1. ISR IN NUMBERS

	2003	2004	2005	2006
Research Team				
University Professors	29	28	33	29
Principal Researchers	01	01	02	06
Post-Docs	08	03	04	02
Ph.D. Students	44	45	47	58
M.Sc. Students	24	24	16	46
Research Engineers/Assistants		10	21	18
Undergraduate Students	26	34	30	16
Total	132	145	154	175
Research Projects	41	32	33	22
Doctoral theses concluded	06	03	03	04
Master theses concluded	06	08	05	04
Publications				
Books	00	00	02	01
In Books	03	06	06	07
In International Journals	26	26	21	25
In National Journals	01	01	01	04
In International Conferences	58	66	67	95
In National Conferences	14	06	04	08
Technical Reports	28	30	28	10

2. RESEARCH TEAM AND INTERESTS

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2.2. CURRENT RESEARCH INTERESTS

The Lisbon pole of ISR is internally organized in 7 laboratories/groups. In this section the main research interests of each one of the laboratories/groups are briefly described.

2.2.1. INTELLIGENT SYSTEMS LAB (IS)

The driving theme of the Intelligent Systems Laboratory is Research and Development of Decentralized Systems, including Multi-Robot, Multi-Agent and Management systems. Our distinctive feature is that we bring together people with a common background on Systems Theory, but different approaches to modeling, analysis and synthesis of Intelligent Systems, mainly coming from:

• Artificial Intelligence, with a focus on multi-agent systems, either virtual (e.g., web agents) or with a physical body (e.g., robots), and special interests on knowledge representation and reasoning, organizational issues, distributed decision making and social relations, organizational issues, biologically-inspired approaches; and

• Systems and Control, with a focus on complex systems consisting of a large number of interconnected embedded systems, e.g., multi-robot systems, multiple-systems process control plants, water irrigation channels, institutional management systems, communication networks, and special interests on modeling, analysis and synthesis methods.

As a consequence, our research borrows results from and provides contributions to a rich set of related fields, such as Discrete Event and Hybrid Systems, Decentralized Control, Sequential Decision Making, (Cooperative) Reinforcement Learning, Logic-based Planning, and Emotions-Based Agents.

We further believe it is very important to apply our methodologies to practical domains, as real-life provides sources of inspiration much richer than pen-and-paper problems. Therefore, we have been exploring the application of our research on Soccer Robots, Rescue Robots and Formation-Flying Spacecraft.

In the sequel, we provide some detail on the research and development topics covered by the Lab members activity in 2006, as well as on the major results achieved.

RESEARCH INTERESTS IN 2006

Discrete Event System Models of Robotic Plans - Most of the existing Multi-Robot Systems (MRS) models are not based on formal approaches. Typically, only a small number of behaviours, tailored to the task at hand, are considered. Furthermore, the emergent overall behaviour when using self-organizing system approaches is usually not predictable, as there is no constructive theory of emergent behaviour. This raises the question of how to design a MRS which is goal-oriented, therefore being able to perform a given mission while meeting a set of specifications. We claim that formal plan modelling methods for robotic tasks enable a systematic approach to modelling, analysis and design from specifications. This is clearly an advantage in goal-oriented systems, but can prove useful in behaviour-based systems as well, where using self-organizing approaches frequently leads to unpredictable behaviour, a certainly undesirable feature for applications requiring safety, robustness and performance guarantees, as in a search and rescue scenario.

Moreover, despite its inherent complexity, such methods allow to model, up to a certain dimension in the number of involved behaviours, events and conditions of world components, scaling up from problems with a limited number of behaviours, whose coordination one can design "by hand", to realistic applications with a considerable number of behaviours, where coordination solutions are not intuitive and require algorithms to handle the large behaviour space. Recent attempts to handle planning under uncertainty have used Markov Decision Processes (MDPs) and Partially Observable MDPs (POMDPs) as a modelling basis. A potential advantage of starting with a Discrete Event model instead is the natural design process and the complexity reduction (with respect to MDPs and POMDPs), since a dynamic model is known and the search for optimal actions can be made in a reduced space. As an example, in POMDPs, the policy maps the probability density function (pdf) over the set of all possible states into an action; if we use a Discrete Event Observer for a Discrete Event System with unobservable events, we will know that, at a given step, the probability of being in a given state is zero, and the policy domain will be a pdf over the set of states with non-zero probability.

Cooperation takes place when, in addition to coordination, formal teamwork models are used. Petri nets (PNs) are especially interesting to model teamwork, as communication signals exchanged by the cooperating teammates often involve synchronization events and transition between discrete states. In PNs, the state information is distributed among a set of places which capture key conditions governing the system, and PNs have increased modularity for model-building. This way, one can build a PN model for the plan of each of the team generalized robots, and then add commitment and synchronization mechanisms, represented by Petri net modules, to establish a relation among the individual plans.

These are topics of 2 on-going PhD Theses at ISLab.

(Cooperative) Reinforcement Learning and Decentralized Sequential Decision Making – Reinforcement Learning has been widely applied in recent years to a wide number of task planning problems concerning a single agent. Most of those concern simulated environments and/or virtual agents, modelled as MDPs. New challenging problems arise when one considers real robotic agents, where partial and noisy observations are more realistic, leading to PODMP models, as well as when a robot team, acting cooperatively, attempts to learn and coordinate each individual robot plan. In fact, reinforcement learning can be considered as an approach to the solution of sequential decision making problems, in the more difficult situation where the model structure may be known, but not its parameters (e.g., transition probabilities in MDPs, as well as observation pdf in POMDPs). Furthermore, cooperation between agents/robots introduces new interesting issues, such as what should teammates share (e.g., policies, state values, world models) or whether they should use game theory to determine suitable equilibria, for the coordinated execution of robotic tasks.

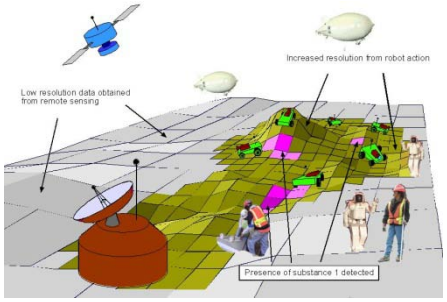
A project focusing on research on decentralized POMDPs and their use to address multi-robot task planning and control of irrigation water plants has been submitted to FCT in 2006. A Master Thesis on methods for cooperative reinforcement learning is close to be defended.

Reinforcement Learning helps programming an autonomous agent through humanlike objectives as reinforcements, where the agent is responsible for discovering the best actions to reach its objectives. Nevertheless, it is not easy to disentangle human objectives in reinforcement like objectives. Inverse Reinforcement Learning determines the reinforcements that a given agent behaviour is fulfilling from the observation of the desired behaviour. An on-going PhD Thesis concerns Inverse Reinforcement Learning topics, and to which extent behaviours learned using a reinforcement function estimated by inverse reinforcement learning can be transferred to robots with different skills and capabilities.

Navigation of Formation Flying Spacecraft – Formation control is currently a hot topic on most Control conferences and journals. Most of the work focus on rendez-vous problems, i.e., taking a set of robots to a pre-defined geometry (this is related to guidance problems, where optimal collision-avoiding trajectories are computed for this purpose), fine control, i.e., to keep the specified geometry, dynamically changing the geometry over time and also on making the formation geometry specifications flexible enough to avoid collisions with obstacles and/or within team members.

