and geochemistry of Brazilian reservoir sediments: an approach to the green revolution in tropical environments. In: P. Van Straaten & N. Oram (Eds.) -Proceedings of the Second International Rocks for Crops Conference, Nairobi e Kisumu, Kenya, pp.171-198.
 - LEONARDOS, O.H.; THEODORO, S.; OLIVEIRA, D.; FONSECA, R. & BARRIGA, F.J.A.S. (2009) - Nutrient assessment of dam sediments in the Amazon for using in local subsistence agriculture: the case of Tucuruí. In: P. Van Straaten & N. Oram (Eds.) -Proceedings of the Second International Rocks for Crops Conference, Nairobi and Kisumu, Kenya, pp.199-223.
 - MORAIS M. M., PEDRO A., RANGEL, M., FONSECA, R., BARRIGA, F. & THEODORO, S., (2009). The Use of Discriminant Analysis to Detect Functional Differences in Two Large Reservoirs in Brazil (Três Marias, São Francisco and Tucuruí, Amazon). In "Sustainable Development: Energy, Environment and natural Disasters". Laura M. G. Duarte & Paulo Pinto (eds.). Fundação Luis de Molina, Évora: 51-67.
- Barriga FJAS, JMRS Relvas, AMS Pascoal, 2009. Some Thoughts on the Future of Exploration for Massive Sulfide Deposits in the Azores Sea. *Deep-Sea Mining of Seafloor Massive Sulfides: A Reality for Science and Society in the 21st Century Science and Policy Workshop*, April 1-2, 2009, Woods Hole, Massachusetts, USA
- Gerbelová H, S Casimiro , C Ioakimidis, M Melo, F Barriga, P Ferrão, in press. Assessment for Carbon Capture and Storage Opportunities: Portuguese Case Study. *GHGT-10 - 10th International Conference on Greenhouse Gas Control Technologies*, Amsterdam, September 2010

Other publications National

- Mateus A., Munhá J., Inverno C., Matos J.X., Martins L., Oliveira D.P.S., Jesus A., Salgueiro R. - Mineralizações no sector português da Zona de Ossa-Morena. "Geologia de Portugal no Contexto da Ibéria", 2ª edição (in press)
- Mateus A., Munhá J., Jesus A. (2008). Mineralizações associadas à sequência gabroica do Complexo Ígneo de Beja. "Ciências Geológicas – Ensino, Investigação e sua História", Vol. II (Geologia Aplicada, Geologia e Recursos Geológicos). (in press)
- Piçarra, JM; Dias, RP; Ribeiro, ML; Solá, R. Barbosa, B; Pais, J e colaboração de Martins, S; Azeredo, A; Cabral, MC; Pimentel, N; Araújo, A; de Oliveira, D; Lisboa, V; Midões, C e Ribeiro; A. 2009. Notícia explicativa da Folha 32-C AVIS. *Laboratório Nacional de Energia e Geologia*, 50 p.
- Carvalho, J. e Gaspar, M. (2009), Breve nota sobre as mineralizações de cobre de vila velha de ródão e o seu interesse arqueomineiro. *Açafa Online* (2) :http://www.altotejo.org/acafa/docsN2/As_Mineralizacoes_de_cobre_de_Vila_Velha_de_Rodao.pdf
- Neiva, A.M.R., Ramos, J.M., (2009) – Petrogenetic links of granite aplite pegmatite sills from Gonçalo wih granites from the Guarda- Belmonte

Group Productivity

area central Portugal. Estudos geológicos V.,19 (2) , págs 251 a 255.

•Lima, S.S.M., Neiva, A.M.R., Ramos, J.M., (2009) geochemistry of garnets from tonalite and granitic aplite pegmatite veins from Caborro – Aldeia da Serra OssaMorena Zone Southern Portugal. Estudos Geológicos v.19, págs 193 a 197.

Barriga F.J.A.S., 2009. Geologia, pp 95-105. In: Monteiro S., ed, Sei Quem Sabe, Fundação Odemira, 175 p

Barriga F.J.A.S., 2009. The Chemistry of Minerals: Revamping historical techniques for educational purposes at the National Museum of Natural History in Lisbon. In: MC Lourenço, A Carneiro, eds, 'Spaces and Collections in the History of Science: The Laboratorio Chimico Overture', pp 256-268. Museum of Science of the University of Lisbon, ISBN: 978-972-98709-6-5

Barriga F.J.A.S., RS Santos (in press). Recursos minerais marinhos, metálicos, não metálicos e energéticos: potencial e impactos ambientais. Vol. Esp. Academia das Ciências de Lisboa

Reis J., Brilha J., Barriga F., Lopes C., Póvoas L. (2009) – O Museu Nacional de História Natural como promotor do património geológico: caracterização preliminar dos visitantes do Departamento de Mineralogia e Geologia. In Brandão J.M., Callapez P.M., Mateus O. and Castro P., International Conference on Geological Collections and Museums. Journal of Palaeontological Techniques, No. 6, p.30.

Brilha J., Barriga F., Cachão M., Couto M.H., Dias R., Henriques M.H., Kullberg J.C., Medina J., Moura D., Nunes J.C., Pereira D.I., Pereira P., Prada S., Sá A. (2009) – Implementação de contextos geológicos para a inventariação do património geológico português. Resúmenes de la VIII Reunión de la Comisión de Patrimonio Geológico de la Sociedad Geológica de España, Daroca, p. 11.

Master and Ph.D. thesis completed

Ph.D. Thesis completed 2009 - Agata Dias - Orientador - Prof. Doutor Fernando Barriga

Geochemistry of deep-sea hydrothermal sediments from the Saldanha and Lucky Strike hydrothermal fields (Mid-Atlantic Ridge)

Ph.D. Thesis completed 2009 - Raul Jorge - Orientador - Prof. Doutor Jorge Relvas

“Caracterização petrográfica, geoquímica e isotópica dos reservatórios metalíferos crustais, dos processos de extracção de metais e dos fluidos hidrotermais em sistemas mineralizantes híbridos na Faixa Piritosa Ibérica”

Industry contract research

•Colaboração na Preparação dos PDMs de Braga, Fafe, Famalicão, Amarante, Sabugal, Paredes, Valongo

•Colaboração no parecer sobre os traçados alternativos do TGV entre Braga e Valença

.Colaboração com a SOMINCOR

•MAEPA: avaliação do potencial em platinídeos associados às ocorrências de cromite nos Maciço de Bragança

Internationalization

•Projecto da European Science Foundation (programa EuroMARC), “Ultraslow spreading and hydrogen-based deep biosphere: a site survey proposal for zero-age drilling of the Knipovich Ridge”. Individual Project (Portuguese team): Sulfide Petrology, Ore Genesis and the Deep Biosphere at Knipovich Ridge

•Coordenador do INETI do projecto “PROMINE – Nano-particle products from new mineral resources in Europe”.