A considerable amount of work on Formation-Flying Spacecraft Guidance, Navigation and Coordination (GN&C) was also spent during this year, within the framework of the ESA project concerning a mission involving three spacecraft flying in formation for high resolution distant planet observations. A low-communication decentralized navigation algorithm was developed to estimate the 6 DoF (translational + rotational terms) full relative state of all the spacecraft using a full-order decentralized filter, based on an Extended Kalman Filter for local measurements, and on Covariance Intersection for the fusion between local state estimates and estimates communicated by other spacecraft, eliminating EKF divergence problems. The algorithm, developed as part of an on-going PhD Thesis, is innovative and displayed excellent results when tested on a realistic simulator of 3 spacecraft flying in formation in a Geostationary Transfer Orbit.

Cooperative Perception – Cooperative robots acting in complex unstructured environments brought a new view of sensors in Robotics: the robots became sensors themselves, in the wide sense of the word "sensor". Whether one thinks of teams of aerial and land robots searching for survivors of a natural disaster in joint work with humans and dogs also endowed with sensors and smart interfaces, or of robots at home interacting with active sensors located in key locations (e.g., a pan-and-tilt camera over a door to inform the robot of its relative location to the door), this new paradigm makes the robot, carrying its own sensors to measure relevant information for the application at hand (e.g., explosive and toxic gases in search and rescue operations), act as a mobile sensor which is part of a network of autonomous robots and humans carrying sensors, as well as of static sensors (e.g., pan-and-tilt cameras, temperature sensors). The network agents (static sensors and robots carrying sensors, as well as humans carrying sensors, all of them endowed with wireless communications capabilities) communicate with each other and cooperate to achieve collective goals. One major problem is how to handle both the uncertainty associated to the information provided by the sensors, and the diversity and amount of information available, when one attempts to improve the information about some specific feature. As an example, if a team of mobile robots and static sensors are deployed over a building section in order to detect and track specific moving objects, the issue is which information to use from the one provided by the different network agents, and how to combine it in a consistent way.

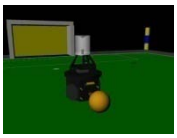


One of the current challenges in autonomous sensor and robot networks concerns the fusion of information from several sensors (some of them carried by mobile robots) to improve the accuracy in the cooperative localization of objects, or to help the wide-sense networked sensors to self-localize. Though many other approaches exist, our focus is on Bayesian approaches to sensor fusion and state estimation, including probabilistic sensor models and how to combine them to obtain a world model, as perceived by a multi-sensor robot, with associated uncertainty; networks of multiple autonomous agents, some of them static sensors, in the sense that they can not wander around, though they may possibly have a few degrees of freedom (e.g, pan-and-tilt cameras), others mobile platforms endowed with several sensors (e.g., cameras, laser, sonar), and how can they combine the information they gather about the world using Bayesian strategies.

One on-going PhD Thesis at ISLab covers some of these topics.

Multiple-Robot Middleware for Intelligent Decision-making - Most of current software architectures currently used with robotic systems enable creating robot testbeds, reducing the user burden concerning communications and data sharing, but requiring the user to define the information flow, decision components and execution flow. On the other hand, several behavior coordination frameworks are available, but usually they are not associated to a programming environment where robotic tasks are described at a reasonable level of abstraction (e.g., programming behaviors as state machines where states represent primitive actions).

In the past two years, brainstorming discussions were held among ISLab members concerning the desirable features of a multi-robot programming framework, namely seen as a development of the previous existing software architecture of the SocRob project. The discussions led to the specifications of the MeRMaID (Multiple-Robot Middleware for Intelligent Decision-making) framework. MeRMaID's goal is to provide simplified and systematic high-level behavior programming for multi-robot teams. It constrains, on purpose, some of the programmer's options, but it is designed to enable both arbitration and fusion behavior coordination mechanisms, as well as to accept plans described by state machines, Petri nets and other types of decision-making algorithms, including fuzzy-logic decision-making and rule-based systems. In 2006, significant progresses were made in the development of the framework first version, which is now available. It enables concurrent multi-platform programming, modularity (for flexible module replacement and easy module edition/modification), and independence from robot hardware (since it includes an Hardware Abstraction Layer). It is developed in C++ and currently runs under the Linux OS.



Two on-going Master Theses are focused on further developing MeRMaID, for usage in the ISocRob Middle-Size and Four-Legged teams (corresponding to different Operating Systems and low-level hardware) and in the new European URUS project. One strong bet of the group is currently to interface MeRMaID (and other existing applications) with realistic simulators, such as Webots (currently running the ISocRob Middle-Size team simulation) and USARSim (on-going efforts concern the integration of ISocRob Four-Legged team simulation and the simulation of RAPOSA and an aerial blimp robot), so as to ease the development efforts, before moving to the actual hardware.

2.2.2. COMPUTER AND ROBOT VISION LAB (VISLAB)

Vision is an extremely powerful sensing modality that allows many living beings to perceive the surrounding world and act accordingly. It provides information with a large spatial resolution and reasonable temporal dynamics, while allowing the measurement of multiple types of properties of the visual world: color, texture, motion, shape, contrast, etc.

Computer vision and image analysis can thus enable a large number of applications, like 3D reconstruction, motion analysis, video surveillance and robotics, to name just a few. More than ever before, the massive deployment and cost reduction of cameras as well as the availability of low-cost, powerful processors have contributed to an increasing number of application opportunities

The research conducted at the Computer and Robot Vision Lab - Vislab has two main goals: (i) the development of new methodologies and tools for computer and robot vision and (ii) demonstrate such methodologies in challenging applications that call for such new tools. The research is organized in two main lines:

- **Vision Based Control and Navigation**
- **3D Reconstruction, Motion Analysis and Surveillance**

a) Vision Based Control and Navigation

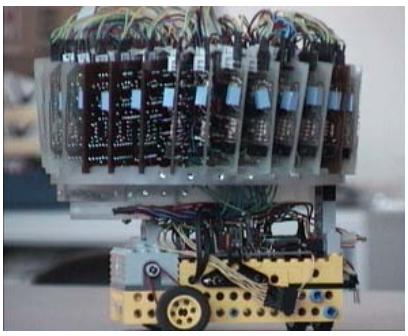
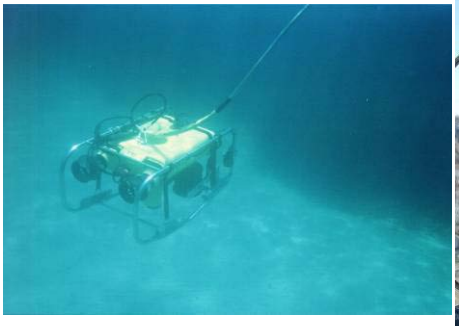
In this topic, we address the fundamental problem of understanding what *relevant* information can be extracted from an image sequence to *control* an artificial system (robot) in order to perform a *given task*. This has been a long standing research line of VisLab, with a particular emphasis on bio-inspired approaches. The bio-inspired approaches serve two complementary goals: (i) the development of flexible and robust artificial vision systems based on lessons learned from biology and (ii) contributing to a better understanding of natural vision systems through the process of building artificial systems in a biologically plausible manner. The following research topics are currently being pursued:

Visual Geometries: Natural vision systems have different geometries (e.g. compound versus corneal eyes). One of the research lines consists in designing non-conventional cameras (e.g. omnidirectional cameras, space-variant sensors) that may be more suitable for a class of visual tasks.