•Projecto do CODES

•Representante Português no “InterRidge Steering Committee” International Cooperation in Ridge-Crest Studies

. Representante português no IODP

. Representante e Chair do ECCORD 2009

•Investigadora Portuguesa Responsável pela Rede Luso-Brasileira de Remediação e Reabilitação de Ambientes Degradados (READE)

•Rede Luso Brasileira de Estudos Ambientais.

•Rocks for Crops Association – IRCA

•Beralt Tin & Wolfram (Portugal), acções de prospecção e pesquisa nas Minas de Sn-Li da Argemela (Fundão).

Government/Organization contract research

H2Deep – EuroMarc /0001/2007,•Projecto do CODESPTDC/CTE-GEX/82678/2006, “Study of the adsorption mechanisms and kinetics in geomaterials and their structural characterisation: implications for processes of natural attenuation of heavy metal contamination and radioactive wastes confinement – KADRWaste”•Project coordinator of the Portuguese team of the Portugal-Tunisia cooperation project, with the Centre de Matériaux of the Technopole Borj Cédria in Tunis, funded by FCT and the Tunisian Ministry of Science. Project ended in 2009

•Member of the team of the project PTDC/EME-MFE/70767/2006 “Strategies for Zero Emission Fossil Fuel Energy in Portugal”.

•Estratégias de Conservação e Reabilitação de Rios Temporários: Caso de estudo da bacia do rio Pardiel, Sul de Portugal (Bacia do Guadiana). PTDC/AMB/73338/2006. 2008-2010•Avaliação e Gestão do Assoreamento de Reservatórios (Três Marias/MG). Edital FINEP 01/2008 - Chamada Publica MCT/FINEP - CT-ENERGIA ELÉTRICA•Projecto Metabronze-Metalurgia e Sociedade no Bronze Final do Centro de Portugal (POCI/HAR /58678/2004)• Participação “Schistresource” coordenado pela Faculdade de Ciências do Porto

•Colaboração no projecto “Magmatismo hidrotermalismo e mineralizações associadas da zona oriental do maciço hercínico Marroquino

•Monografia das mineralizações do Norte de Portugal •Estudo das 26 pedras ornamentais granitos calcários mármores gabros Portuguesas,

Group Productivity

Brasileiras, Venezuelanas, Espanholas, Finlandesas Chinesas, Egípcias do Irão etc. • Colaboração nos trabalhos de Conclusão do PROT NORTE

Future Research

Objectives

We are preparing a suitable proposal for the newly announced program of research in natural resources in the sea floor areas presently under Portuguese jurisdiction, beyond the 200 mile limit. This will focus on seafloor massive sulphide deposits, and will consist on selection of favourable areas based on geology (including submarine volcanology) and geomorphology, followed by geophysical, geochemical and mineralogical exploration surveys, partly conducted in submersibles. The best targets will be proposed for drilling, both shallow and deep drilling (IODP).

Uranium research will focus in two main areas: i) exploration tools for use in the Nisa region; ii) Geochemistry and mineralogy applied to environmental studies for installation of a biorreactor for treatment of contaminated waters in the Urgeiriça area.

Outreach activities will continue to develop, especially with development of the second phase of the musealisation of Lousal, with "Underground Visit to the Lousal Mine", a new project funded by QREN and a network of funding entities, to a total of nearly 10M€. Creminer will collaborate with Museu Nacional de Historia Natural largely in supplying geological contents to the project.

Funding, source, dates

Projects funded

PTDC/GIN/67027/2006 INCA 01-09-2007 FCT Diogo Rosa

PTDC/ENR/70767/2006 ZeroEm 21-12-2007 FCT P Ferrão/F Barriga

EUROMARC/0001/2007 H2Deep 01-09-2007 FCT F Barriga

SOMINCOR MinMetAp 2009 F Barriga/ J Relvas

LOUSAL - Foundation Frederic Velge Underground Visit to the Mine 2010-2011 Funding under discussion Jorge Relvas/F Barriga

Projects under evaluation

PTDC/BIA-ECS/111085/2009 DECON8 Mário Abel Gonçalves

PTDC/HIS-ARQ/111376/2009 MetalMatch Luis Gaspar

PTDC/MAR/111306/2009 Terific Ana Filipa Marques

PTDC/CTE-GIX/116204/2009 METMOB Isabel Costa

PTDC/CTE-GIX/114208/2009 ZHINC_Proposal Jorge Relvas

Group Description	
Title of Research Group:	(RL-EEI-LA09-133) Robotic Monitoring and Surveillance
Principal Investigator:	Jose Alberto Rosado Santos Victor
Main Scientific Domain:	Engenharia Electrotécnica e Informática
Objectives & Achievements	
General Objectives	
<p>We develop new methods, algorithms and systems for robotic monitoring & surveillance by autonomous, heterogeneous sensor and robot networks and demonstrate their use in realistic applications.</p> <p>Such networks can meet the sampling and/or dynamic specifications required by the observed phenomena, e.g. human activity monitoring and classification. Each node can act and reconfigure the network to improve perception and uncertainty, interact with humans or (re-)establish communication links. Extended (autonomous) unsupervised operation requires de-centralized decision-making.</p> <p>We consider 3 hierarchical levels:</p> <ul style="list-style-type: none"> - Single/cooperative robot navigation, formation control & decentralized decision making under uncertainty - Vision-based activity recognition and cooperative perception in heterogeneous camera/robot networks. - Development of cognitive robot assistants (network nodes) able to interact socially with humans <p>As we conduct multidisciplinary research that touches biology, neuroscience, psychology, medicine or social sciences, we nurture the emergent area of biologically inspired systems and bioengineering.</p>	
Main Achievements	
<p>Our research activities are structured according to 3 general application areas of public interest illustrating different hierarchical levels. The achievements include theoretical contributions and application-relevant results, developed in the context of large-scale international collaborative efforts.</p> <p>General achievements</p> <ul style="list-style-type: none"> - Involvement in large scale EU Projects (URUS, ROBOTCUB and ITER). - Efforts to coordinate the contributions to FCT and EU project proposal calls. - High level of internationalization and aggressive involvement in applications to international (mainly EU) projects. - Multidisciplinary research conducted with experts in the areas of neuroscience, biology, psychology, medicine and social sciences. <p>(i) Search and rescue, field and urban robotics:</p> <ul style="list-style-type: none"> - (Muti-)robot task plan representation using discrete event systems - Decision-theoretic approach to decentralized planning under uncertainty; - Key contributions to EU Project URUS in cooperative navigation, control and perception - Social sciences inspired approaches to collective robotics (Institutional Robotics) - Development of middleware for multi-robot systems and build-up of an experimental testbed for networked robot systems (ISRobotNet) - New FCT project on indoor/outdoor cooperative perception and formation control - <p>(ii) Surveillance of urban areas:</p> <ul style="list-style-type: none"> - Methodologies for recognizing human activity from video with learning capability - Calibration of distributed cameras with different geometries - Probabilistic models of sensor measurements, localization and active cooperative perception using POMDPs <p>(iii) Cognitive robotic assistant:</p> <ul style="list-style-type: none"> - Biologically plausible models for object affordances including verbal descriptions - Model for (top-down and bottom up) attention in humanoid robots - Model for social learning mechanisms - Installation of the iCub robot in Vislab@ISR. - Tracking and software developments with the iCub <p>Biologically inspired methods and biomedical engineering</p> <ul style="list-style-type: none"> - 3D reconstruction of carotid arteries and plaque 	

Objectives & Achievements

- 5 M.Sc. theses completed
- Two national patents approved
- Strengthened collaboration with IMM, St. Mary Hospital and Instituto Gulbenkian de Ciência
- Two new FCT projects approved

Research Line Output

Collaborative Publications in peer review Journals

The research work carried by some of the groups involved in this thematic area is highly multidisciplinary, routinely involving teams from engineering and computer science, neuroscience, psychology, linguistics or social sciences. We have listed some of these works to express this multidisciplinary component. They are clearly separated from those that result from the collaboration of different groups.

JOURNAL PUBLICATIONS INVOLVING DIFFERENT GROUPS

- Tracking objects with generic calibrated sensors: an algorithm based on color and 3D shape features, M. Taiana, J. Santos, J. Gaspar, J. Nascimento, A. Bernardino, P. Lima, Robotics and Autonomous Systems, in press. [VisLab + ISLab]

OTHER MULTIDISCIPLINARY JOURNAL PUBLICATIONS (with external authors)

- Seabra, José C.R.; Pedro, L. Mendes.; Fernandes e Fernandes, J.; Sanches, João M, A 3-D Ultrasound-Based Framework to Characterize the Echo Morphology of Carotid Plaques, IEEE Transactions on Biomedical Engineering, Volume 56, Issue 5, May 2009 Page(s):1442 - 1453.
- A Computational Model of Social-Learning Mechanisms, Manuel Lopes, Francisco S. Melo, Ben Kenward and Jose Santos-Victor. Adaptive Behaviour, 17(6), pp467-483, 2009.
- M. Silveira, S. Heleno, Separation between Water and Land using Region Based Level Sets, IEEE Geoscience and Rem. Sensing Letters, V6(3), 2009.

Collaborative Other Publications

International publications (different groups)

- "ISRobotNet: A Testbed for Sensor and Robot Network Systems", M. Barbosa, A. Bernardino, D. Figueira, J.Gaspar, N. Gonçalves, P.Lima, A.Pahliani, J.Santos-Victor, M. Spaan, J. Sequeira, Proc. IROS, St. Louis, MO, USA, 2009 [ISLab + VisLab + MRLab]
- "Multi-agent Sequential Decision Making in Uncertain Domains", M. Spaan, N. Gonçalves, J. Sequeira, Proc. of AAMAS Workshop on Multi-agent Sequential Decision-Making in Uncertain Domains, Budapest, Hungary, 2009. [ISLab + MRLab]
- "From Pixels to Objects: Enabling a spatial model for humanoid social robots", Dario Figueira, Manuel Lopes, Rodrigo Ventura, Jonas Ruesch, Proc. of ICRA , Kobe, Japan, 2009 [VisLab+ISLab]
- Towards a spatial model for humanoid social robots", D.Figueira, M. Lopes, R.Ventura, and J. Ruesch, In Progress in Artificial Intelligence (EPIA), Vol.LNAI 5816, pp 287–298. Springer, 2009. [VisLab + ISLab]

National

- A.Khmelniskii, R. Ventura and J. Sanches, Chromosome Pairing Using Mutual Information in Bone Marrow Cells, 15th Portuguese Conf. Pattern Recognition (RecPad), Aveiro, Portugal, 2009. [ISLab, SPLab]
- D.Vicente, J.C. Nascimento, J. Gaspar, Assessing Control Modalities Designed for Pan-Tilt Surveillance Cameras, 15th Portuguese Conf. Pattern Recognition (RecPad), Aveiro, Portugal, 2009. [VisLab+SPLab]

Multidisciplinary Pubs (w/ external authors)

- Pedro Pires, Teresa Paiva (MD) and João Sanches, Sleep/Wakefulness state from actigraphy, 4th IBPRIA, Póvoa de Varzim, Portugal, June 2009.
- E.Hudlicka, S. Payr, R.Ventura, C. Becker-Asano, K.Fischer, I. Leite, A. Paiva, and C. von Scheve, "Social interaction with robots and agents: Where do we stand, where do we go?", Proc. of 2009 Intl Conf Affective Computing & Intelligent Interaction (ACII), 2009.
- A.Ortega, B.Dias, E.Teniente, A. Bernardino, J.Gaspar and J. Andrade-Cetto, Calibrating an Outdoor Distributed Camera Network using Laser Range Finder Data, IROS, St.Louis, USA, 2009.
- J. Hörnstein, L. Gustavsson, F. Lacerda, J. Santos-Victor, Multimodal Word Learning from Infant Directed Speech, IROS, St. Louis, USA, 2009.
- M. Lopes, A. Bernardino, J. Santos-Victor, C. von Hofsten, K. Rosander. Biomimetic Eye-Neck Coordination. IEEE ICDL, Shanghai, China, 2009.

Master and PhD thesis completed

COMPLETED THESES

- Diogo Vicente, "Event Detection with Pan-Tilt Cameras", M.Sc. Thesis, Instituto Superior Técnico, Outubro 2009. [VisLab + ISLab]

ONGOING THESIS

- Guilherme Santos, "Chromosome identification and pairing in optical microscopy images", Initiated: 2009. [VisLab+ISLab]

MULTIDISCIPLINARY JOINT PROJECTS

Research Line Output

- The ISRobotNet is a testbed for Networked Robot Systems developed by MRLab together with VisLab and ISLab, composed of an indoor area of around 160 m² with 10 webcams placed at the ceiling such that some of the fields of view do not overlap. The cameras are distributed in 4 groups, each of which is managed by its own computer, namely for image acquisition. The managing computers are connected to the ISR/IST network and can be accessed by duly authorized external parties. Ongoing work will extend the number of cameras and the usable indoor space to include multiple floors. Robots will use the same elevators as ordinary people to move between floors. Besides the camera sensors, four Pioneer AT and one ATRV-Jr robots are available. Each of the robots is equipped with sonars, onboard cameras, laser range finder and is Wi-Fi connected to the network. [ISLab+LRM+VisLab]
- URUS: Ubiquitous networking Robotics in Urban Settings, in the areas of distributed perception, distributed decision making, human robot interfaces and gesture recognition. The recently created ISRobotNet, infrastructure will be used as the main testbed for experiments with networked robots and sensors which has provided the basis for the development of novel approaches, algorithms and tests with real platforms, including its use by our international partners. [VisLab, MRLab, ISLab]
- ROBOTCUB – An Open Framework for Research in Embodied Cognition, is one of the EU projects with largest impact in Europe and internationally. It pursues the twin goals of developing a standard humanoid robot with free access to all designs and software and to use this robot to study cognition. [VisLab and some contributions from ISLab]
- ITER TCS/ATS - Activities related to the development of an Air Transfer System prototype and Cask Transfer System Virtual Mockup, is a project in the frame of ITER-International Thermonuclear Experimental Reactor. It aims at evaluating navigation methodology and in particular the optimal trajectories of a large mobile robot that will operate in ITER and to provide technical consultancy to ITER. [MRLab with contributions from ISLab]
- Promoting a collaboration protocol with Lisbon city authorities aiming at the participating in joint projects related to urban robotics. This is a direct consequence of the involvement with the EU Project URUS that concerns the deployment of robotic technologies in urban centres, particularly of historical cities such as Barcelona and Lisbon. [MRLab, VisLab, ISLab]