Vision based control/Active vision: the active control of the visual sensors may ultimately constrain and simplify the recovery of visual information. The design of vision-based control systems has been

tackled for a long time covering many types of robotic systems: mobile (land, air and underwater) vehicles, robotic heads, etc.

Visual Representations for navigation: Many studies in animal navigation suggest that metric localization is not always required. As a consequence, the computational effort can be dramatically reduced, when compared with systems that aim to perform highly accurate metric localization. We investigate visual representations that support navigation strategies that avoid metric localization.

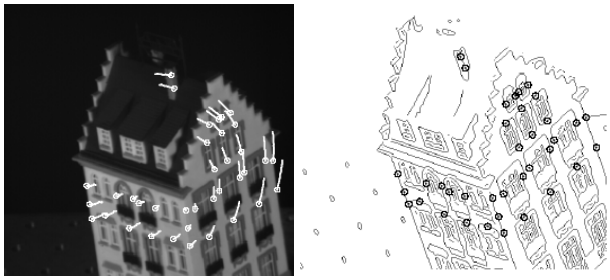

This line of research has evolved towards cognitive systems, with the ability to learn in an open-ended way from long periods of observation. For example, video surveillance systems can learn how to understand human behavior from video observations and adjust the system's performance to the actual observation context. Another example is the study of techniques allowing a complex system to develop and adapt over long periods of time.

In the recent years, this line of research has been carried out in the context of humanoid robots that learn how to perform complex tasks through observation. This work has been undertaken in a tight collaboration with neuroscientists and developmental psychologists. Neurophysiology tells us how the perceived information is processed in the brain and which brain areas are responsible for certain (visual) tasks.

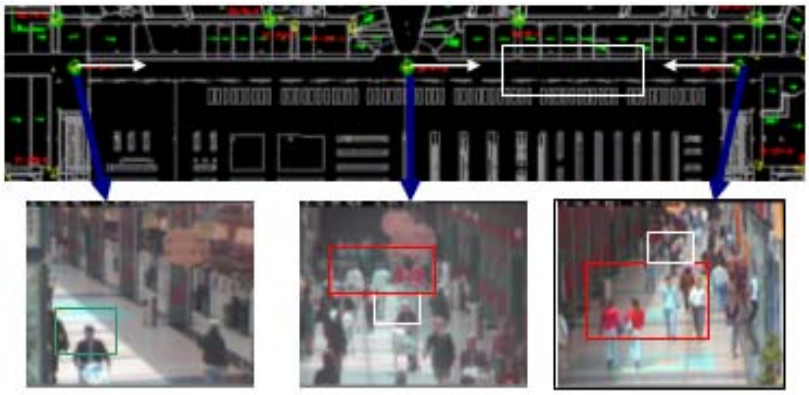
Our main experimental platform for this line of research is Baltazar, a humanoid robot with an articulated arm/hand and a binocular head (see photo). We investigate sensorimotor coordination, learning and programming by demonstration. To a large extent, this approach is inspired by the development of human infants. The robot first learns how to control its own body. Then, the robot starts exploring the surrounding objects. Finally, in the most advanced phase, the robot will interact with and learn from people.

b) 3D Reconstruction, Motion Analysis and surveillance

The theme of ***3D motion Analysis and Reconstruction*** is devoted to the retrieval of information about the scene structure (geometry) or camera motion from video sequences. Work has addressed the problem of estimating the 3D motion of a camera from an image sequence. Several visual cues were exploited for this purpose: the visual motion and occlusions. Regarding 3D reconstruction, work has focused on developing optimal approaches for matching image features, which is a fundamental step in most 3D vision systems. In addition, the depth estimation process has been formulated in an optimal way by itself.



Another vibrant line of research is that of video surveillance systems able to understand human activities. As the number of CCTV cameras deployed in public spaces grows very rapidly, it is no longer possible to rely on human operators to continuously monitor an overwhelming number of visual streams. Instead, we need systems that will interpret the human behavior in video imagery and call for the security operator attention only when an alarming event was observed. The research carried out in this domain included the definition of feature detectors and design of classifiers for the recognition of human activities.



Research in all these topics has been carried out both at the level of the fundamental methodologies and also for applications. As the knowledge in these various aspects matures inside the group, research projects have been proposed, including national and European Projects.

2.2.3. MOBILE ROBOTICS LAB (LRM)

The research interests of the people in the LRM span over the key areas in Robotics. Among these are the cooperation among multiple robots and the human-robot interaction. Both the former and the later encompass a broad range of frameworks and techniques. Control architectures, kinematics and dynamics modelling, networked robot systems are just some of the numerous topics addressed within cooperation. The interaction between humans and robotics has been addressed by the LRM researchers using concepts from semiotics. The basis components for a formal framework have been defined within national research projects and published in several international journals.

Multiple robotics applications are being considered at the LRM (see the projects section below). The research factor here is often reduced relative to the development and engineering aspects. Still, the technological development of several undergraduate projects fosters the research in areas such as companion and personal assistant robots.

We are also currently interested in topological navigation from multiple perspectives. After some previous work on topological mapping and localization, we are now interested in the problem of *navigation*. In single robot scenarios, this translates into the problem of a mobile robot moving from an initial state to a final state. We are currently using POMDPs (partially observable Markov decision processes) to model this class of problems and studying how adaptive/learning algorithms can be applied to tackle this class of robotic tasks.

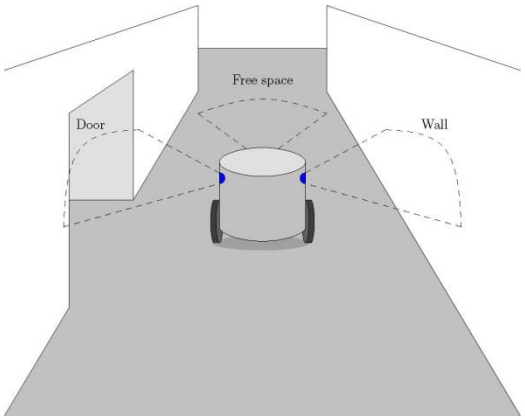


Fig. 1. Typical setting considered in single-robot topological navigation tasks.

We are also considering multi-robot versions of this problem, where a team of robots must move from an initial configuration to a target configuration. To address this complex problem we adopt the model of POSG (partially observable stochastic games) and have been developing adaptive/learning methods that allow the team of robots to coordinate in this task (avoiding collisions, for example) with minimum communication.

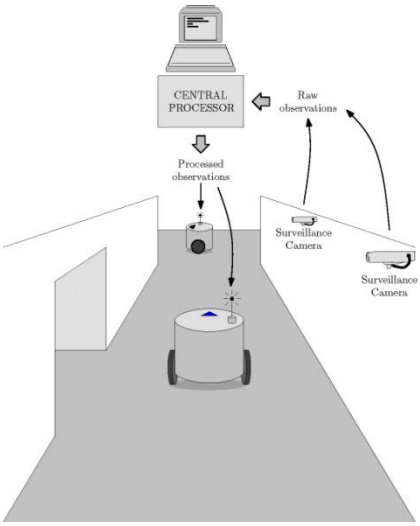


Fig. 2. Typical setting considered in multi-robot topological navigation tasks.