Future Research

Other Information

a) JOINT INTERNATIONAL PROJECTS

On-going EU projects that will potentially involve more than one group, approved last year (FP7 ICT Call 4 and ITER), are:

- HANDLE: Developmental pathway towards autonomy and dexterity in robot in-hand manipulation.
- First-MM: Flexible Skill Acquisition and Intuitive Robot Tasking for Mobile Manipulation in the Real World.
- ROBOSOM: Robot Sense of Movement
- ITER TCS/ATS: Activities related to the development of an Air Transfer System prototype and Cask Transfer System Virtual Mockup

We will pursue an aggressive policy of participation in EU Projects involving the several ISR groups participating in Theme B and international collaboration at the European level. Currently, 3 proposals involving more than one of these groups are being prepared for FP7 ICT Call 6:

- one IP project on interaction between many robots and many humans, with an emphasis on social learning and human-robot interaction;
- one STREP on collaboration human-robot that takes into account the human-in-the-loop for the purpose of learning and augmenting human capabilities.
- one IP on humanoid technologies, learning, adaptation and interaction.

b) JOINT NATIONAL PROJECTS

Similarly, we will keep pursuing a policy of encouraging joint national projects, submitted to FCT calls, among ISR groups and between them and other Portuguese groups, within Theme B research topics. Currently, there are several on-going examples of such projects:

- BIOLOOK: Biomimetic Oculomotor Control for Humanoid Robots [VisLab + SPLab]
- DecPUCS: Decentralized Planning Under Uncertainty for Cooperative Systems [ISLab+MRLab]
- ARGUS: Activity Recognition and Object Tracking Based on Multiple Models, (w/ cooperation with Instituto de Telecomunicações and INESC-ID)
- VISTA: Vision based Touch interaction Anywhere, (w/ Faculdade de Ciências, UL)
- ADDI: Automatic computer-based Diagnosis system for Dermoscopy Images, (w/ Faculty of Sciences of the U.Porto)
- PCMMC: Perception-Driven Coordinated Multi-Robot Motion Control, Jan. 2010 - Dec. 2012 (with INESC-Porto, ISEP/IPP)
- BioInstBots: From Bio-Inspired to Institutional-Inspired Collective Robotics, Feb. 2010 - Jan. 2013 (with IGC/FCG)

Part of the work in networked robots and sensors has inspired joint work on energy consumption monitoring and management in buildings with the Energy group of IN+ (Thematic Area C), through a PhD thesis. One sensor network will be installed at IST-Tagus Park for this purpose. One FCT project proposal was submitted to the 2009 call.

c) INVOLVEMENT IN INTERNATIONAL PARTNERSHIPS

The groups involved in this Thematic Area are currently involved in several international partnerships :

- CMU-Portugal Program, established by the Portuguese Government with several PhD students and one multidisciplinary project proposal submitted.

Future Research

- IST-EPFL Joint Doctoral Initiative, in the Focus Areas of Distributed and Cognitive Robotics and Biological and Biomedical Imaging.
- MIT-Portugal Initiative with a project submitted last year and the supervision of a PhD student with researchers from IN+/Thematic Area D concerning the use of camera and robot networks to monitor energy efficiency in buildings

d) RESTRUCTURATION OF ISR GROUPS

ISR's ISLab and MRLab will merge into the IRSLab (Intelligent Robots and Systems Lab) so as to consolidate their current common research interests and work, as well as to increase their critical mass and number of researchers. The new IRSLab will reinforce the research focus on some of the topics currently studied by ISLab and MRLab.

e) FUTURE HIRING NEEDS

The possibility of hiring new researchers in 2010, particularly in the domains of video surveillance and cognitive robots will be critical for the consolidation of the work done. Difficulties in hiring are hampering a stronger development of these topics. The reason for these difficulties are on one hand the dependence on the evaluation of the LA which has been postponed since 2006 and legal and administrative/bureaucratic constraints that make the hiring process extremely long.

Similarly, due to the use of complex experimental infrastructures and in order to further promote the collaboration between groups it would be important to hire a research engineer/technician in 2010.

It should be stressed that several researchers are currently hired by different project funds but these do not usually have the mid-term horizon that would attract more good candidates.

Future Plans

We will continue the strong involvement of members of this area in the topics of human-robot interaction, cognitive architectures, cooperative perception, decision-theoretic decentralized planning under uncertainty, human activity surveillance and recognition, and gesture recognition.

One distinctive feature of this research line is the exploration of multidisciplinary, thought-provocative research topics, which have demonstrated potential for introducing breakthrough concepts in several areas, from cognitive and collective robotics to biomedical image processing. Among them are the well-established international collaborations with psychologists, neuroscientists and computer scientists on cognitive robotics and human-robot interaction for more than 10 years, as well as with biologists, economists, computer scientists and social scientists (e.g. the new FCT BioInst-Bots project), and with medical doctors on medical image analysis using ultrasound and MRI images.

Concerning some of our key research activities, we envisage for 2010:

- Further developing the use of the iCub platform as a training centre for ISR, national and international researchers interested in cognitive robotics, learning and interaction.
- Continue using the ISRobotNet networked robot system as the main testbed for experiments with networked robots and sensors, open to our international partners.
- Promote the interaction amongst researchers of the Thematic Area by encouraging the submission of joint project proposals and organizing informal workshops for exchange of ideas.

Regarding applications, we will continue extending our work in (i) search and rescue to field robotics activities and applications, (ii) human activity recognition and (iii) cognitive robotic systems able to interact with humans, where humanoids technologies provide a clear example and new challenges, notwithstanding their relevance for public policies, and potential for innovative results on unstructured environments blending sound theory and technological developments.

Group Description	
Title of Research Group:	(RL-EME-LA09-137) Sustainable Technologies and Environmental Systems
Principal Investigator:	Paulo Manuel Cadete Ferrao
Main Scientific Domain:	Engenharia Mecânica

Objectives & Achievements

General Objectives

The objective is undertaking multidisciplinary research to develop and evaluate emerging and alternative complex engineering systems for sustainability, e.g. in terms of socio-economic development and environmental quality, creating a more prosperous and sustainable society.

Technologies will be developed and assessed under a systems view, comprising the environmental implications of materials, energy, and products in modern societies. To achieve these objectives, research and development activities involve assessing advanced systems, but also analyzing the global carbon bio-geochemical cycle and materials flows in the economy

Main research areas are:

- Eco-design for sustainability
- Advanced integrated combustion and thermal systems
- Total life-cycle energy chain and environmental impact assessment
- Carbon cycle analysis
- Economy material flows
- Techno-economic assessment, technological change and systems integration
- Development of industrial ecology models applied to economic systems with emphasis on national and urban systems

Main Achievements

The activities developed within this topic were multidisciplinary, linking basic and applied research to technology development, and focused on the issues of sustainability, namely in terms of the needs to secure the quality of the environment, together with the management of energy resources and economic development.

In this context, the Laboratory of Environmental Systems has been able to:

- Support a PhD Program on Sustainable Energy Systems, in the context of the MIT-Portugal Program
- Develop major methodologies and tools that bring together economy and environment in the assessment and the design of new products (Eco-design tools) and new policies (e.g.: National Integrated framework for Residues Management, Hybrid Economic Input-Output-Life Cycle Assessment or Life Cycle Activity Analysis).
- Support entrepreneurial initiatives in Industrial Ecology in Portugal, such as the design of a variety of new companies aimed at recycling and further processing end-of-life products or the design and implementation of an Eco-Industrial park at Chamusca.
- Create a network for sustainability in Portuguese agriculture, comprising close to 100 farmers, occupying 0.7% of Portugal, and close to 30 partners, including universities, NGOs and private firms.
- Provide support to Portuguese public policy on the use of natural carbon sinks (including geological carbon sequestration).
- Demonstrate the use of natural fiber based composites for auto-components
- Develop new urban metabolism models.

Research Line Output

Collaborative Publications in peer review Journals

The research conducted within some of the groups of this thematic area is intrinsically highly multidisciplinary, combining e.g. engineering disciplines with natural sciences, economy and management. Joint, trans-disciplinary publications are starting to appear (see below). However, some of the new activities started during 2008 gained momentum in 2009. These consist of highly transdisciplinary work, particularly that involving the group of sustainable energy and the research team of CREMINER.

Collaborative Other Publications

Gerbelová H, S Casimiro , C Ioakimidis, M Melo, F Barriga, P Ferrão, in press. Assessment for Carbon Capture and Storage Opportunities: Portuguese Case Study. GHGT-10 - 10th International Conference on Greenhouse Gas Control Technologies, Amsterdam, September 2010 (Submitted in 2009)

Master and PhD thesis completed

xx

Future Research

Other Information

FCT Project on Carbon Capture and Sequestration: it combines the skills in environmental assessment of carbon capture technology with skills on geological survey for sequestration fields in Portugal. The project continued active in 2009. It involves researchers from IN+ and CREMINER. We are planning to organize a n international workshop on CCS, including engineering, geological and interface aspects, in an eminently co-operative action, which will certainly contribute to the ties within the LA and to advancements in this critical societal topic

Future Plans

The development of engineering systems can and should be rooted in the understanding of natural systems, biological and/or geological. Sustainable development systems will respect nature and will simultaneously be inspired in natural systems.

A major line of research is, building on the strong interdisciplinarity of ISR-LA, the exploration of formal analogies between different fields in the natural, social and engineering sciences:

- The analogy between Thermodynamics, Microeconomics, Evolution and Engineering Optimisation, built on their common use of constrained optimization formalisms.
- The analogy between ecosystems and industrial systems, based on mass and energy flows, under the heading of Industrial Ecology. A similar analogy can be drawn with geological systems and cycles.
- The analogy between organisms and industrial and urban systems, under the headings of Industrial Metabolism and Urban Metabolism.
- The analogy between coordination in (human and non-human) social systems and "societies" of autonomous robots, exploring the methods of game theory and institutional economics (ISR).

The study of dam reservoir sediments, especially their possible uses (fertilizers, construction materials) is a specific line of research started in Creminer years ago, which is evolving into collaborative research with researchers for ISR and IN+, given their strong links with both marine technology and engineering systems.

ISR-LA will aim at developing integrated models of environment-energy-economy interaction, at multiple spatial scales (cities, regions, countries), using the models such as input-output, computable general equilibrium modes, and economic growth.

Group Description	
Title of Research Group:	(RL-EEI-LA09-145) Signal Processing for Communicatio Networks and Multimedia
Principal Investigator:	Joao Paulo Salgado Arriscado Costeira
Main Scientific Domain:	Engenharia Electrotécnica e Informática

Objectives & Achievements

General Objectives

Thematic area D is structured around the development of advanced mathematical tools leading to solutions in the following application areas: Wireless Communications, Information Processing in Sensor Networks and Visual Recognition. All these areas have in common the fact that, quite often, the way problems are formulated they boil down to large-scale, nonlinear and sometimes distributed optimization problems. In terms of impact on society, besides the provision of innovative cut-crossing methodologies, the thematic area proposes to develop and deliver concepts and testbeds leveraging some projects and partnerships that will incorporate these methodologies. Currently the main developments are the following: a) A distributed mobile/static networked platform for sensing and decision. b) A large scale image database search and retrieval system of image content. The main driver are activities developed in two multidisciplinary projects and an international partnership with CMU. These main drives of research hinge on the work done with mathematicians and engineers through partnerships and direct hiring.

Main Achievements

As referred, the main drive of area D is supported on research both with CMU and on two areas with new collaborative projects approved in 2009 that frame the developments:

- 1 - A collaborative project to create a mobile network of pollution sensors using a bus fleet. This platform is to be extended in the future for multiple sensing modalities (image, sound etc).
- 2 - A collaborative project for recognizing and categorization of a large (1M+) database of images of art.
- 3 - Initial development and deployment of the CMU-firefly sensor network for environment monitoring

Some achievements that enable these projects are:

-In coop. between (SPIG) and (DSOR), algorithms for sensor and target localization and tracking from range data in a WSN setting(e.g. firefly). In particular these algorithms can handle outliers which is a more realistic assumption.

-Together with CMU faculty and students, a new non-combinatorial optimization algorithm was developed to tackle the sensor selection problem in WNS's. This algorithm approaches a NP-hard problem by finding a nearly-optimal solution but with polynomial complexity. Also, it solves (as a by product) the linear dimensionality reduction problem, arising in many signal processing and patt. Recog. tasks.

- A 3D reconstruction of non-rigid/articulated objects from video sequences with direct application in biomechanics. This was a direct consequence of the following mathematical development:

-A new result on minimizing a quadratic function on Stiefel manifolds and the generalized Procrustes problem for 3x2 truncated orthogonal matrix. The new approach obtained a tight convex relaxation of the basic problem, thus reducing it to a simple convex optimization problem. Done in cooperation with mathematicians from CELC-Fac C. UL,.

-A correspondence algorithm with low complexity to match images to previously learnt patterns. This problem and its solutions also motivated the following mathematical achievement (in cooperation with mathematicians):

A new theorem demonst. that if some entries of a permutation matrix are known, the (combinatorial) correspondence problem has unique solution in the domain of the doubly-stochastic matrices. As a consequence, it can be easily solved using linear programming techniques.