2.2.4. SIGNAL AND IMAGE PROCESSING GROUP (SIPG)

Research at the Signal and Image Processing Group (SIPG) focus on the development of fundamental theory for signal processing on manifolds, e.g., performance bounds, optimization algorithms, filtering, manifold learning. Application areas are: wireless communications, including blind equalization and source separation; underwater, including acoustic communications and video compression and analysis; time-frequency analysis; genomic signal processing; image analysis, including statistical modeling; and video processing, including motion estimation, tracking of deformable models and inference of 3D structure.

2.2.5. EVOLUTIONARY SYSTEMS AND BIOMEDICAL ENGINEERING LAB (LASEEB)

The research work of this group focus on biologically inspired new algorithms and paradigms for search and optimization and biomedical signal and imaging processing algorithms. The potential of the results have been demonstrated in applications. A few recent results will be presented below.

In the Evolutionary Algorithms: The extension and validation of adaptation of the Olive Fly Model (*Bractocerao olea*) using Evolutionary Approach has captured new interest, namely with Bayer Department of Plant Protection, where a field validation program is still on going. The first results are shown in the following figures:

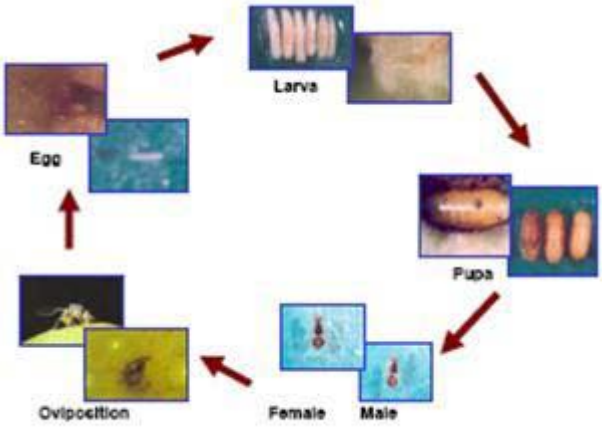


Fig. 1. Olive fly's cycle.

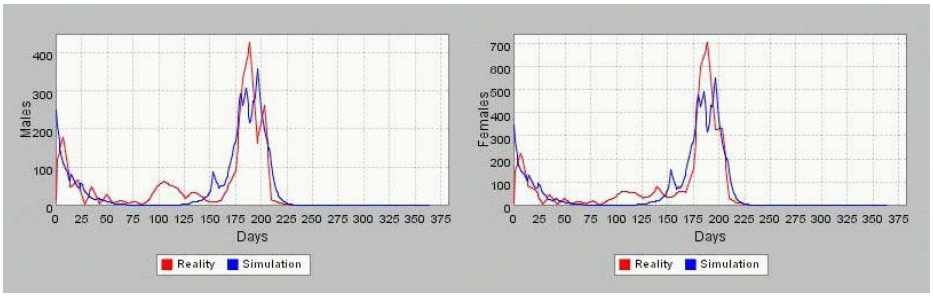


Fig. 2. The simulated population and capture data for male and female adults.

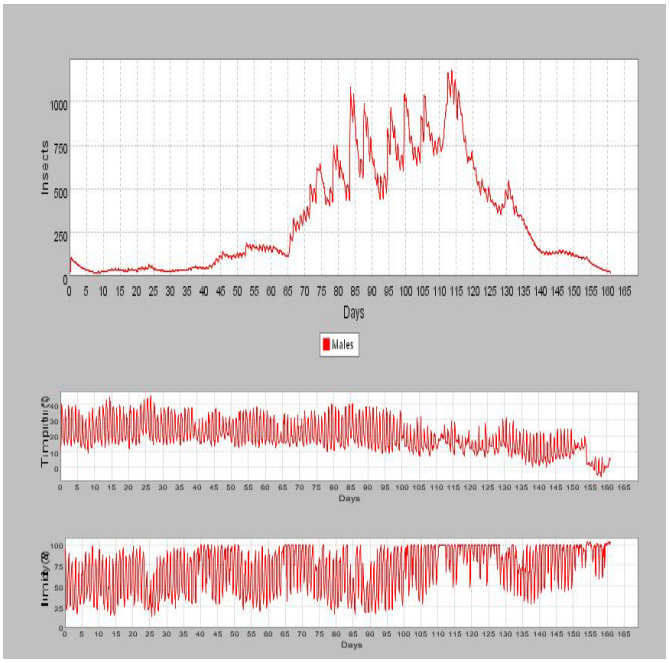


Fig. 3. Simulation of the male adult fly's population.

A new topic of research in this area is the use of Swarm Stigmergy and Self-organization paradigms for edge extraction and image segmentation. Example comparative results are shown in the figure below:

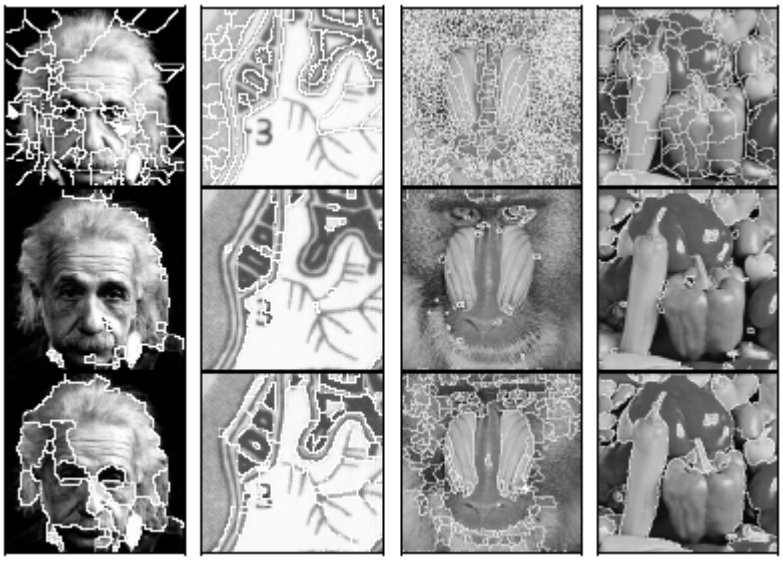


Fig. 4. Segmentation of images *Einstein, Map, Baboon, Peppers* with classical Watershed algorithm (1st row) and a Watershed algorithm based on SFPS (2nd row) and SVPS (last row) pheromone maps.

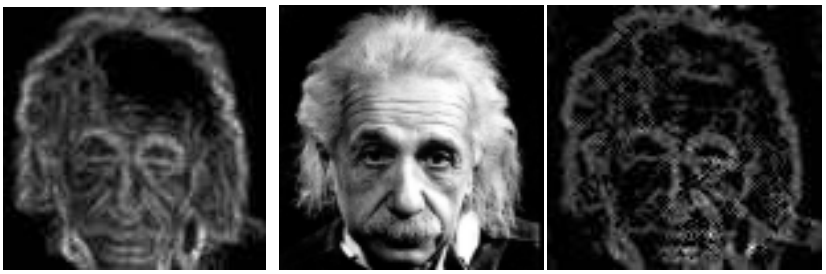


Fig. 5. From left to right, original image, pheromone map after 50 and 100 iterations.