Research Line Output

Collaborative Publications in peer review Journals

Publications with external collaboration
 Centro Estruturas Lineares e Combinatoria (CELC) - Fac. Ciencias UL, Univ. Columbia- USA
 M. Dodig, M. Stosic: Singular systems, state feedback problems, Linear Algebra and its Applications 431 (2009), 1267-1292.
 M. Mackaay, M. Stosic, P. Vaz: $sl(N)$ invariant of links using foams and the Kapustin-Li formula, Geometry & Topology 13 (2009), 1075-1128
 M. Dodig, M. Stosic: Similarity class of a matrix with a prescribed submatrix, Linear and Multilinear Algebra, vol. 57, issue 3 (2009), 217-245.
 M. Stosic: Khovanov homology of torus links, Topology and its Applications 156 (2009), 533-541.
 4 more publications have been submitted involving mathematical developments motivated by engineering problems.

Collaborative Other Publications

In collaboration with multiple institutions (CELC-Univ. Lisboa,; Univ. London, Univ. Trento, Univ. Boston, Carnegie Mellon Univ).
 M. Paladini, A. Del Bue, M. Stosic, M. Dodig, J. Xavier, L. Agapito: Factorization for Non-Rigid and Articulated Structure using Metric Projections,

Research Line Output

Proc. of CVPR 2009 - IEEE International Conference on Computer Vision and Pattern Recognition, Miami, USA, 2009.

A. Del Bue, M. Stosic, M. Dodig, J. Xavier: 2D-3D Registration of Deformable Shapes with Manifold Projection, Proceedings of ICIP 2009 - IEEE International Conference on Image Processing, Cairo, Egypt, 2009

J. Gomes, M. Stojanovic, "Performance analysis of filtered multitone modulation systems for underwater communication", Proceedings of MTS/IEEE OCEANS'09, Biloxi, USA, October 2009.

D. Bajovic, B. Sinopoli and J. Xavier, "Robust linear dimensionality reduction for hypothesis testing with application to sensor selection", 47th Allerton Conference on Communication, Control, and Computing, Illinois, USA, October 2009

D. Bajovic, B. Sinopoli and J. Xavier, "Sensor selection for hypothesis testing in wireless sensor networks: a Kullback-Leibler based approach", 48th IEEE Conference on Decision and Control - CDC'09, Shanghai, China, December 2009

J. Mota, J. Xavier, P. Aguiar and M. Puschel, "Distributed algorithms for basis pursuit", 2nd International Workshop on Signal Processing with Adaptive Sparse Structured Representations, Saint-Malo, France, April 2009

Multiple Groups or Multidisciplinary

P. Ekim, J. Gomes, J. Xavier and P. Oliveira, "ML based sensor network localization and tracking: batch and time-recursive approaches", 17th European Signal Processing Conference - EUSIPCO 2009, Glasgow, Scotland, August 2009. - rated top 5% in the conference.

M. Marques, M. Stosic, J.P. Costeira: Subspace matching: Unique solution to point matching with geometric constraints, Proc. of ICCV 2009 - 12th IEEE International Conference on Computer Vision, Kyoto, Japan, 2009.

Master and PhD thesis completed

A. Silva, "Environmental based underwater communications", PhD Thesis, Instituto Superior Técnico, March 2009. (co-supervisor, with S. Jesus)

Future Research

Other Information

Besides the set of international/national projects, activity in the thematic area is pushed forward by a strong involvement in the CMU-Portugal program, where 11 PhD students and more than 10 faculty from both universities cooperate. Also an history of common developments with mathematicians is an asset which we intend to keep exploring. In this context not only we propose to contribute to the deliverables listed below (future plans), enabling joint cooperation and joint infrastructure with Carnegie Mellon, but also we will be co-organizers of the Carnegie-Mellon Portugal conference and Doctoral Consortium which will get together all students of the program.

Joint developments at the industrial level are underway using technology transfer programs, in particular with ESA and MDUSpace - a portuguese technology supplier for VW (see http://www.esa.int/esaCP/SEM0AKOJH4G_index_0.html).

Future Plans

We propose to direct our research along two vectors:

1 -The development of a mobile sensing ecosystem – Bootstrapped by a recently approved project (FCT-URBISNET) that proposes to build a network of pollution measuring system using the bus fleet, the thematic area will pursue the objective of developing a multi-sensing mobile platform applied to urban environments. This platform will include several sensing modalities (besides environmental sensors) such as video cameras and microphones.

-The distinctive feature here is that the challenges we address are essentially in the domain of the large-scale distributed nonlinear signal processing: We propose to estimate dense dynamic fields (like CO₂ in a city) with a sparse set of moving sensors which blurs the data and thus pose huge challenges at the mathematical modeling level. Also, the huge volume of data, calls for a whole new range of compressed sensing methodologies and combinatorial-like algorithms that can efficiently manage and sample the phenomena, not to mention the obvious need for localization and target tracking algorithms.

2 – The development of a system for indexing and retrieving image by content – Leveraged also by project FCT-PrintArt (partnership with a Museum and Fac. Letras) and FP7-IMAGESEG3D which addresses the problem of interpreting cataloguing and indexing large collections of images of paintings/engravings. This is the "contained" version of "the Internet" where users want to search information by contents rather than tags. The question to answer is "give me images like this one". Again, problems here face challenges at the computational level: Very fast, very large scale (nonlinear) optimization algorithms are needed, new rank decompositions and sparse/efficient representations. This issue pops up in the previous area when we put video/sound on a mobile vehicle roaming in a city.

The significant issue here is that the approach requires a whole new set of tools that can only be developed recurring to a strong investment in new methodologies deeply rooted in mathematical disciplines which the past cooperation and selective hiring assures.

Group Description	
Title of Research Group:	(RL-EEI-LA09-151) Technologies for Ocean Exploration
Principal Investigator:	António Manuel dos Santos Pascoal
Main Scientific Domain:	Engenharia Electrotécnica e Informática

Objectives & Achievements

General Objectives

The main goal of thematic area A is to carry out research and development in marine science and technology for a better understanding of the oceans, and to use this knowledge for the sustainable benefit of society. The area brings to the core of its R&D activities research groups with different expertise and encompasses a wide spectrum of activities that touch upon theoretical and practical issues in marine science and technology. The program targets the Azores as a natural laboratory for the study of a number of challenging scientific issues in the fields of biological, chemical, geological, and physical oceanography. At a technological level we strive to bring advances in robotics, communications, and systems and information theory to bear on the development of advanced marine platforms (including autonomous vehicles) and sensor systems that will afford marine scientists far more efficient tools than available today to study the ocean and its frontiers. Conversely, strong cooperation links established with marine scientists impact on the definition of new theoretical and technological problems that are motivated by challenging mission scenarios.

Main Achievements

The following representative examples mirror some of the major achievements in engineering and science, and on the development of tools for marine exploration.

Engineering:

Development of a new breed of algorithms for i) multiple vehicle cooperative path planning under temporal and energy expenditure constraints, with due account for temporal or spatial deconfliction requirements and ii) multiple vehicle time-coordinated path following control in the presence of communication failures.

Science:

Through IMAR, the Associated Lab has become the world leading research center for the study of the deep-sea chemo-synthetic mussel *Bathymodiolus* and the 14th Web of Knowledge ranked institution (as University of the Azores) on the study of hydrothermal vent extreme ecosystems. The implementation and refurbishing of LabHorta initiated in 2008 and the installation of CoraLab (a laboratory for the study of cold waters corals) have shown to be major milestones in the studies of the deep-sea ecosystems.

In what concerns marine geology, the areas of work included the Azores Sea, the Southwest Pacific, and the Arctic Ocean (Loki's Castle), the latter having been discovered in 2008 with the participation of Creminer. Public outreach through Creminer continued to be particularly noteworthy, with involvement in the National Museum of Natural History and in the setting-up of the Lousal "live science" center in Southern Portugal and the Quartz Museum in Viseu.

Bridging the gap between science and technology:

i) Demonstration of cooperative vehicle motion control with four autonomous marine robots in the scope of the EU GREX and FREESUBNet projects that involve the DSORL and IMAR. This important milestone has received considerable attention among the marine robotics community worldwide.

ii) Demonstration at sea of a completely "retrofitted" version of a GPS Intelligent Buoys Positioning System, in the scope of the FCT RUMOS project.

iii) Design, development, and test of an integrated Ultra Short Baseline (USBL) and Inertial Navigation System (INS) to be used as a low cost navigation system for underwater robotic vehicles (in the framework of the FCT RUMOS project).

The vitality of the area is patent in the number of projects in which its members participate: 16 EU and 10 nationally funded projects.

Research Line Output

Collaborative Publications in peer review Journals

The research work carried out by the members of Thematic Area A covers a large spectrum of issues that stand at the crossroads of engineering and science. The following representative list of publications reflects this fact and describes work that either involved different research groups or is the outcome of intensive cooperation links with external co-authors.

Aguiar, A. and J. Hespanha, "Robust Filtering for Deterministic Systems with Implicit Outputs," *Systems & Control Letters*, Vol. 58, No. 4, pp. 263-270, Apr. 2009.

Afonso P, Fontes J, Guedes R, Tempera F, Holland KN, Santos RS (2009) A Multi-Scale Study of Red Porgy Movements and Habitat Use. In: Nielsen JL, Arrizabalaga H, Fragoso N, Hobday A, Lutcavage M, Sibert J (eds) *Tagging and Tracking of Marine Animals with Electronic Devices*, Vol 9, p 423-443

Research Line Output

Bashmachnikov I, Machin F, Mendonca A, Martins A (2009) In situ and remote sensing signature of meddies east of the mid-Atlantic ridge. *Journal of Geophysical Research-Oceans* 114

Cuvelier D, Sarrazin J, Colaco A, Copley J, Desbruyeres D, Glover AG, Tyler P, Santos RS (2009) Distribution and spatial variation of hydrothermal faunal assemblages at Lucky Strike revealed by high-resolution video image analysis. *Deep-Sea Research Part I-Oceanographic Research Papers* 56:2026-2040

Dias, Á. S., Mills, R. A., R. Costa, I., Costa, R., Taylor R. N., Cooper, M. J. and Barriga, F. J. A. S. (accepted) Tracing fluid-rock reaction and hydrothermal circulation at the Saldanha hydrothermal field. *Chemical Geology*

Machado J, Lopes-Lima M, Damasceno-Oliveira A, Colaco A, Andrade J, Silva D, Jimenez-Lopez C, Rodriguez-Navarro A, Checa A (2009) The influence of hydrostatic pressure on shell mineralization of anodonta cygnea. *Journal of Shellfish Research* 28:899-904

Ghabcheloo, R., A. Aguiar, A. Pascoal, A. Silvestre, I. Kaminer, J. Hespanha, "Coordinated path-following in the presence of communication losses and time delays," *SIAM Journal on Control and Optimization*, Vol. 48, No. 1, pp. 234-265, January 2009.

Vasconcelos, J., M. Athans, S. Fekri, C. Silvestre, and P. Oliveira, "Stability- and Performance-Robustness Tradeoffs: MIMO Mixed-mu vs Complex-mu Designs," *International Journal of Robust and Nonlinear Control*, vol 19, n^a 3, pp. 259-294, February 2009.

Collaborative Other Publications

As in the previous item, the following list of representative publications describes work that either involved different research groups or is the outcome of strong cooperative links with external co-authors.

Barriga FJAS, JMRS Relvas, AMS Pascoal 2009. Exploration of Massive Sulphide Deposits on the Sea Floor. ICES International Symposium Issues Confronting the Deep Oceans, Horta, Azores Portugal, Gui Menezes and Robert Brock, eds, pp 38-39

Barriga FJAS, JMRS Relvas, AMS Pascoal, 2009. Some Thoughts on the Future of Exploration for Massive Sulfide Deposits in the Azores Sea. Deep-Sea Mining of Seafloor Massive Sulfides: A Reality for Science and Society in the 21st Century Science and Policy Workshop, April 1-2, 2009, Woods Hole, Massachusetts, USA

Barriga FJAS, RS Santos (in press). Recursos minerais marinhos, metálicos, não metálicos e energéticos: potencial e impactos ambientais. Vol. Esp. Academia das Ciências de Lisboa

Carreiro-Silva, M., E. Giacomello, A. B. Henriques, J. Jakobsen, K. Jakobsen, G. Menezes, T. Morato, F. M. Porteiro, F. Tempera & R. S. Santos 2009. Seamount Research in the Azores - Sea based and land based observatories: New approaches for the integrated study of biodiversity and ecosystem functioning of seamounts. *MARS Newsletter*, 9 (Autumn 2009): 12-15.

Fontes, J., A. Pascoal, Joerg Kalwa, L. Brignone, T. Glotzbach, M Arredondo. Final Tests in the scope of the EU GREX project 035223 (Coordination and control of cooperating heterogeneous unmanned systems in uncertain environments). GREX project Report, Nov. 2009, 89 pages.

Pinar Ekim, João Gomes, João Xavier and Paulo Oliveira, "ML-based Sensor Network Localization and Tracking: Batch and Time-recursive Approaches," 17th European Signal Processing Conference (EUSIPCO'09), Glasgow, Scotland, August 2009.

Reza Ghabcheloo, Isaac Kaminer, António Aguiar, António Pascoal, "A General Framework for Multiple Vehicle Time-Coordinated Path Following Control," Proc. American Control Conference, Saint Louis, USA, June 2009.

Bruno Guerreiro, Carlos Silvestre, Rita Cunha, Chengyu Cao, and Naira Hovakimyan, "L1 Adaptive Control for Autonomous Rotorcraft," Proc. American Control Conference, Saint Louis, USA, June 2009.

Master and PhD thesis completed

The following projects have fostered intensive cooperative work between the DSORL, IMAR, and the Signal and Image Processing Group at both National and European levels. All projects address issues that require a strong symbiosis between engineering and marine science.

[1] EU "FREESUBNET- Marie Curie Research Training Network". The purpose of FREESUBNET is to provide a European-wide excellence in quality training to young and experienced researchers in the emerging field of Cooperative Autonomous Intervention Underwater Vehicles (AUVs), which are steadily becoming the tool par excellence to carry out scientific and commercial missions at sea without tight human supervision.