Also under varying environment and population size. More efficient strategies have been devised for dynamic environment with objective switching.

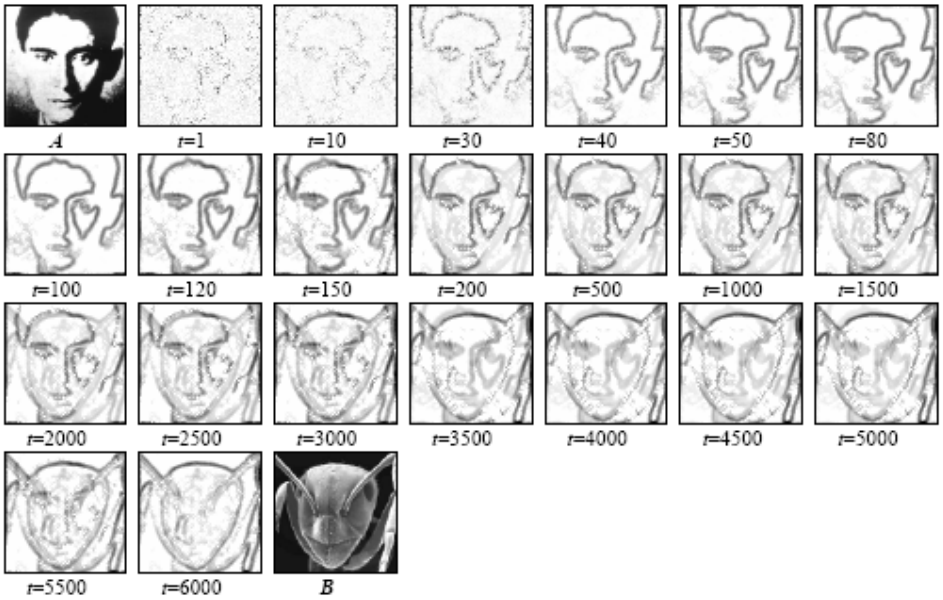


Fig. 6. One swarm (3000ants) is thrown to explore *Kafka* digital image (A) for 6000 iterations. At *r*=100, the *Kafka* image *habitat* is replaced by *Red Ant* image (B). Evolutions of swarm cognitive maps (pheromonal fields) are shown for several iterations. Darker pixels correspond to higher concentrations of pheromone.

A new hybrid evolutionary algorithm based on simulated annealing and applied to automatic weekly time tabling has been implemented and a screen shot of the program output is shown below:

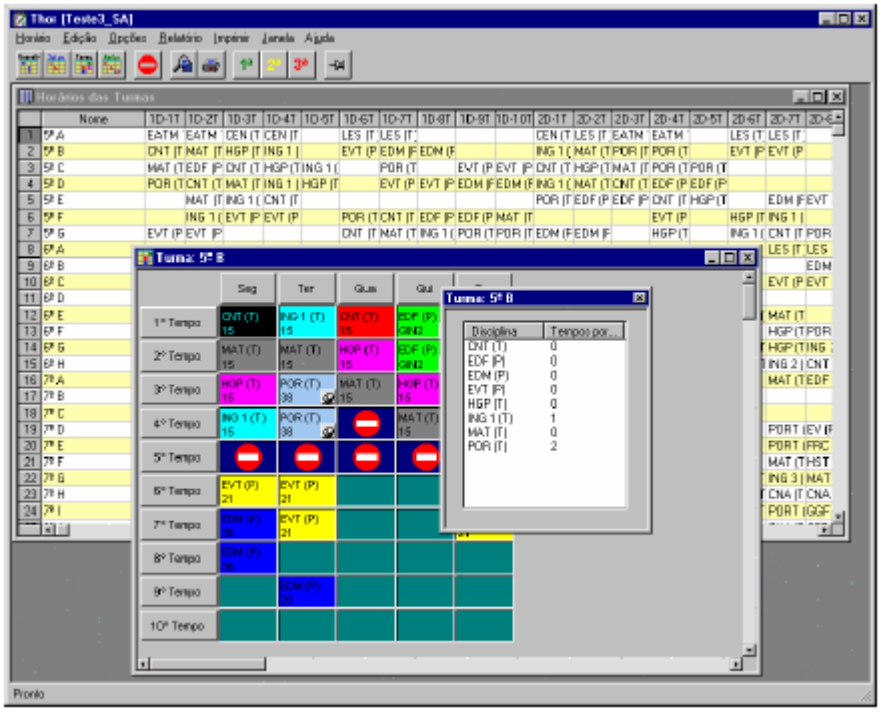


Fig. 7. Graphical user interface.

In the Biomedical Engineering area, the group has contributed to the research and normalization in young children population of the Cyclic Alternating Pattern paradigm for NREM sleep microstructure. A full study on Excessive Daytime Sleepiness has been started in collaboration with the State University of Sao Paulo (UNESP). The Classification and Dynamic organization of Phasic Events in the Sleep EEG code named "ascending Activation is currently applied to the EDS project.

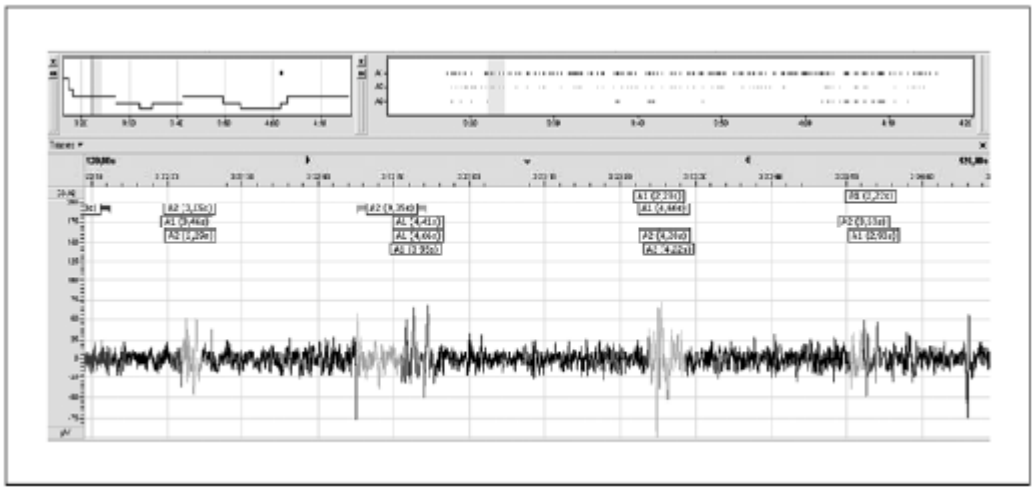


Fig. 8. Stage 2, 2 minutes epoch scorings

A new tool that performs interactive enhancement of digital mammograms making easier the optical perception and evaluation of breast masses from surrounding tissue. The tool is based on the Interactive Evolution of a Density Weighted Contrast Enhancement (DWCE) filter. After an average of 25 interactive enhancements of a given digital mammogram, the physician is able to obtain a good enhancement according to his/her particular criteria of analysis) of suspicious formations in the breast tissue. Results are presented using digital mammograms from the Digital Database for Screening Mammography (DDSM) available from the University of South Florida (USF).

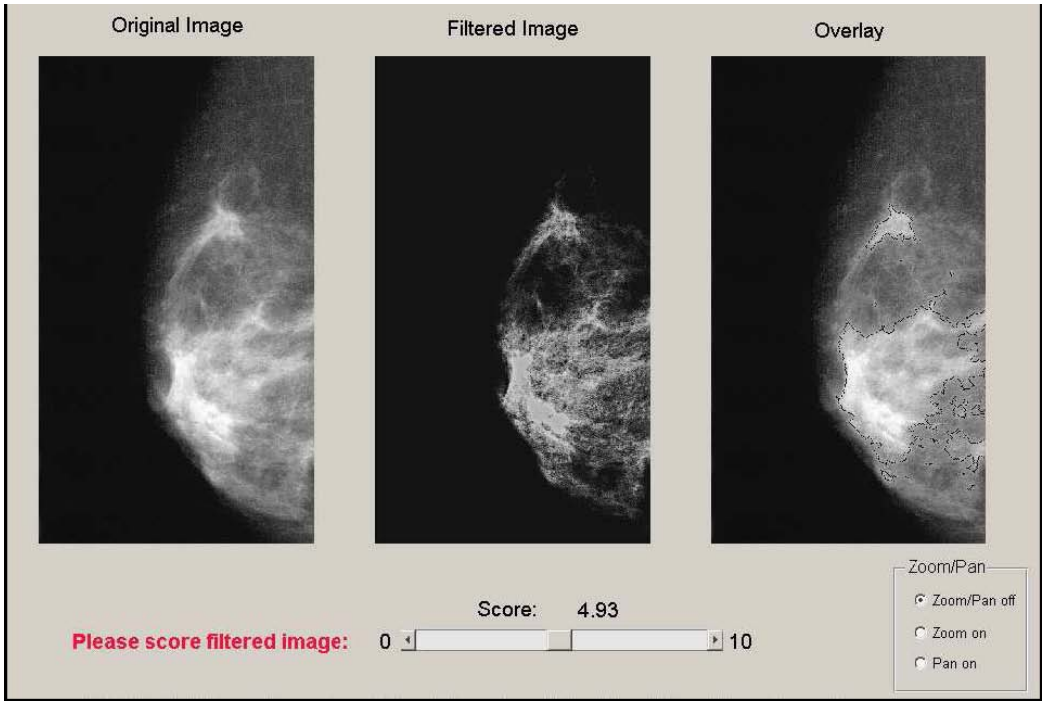


Fig. 8 – Manual scoring interface.

2.2.5. DYNAMICAL SYSTEMS AND OCEAN ROBOTICS

From an engineering standpoint, a large spectrum of problems was addressed, the solutions of which are key to the development of advanced technology for marine exploration. Theoretical work focused on algorithms for navigation, guidance, and control of autonomous systems, as well as coordinated motion control of multiple heterogeneous uninhabited systems. Especially relevant were the development of new methodologies for robust adaptive control of highly uncertain systems, vision-based pose estimation and motion control, acoustic and geophysical-based navigation, trajectory tracking and path following for marine and aerial vehicles, and coordinated control of multiple marine vehicles in the presence of stringent communication constraints. Work was also done towards the development (and at sea testing) of the network tomography concept for rapid environmental assessment: data fusion based on 3D empirical orthogonal functions and coherent spatial matched filtering.

From a practical standpoint, 2006 witnessed the participation of ISR researchers in i) tests with the MAYASub AUV in Goa (India) in the scope of a joint Indo-Portuguese project in which the IMAR-DOP/UAç also participates, ii) tests with the MEDIRES platform for automatic breakwater surveying in Sines, and iii) the MOMARETO cruise in the Azores, where, in cooperation with the IMAR/DOP/UAç, instrumentation and algorithms for acoustic backscatter data acquisition were used to automate the process of marine habitat mapping classification near deep water hydrothermal vents. The year 2006 witnessed also the start of three large European projects in the general areas of marine science, underwater archaeology, and marine robotics.

3. RESEARCH ACTIVITIES

3.1. RESEARCH PROJECTS

This section contains a brief description of the R&D projects in progress at ISR (Lisbon), IST and University of Algarve during 2006, under the supervision of ISR members. The subsections define the main areas of intervention where the projects are being developed. The projects resulting from contracts celebrated with ISR and managed by this private research institution are identified by (*) on the title; all the remaining projects refer to contracts celebrated and managed by IST and University of Algarve.

3.1.1. UNDERWATER AND OCEAN ROBOTICS

Project name: RUMOS - ROBOTIC UNDERWATER VEHICLES AND MARINE ANIMALS TRACKING SYSTEMS

Project leader within ISR: Prof. Paulo Oliveira (ISR/IST)

Project description: The main purpose of the project is the development of a set of devices and methodologies for precise estimation of trajectories of underwater robotic vehicles (autonomous and remotely operated) and marine animals.
In order to overcome the problems that occur due to the highly noise environment and the presence of a multitude of disturbances a number of efforts must be set forth to overcome the problem at hand.
The topics include:
i) Mission scenario characterization;
ii) Development of high gain power amplifiers for acoustic wave generation;
iii) Development of very-low noise acoustic data acquisition systems;
iv) Study and development of accurate navigation algorithms for sensor fusion;
v) Development of post-processing techniques for very precise trajectories estimation;
vi) Accurate and real-time monitoring of 3D trajectories in selected coastal and oceanic fish species.

Research Areas: Underwater Positioning Systems, Tracking Systems, Sensor Fusion, Behavior and Ecology of fishes
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL)
External Partners: IMAR/ Department of Oceanography and Fisheries, Univ. Azores
Initiated: December 2005
Conclusion: December 2008
Classification: POCI/MAR/55609/2004
Documents produced in 2006:

♦

Project name: MAYASub – DEVELOPMENT OF A SMALL AUV FOR SCIENTIFIC AND COMMERCIAL APPLICATIONS

Project leader within ISR: Prof. António Pascoal (ISR IST)

Project Coordinator: Prof. António Pascoal (ISR/IST)

Project description: The key objective of the project is to develop and demonstrate the performance of a small, modular, autonomous underwater vehicle (AUV) for scientific and commercial applications. Envisioned missions include geological and oceanographic surveys, marine biology studies, marine habitat mapping for environmental management, inspection of harbours and estuaries, and marine pollution assessment, to name but a few. Vehicle miniaturization will be achieved by resorting to small embedded processors, miniaturized sensors, and high performance actuators.

Modularity will allow for easy vehicle reconfiguration according to different mission scenarios. Reduced weight will make it possible to launch and retrieve the vehicle by resorting to small ships of opportunity. The ultimate goal of the project is the development (by a Portuguese-Indian consortium) of two copies of a highly reliable mobile platform that will act as a natural extension of its support ship, effectively allowing an operator to probe the surrounding 3D environment from the comfort of his/her lab at sea.

In 2005 the design of the systems for navigation, guidance, and control of the MAYA_type AUU was consolidated. The first tests with the control systems for the vertical and horizontal plane will take place in Goa, India in February-March 2006. At a mechanical/electrical level, the work focused on the study of a safety device for weight release upon vehicle failure detection as well as on the control plane (fins) arrangement for increased maneuvering performance.