Research Groups: DSORL, IMAR, Signal and Image Processing Group

URL: <http://www.freesubnet.eu/>

[2] EU "GREX-Coordination and Control of Cooperating Heterogeneous Unmanned Systems in Uncertain Environments": development of advanced systems for multiple vehicle cooperative navigation and control with applications to marine science.

Research Groups: DSORL, IMAR, and Signal and Image Processing Group

URL: <http://dsor.isr.ist.utl.pt/Projects/Grex/>

[3] "NAV-Development and Application of Advanced Nonlinear Control Techniques for the Coordination and Motion Control of a Network of Autonomous Vehicles": the goal of this project is to develop, implement and test advanced robust control strategies for the coordination and cooperative motion a network of autonomous vehicles (NAV). The research work is driven by the high-impact field of marine robotics. It is expected that the methodologies and techniques developed in NAV-Control will contribute to the development of important tools for ocean exploration and exploitation.

Research Line Output

Research Groups: DSORL and IMAR

URL: <http://users.isr.ist.utl.pt/~pedro/NAV>

[4] "OBSERVFLY-Uninhabited Aircraft for Marine Science Applications": the project aims to develop a versatile UAV prototype that can take-off and land either on an opportunity airstrip (using the landing gear) or on a bay or harbor (as a seaplane). The aircraft will be designed for marine science applications with special emphasis on the location and tracking of marine mammals and commercially important or threatened pelagic species such as the Atlantic Tuna.

Research Groups: DSORL and IMAR

[5] "RUMOS-Robotic Underwater Vehicles and Marine Animals Tracking Systems": the main purpose of the project is the development of a set of devices and methodologies for accurate estimation of trajectories of underwater robotic vehicles (autonomous and remotely operated) and marine animals.

Research Groups: DSORL and IMAR

Future Research

Other Information

Actions involving more than one group

1. Workshop organization.

FREEsubNET Workshop in the Azores. The 4th and final EU FREEsubNET Network Workshop will be held from the 19th to 23rd of July 2010 in Horta, Faial, Azores, Portugal. The two Associated Lab partners IMAR/DOP/UAzores and ISR/IST will host and organize the event, for an expected audience of 25 Early Stage Researchers. The workshop focuses on scientific application of marine technology and consists of a series of talks and lectures from experts as well as practical work at sea and in the laboratory. In this respect, it will be a very unique event in that it will afford the participants a fast paced introduction to challenging issues on cooperative marine robotics, navigation, and advanced scientific sensor suites, as well as hands-on experience on marine habitat mapping and fish tracking.

2. On-going projects (funded by the EU and National)

Cooperative work between the IMAR/DOP/UAzores, the DSORL, and the Signal and Image Processing group will continue in the scope of the EU "FREESUBNET- Marie Curie Research Training Network" and the NAV (Development and Application of Advanced Nonlinear Control Techniques for the Coordination and Motion Control of a Network of Autonomous Vehicles) and OBSERVFLY(Uninhabited Aircraft for Marine Science Applications) projects.

3. Possible future projects (EU and National funding)

In line with the strategy adopted in Thematic Área A, two proposals will be submitted to the EU in response to FP7 ICT calls. Both proposal involve the IMAR/DOP/UAzores, the DSORL, and the Signal and Image Processing group.

- MORPH - one 5-year IP on the development of advanced morphed marine robotic vehicles with cognitive capabilities, for scientific and commercial applications.
- MARINERoboticsNet - a Marie Curie Research Training Network bringing together key European players in the marine robotics area and related scientific/commercial applications.

The study of dam reservoir sediments is a specific line of research started in Creminer years ago, which is evolving into collaborative research with ISR researchers, given their strong links with marine technology. Two projects were submitted to FCT involving Creminer and ISR researchers.

4. Dissemination actions.

It is expected that 2010 will witness the consolidation of a strong cooperative link established with the municipality of Cascais that will afford the researchers of the Associated Lab a workshop space (Marine Science and Technology Workshop) for large equipment assembling and testing in the vicinity of the ocean. As part of the cooperation agreement, the Associated Laboratory (namely the DSORL, the Signal and Image Processing Group and CREMINER) will carry out demonstrations of advanced robotic equipment for the public at large, with real-time transmissions from the sea. The office of EurOcean, the European portal for marine science and technology - with its office in Lisbon - has agreed to be an active partner in the dissemination actions envisioned. Namely, it will disseminate info about the events, including cruise plans and cruise reports, as well as info related to "real-time" transmissions, whenever possible.

5. Prototypes.

The year of 2010 will witness the development and testing of the following prototypes in the scope of collaborative projects involving the DSORL, the Signal and Image Processing Group, the IMAR/DOP/UAzores, and CREMINER.

- i) Full Development and testing of a Fixed Wing Unmanned Aircraft tailored for marine science applications under the OBSERVFLY project.
- ii) Completion and testing of a Small Fleet of Semi-Submersible Vehicles of the MEDUSA-type (proprietary of ISR/IST), in the scope of the EU-funded CO3AUVs project, for cooperative missions involving human divers in the loop

Future Plans

Cooperative links established in the scope of Thematic Area A will be further exploited with the objectives of: i) intensifying the transfer of technology to scientific end-users, effectively affording marine scientists better tools for ocean exploration and mapping, ii) defining mission scenarios that warrant the use of advanced technology, and iii) executing common missions at sea in the Azores and in the continent.

Future Research

The following are representative examples of planned activities:

A. Marine habitat mapping / observation and tracking of marine mammals and fish schools using aerial and marine autonomous vehicles.

Objective: to substantially improve the methods to do fish telemetry (a theme that has been strongly motivated by joint work of DSORL and IMAR in the scope of the EC projects FREEsubNET and GREX). Within the FCT OBSERVFLY project, a versatile UAV for location and tracking of marine mammals will be tested. Work will also continue on the development of advanced methods for marine habitat mapping using robotic vehicles, in the scope of the EC CO3AUVs and TRIDENT projects.

B. Harbour security and dam/coastal areas surveying and monitoring using autonomous surface and underwater vehicles.

Objective: development of advanced robotic systems for the above mentioned goals, by availing ourselves of our complementary scientific/technical expertise. Especially relevant is the use of marine robots to monitor sediment accumulation in dams to aid in establishing management policies. Two projects were submitted to the FCT to this effect, involving ISR researchers.

C. Ecosystem studies.

Objectives: bio-telemetry studies of top predators together with habitat mapping at the level of seafloor and water column. New sensors and permanent stations, including landers, are being deployed in seamounts around the Azores, namely the Condor (Morato et al., Oceanography March 2010) Together with the fixed observatory type studies of seamount and vents ecosystems, we will continue tagging several species with acoustic and satellite transmitters incorporating data-loggers for different types of environmental and physiological data acquisition. Many of the R&D initiatives will take place in the framework of a number of EU projects that include HERMIONE, CoralFish, MADE, ESONET NoE.