The MAYA AUV – Mechanical Design of the NIO, India

Research Areas: Marine Vehicle Design, Hydrodynamic Parameter Estimation and Identification, Navigation, Guidance, and Control, Acoustic Marine Sensors, Underwater Positioning and Communications
Laboratories: Dynamical Systems and Ocean Robotics Lab (DSORL), VISLAB
External Partners: RINAVE (PT), IMAR/DOP/Univ. Azores (PT), National Institute of Oceanography (NIO) , Dona Paula, Goa, India, System Technologies (ST), Ulverston, UK
Initiated: January 2003
Expected conclusion: July 2007
Classification: AdI (Agência de Inovação)
Documents produced in 2006:

♦

Project name: EXOCET/D – Extreme ecosystem studies in thr deep Ocean: Technological Development

Project leader within ISR: Prof. António Pascoal (ISR/IST)

Project Coordinator: Dr. Pierre Marie Sarradin, IFREMER (FR)

Project description: The aim of this project is the technological development of a specific instrumentation suite allowing the study of natural or accidentally perturbed ecosystems found in the deep ocean. These

ecosystems are related to the emission of reduced fluids (cold seeps, hydrothermal vents), peculiar topographic structures (seamounts, deep corals), massive organic inputs (sunken woods) or to unpredictable events (pollution, earthquakes). Beside their insularity in the abyssal plain, the targeted ecosystems are characterised by patchy faunal distributions, unusual biological productivity, steep chemical and/or physical gradients, high perturbation levels and strong organism/habitat interactions at infra-metric scales. Their reduced size and unique biological composition and functioning make them difficult to study with conventional instrumentations deployed from surface vessels. Their study requires the use of submersibles able to work at reduced scales on the seafloor as well as the development of autonomous instruments for long-term monitoring (seafloor observatories).

The general objective of the EXOCET/D is to develop, implement and test specific instruments aimed at exploring, describing and quantifying biodiversity in deep-sea fragmented habitats and to identify links between community structure and environmental dynamics. Inboard experimental devices will complement the approach, enabling experiments on species physiology. The EXOCET/D working fields include: video and acoustic imagery; *in situ* analysis of habitat chemical and physical components; quantitative sampling of organisms; *in vivo* experiments; 4D integration of multidisciplinary data; implementation on European deep-submersibles as well as validation during demonstration actions. The *work of IST/ISR focuses on the development of the acoustic systems that are required to acquire acoustic backscattering data obtained with a mechanical scanning pencil beam sonar.* The data will be used for remote marine habitat classification. The final system developed by IST/ISR will be installed on-board the VICTOR ROV, property of IFREMER, for inspection of deep water hydrothermal vent communities during a cruise that will take place in August 2006. The figures below illustrate part of the activity developed in the course of the project.

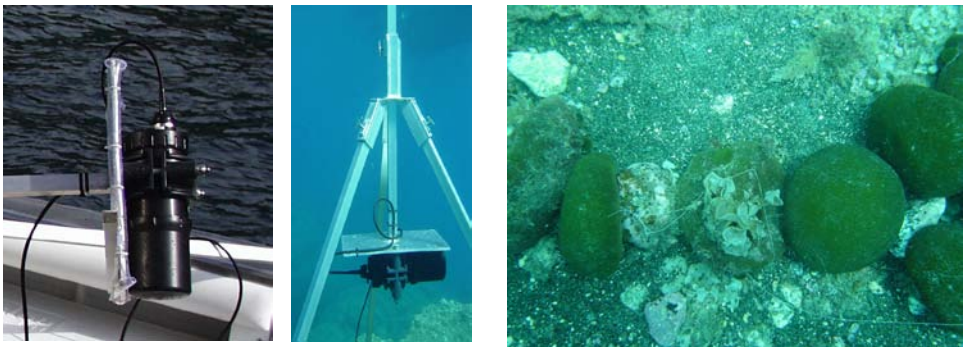


Fig. B.

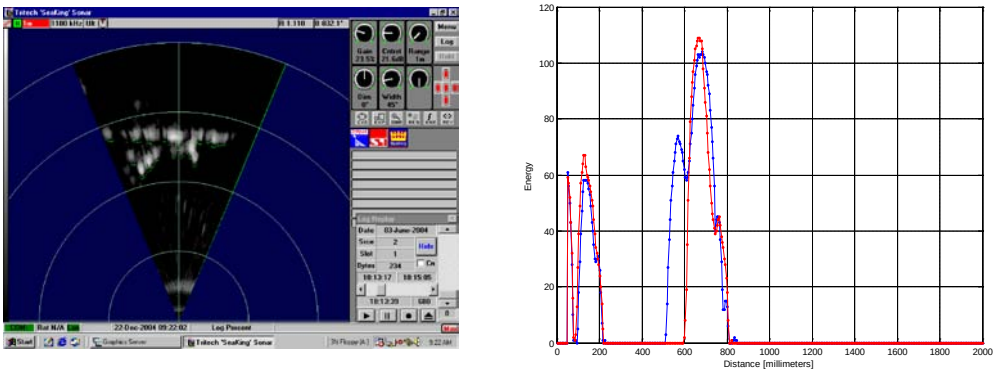


Fig. C

Figure B. Left: view of mechanical scanning sonar: Middle: the sonar installed underwater; Right: organisms (algae) to be identified remotely.

Figure C. Left: sonar image obtained underwater. The "image" of the organisms on the seafloor is visible; Right: data acquired showing the backscatter data. The second sequence of impulses represents "true" backscatter.

Research Areas: Acoustic data acquisition and processing, real time-systems, navigation
Laboratories: DSORLab
External Partners: IFREMER (FR), IMAR/DOP/Univ Azores (PT), AWI (GER), UPMC (FR), CNRS (FR), Cardiff University (UK), Heriot-Watt Univ. (UK), U. Algarve (PT), Univ. Bremen (GER), SeeByte (UK), Systea (IT), Capsum Gmbh (GER), and KC-Denmark (DK)
Initiated: January 1, 2004
Expected conclusion: December 31, 2006
Classification: EC funded project, 6th Framework Programme
Documents produced in 2006:

♦

Project name: **MEDIRES –** METODOLOGIAS DE DIAGNÓSTICO E INSPECÇÃO ROBOTIZADA DE ESTRUTURAS SUBMERSAS (Methodologies for Surveying and Diagnosis of Semi-submerged Structures)

Project leader within ISR: Prof. Carlos Silvestre (ISR/IST)

Project Coordinator: Dr. João Alfredo Santos (LNEC)

Project description: The cost of a rubble-mound breakwater, its expected behaviour, as well as the consequences of its failure, do justify the existence of a monitoring programme which helps in the decision making process relative to the timing of the maintenance, or even repair, works. However, the continuous monitoring of the status of any given breakwater stretch is not yet feasible. That is why the most common procedure consists of the periodic inspection of these structures. The goals of the MEDIRES project are twofold:

I- To use the latest technological breakthroughs in positioning, navigation and control of surface autonomous vehicles to develop new techniques for accurate and efficient inspection of the geometry of semi-submerged structures with application to rubble mound breakwaters. This activity will end up with the development of a tool, named IRIS, for high accuracy surveying of both the above water and submerged parts of the armour layer of rubble-mound breakwaters (or semi-submerged structures, in general). This tool that can be used in autonomous mode or equip an Autonomous Surface Craft to produce tri- dimensional surveys with the spatial regularity required to this kind of structures;
II- To condense the large volume of data from the periodic inspections into a small set of parameters that enables the characterization of the structure's status and evolution. The definition of the parameters thresholds, needed for the structure's diagnosis, will be based on LNEC's past experience as well as on results from scale model tests.

The tool (IRIS) will be designed to equip the autonomous catamaran DELFIMx. Within the framework of this project, accurate path following control and navigation systems will be developed in order to guarantee the repeatability of the maneuvers so as to ensure the quality of the survey data sets obtained. Nevertheless, the IRIS can be used in standalone mode without the autonomous vehicle.

The autonomous catamaran, named DELFIMx, is capable of following pre-assigned trajectories with a high level of accuracy. It is equipped with two back electrical thrusters and can travel at a maximum speed of 5 knots. In order to determine its position and speed it uses differential GPS and an attitude reference unit. Using the information available from its motion sensor suite the catamaran DELFIMx computes its actual position and orientation and respective velocities.A real time computer network developed at the Institute for Systems and Robotics is used in the autonomous vehicle DELFIMx. This network was specially designed for multi-vehicle robotic applications, uses wireless modems, and implements TDMA (Time Division Multiple Access). The network will effectively allow an operator to supervise the IRIS tool during the survey. Figure 2 depicts the concept of the Catamaran DELFIMx equipped with the IRIS,

during a typical breakwater survey. The figure shows how the tool is placed in the Catamaran and illustrates how the 2D laser range finder and the sonar profiler can be used in a breakwater survey mission.

The inspection techniques to develop within the framework of this project will be tested in Sines' West breakwater and in the breakwater of the Avilés port (in Astúrias, Spain). Several surveys will be conducted during the project, to identify and tune the algorithms and tools for online data set acquisition and off-line processing.

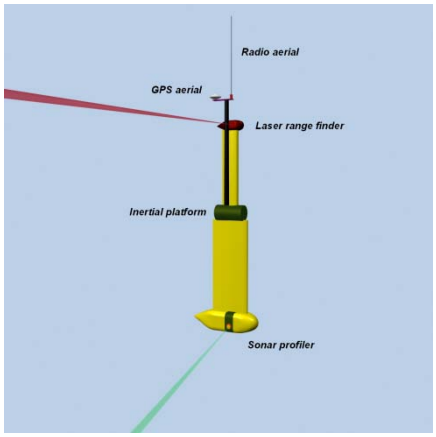


Figure 1

Figure 2

So far, two surveys of the armour layer of Sines west breakwater were carried out with IRIS. The first one took place on June 2003, while the second took place in June 2004. In the 2003 survey, the first time ever IRIS was used, it become obvious that at least two not so small details had been overlooked that far.The first one was related to the measurement of the Earth magnetic field that was fundamental to find the IRIS' heading. In order to get heavier Antifer cubes at the head of the breakwater, hematite, an iron ore, was included in the concrete aggregates. That is the cause for the darkish area at the breakwater head in the pictures of Sines west breakwater. This means that the heading measurements from the electronic compass were disturbed by the structure. This problem lead to the development of the procedure to estimate the IRIS heading that is now implemented: two GPS receivers, one at the fore and another at the aft of the support vessel give the vessel's heading and IRIS heading.

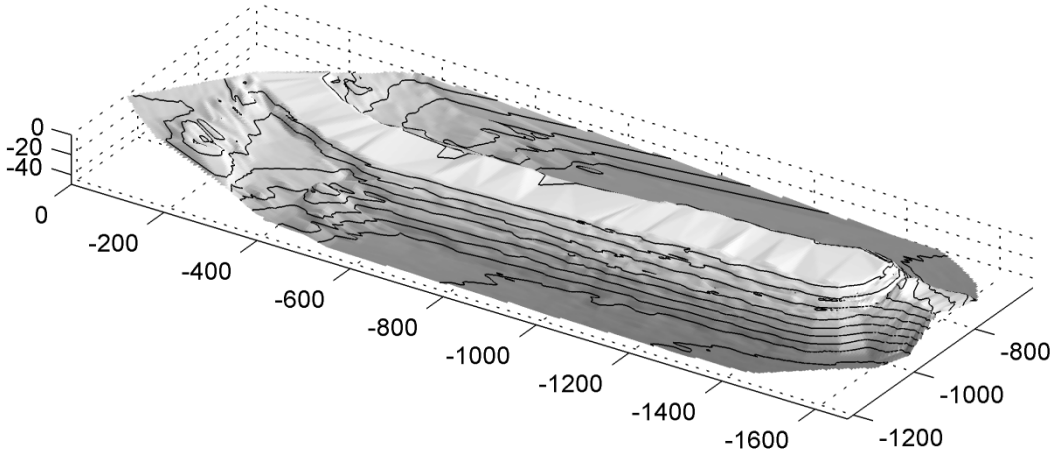
a)  b) 

Figure 3. The IRIS high accuracy measuring device. a) Detail of the mechanically scanned high aperture sonar profiler; b)View of IRIS installed in the support vessel.

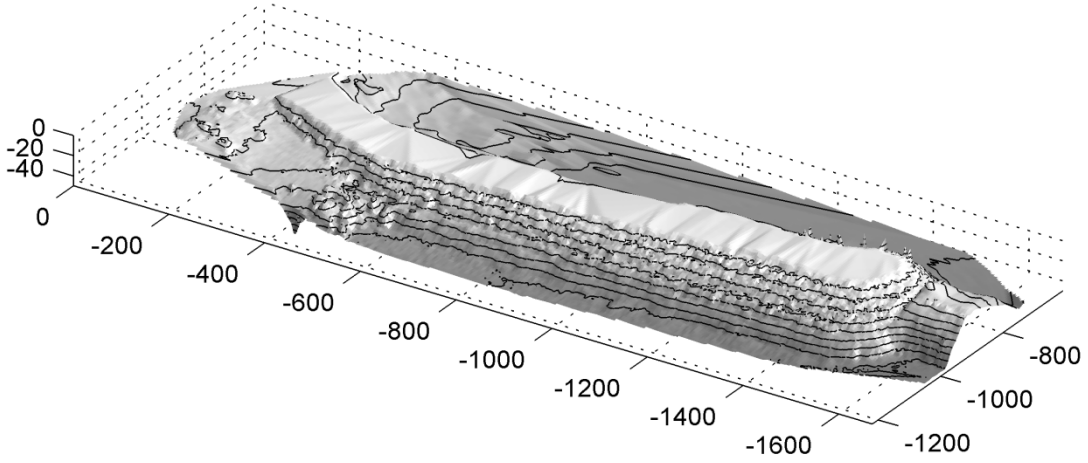
So far, the MEDIRES project produced a pre-prototype of the high-accuracy measuring device that is presented in Figure. 1. It surveys only the submerged part of rubble-mound breakwaters. The figure

shows a detail of the mechanically scanned high aperture sonar and the IRIS pre-prototype mounted on the support vessel.

Figure 4 shows that the survey produced by IRIS is quite comprehensive. Instead of an ensemble of surveys from sections along the breakwater, one has a very good scan of the armour layer (in this part of the structure alone 63969 points were surveyed). This large number of surveyed points implies a finer detail in the description of the armour slope, as can be seen in the figure.



a) Previous Survey



b) IRIS Survey

Figure 4. a) Perspective of the surface obtained with the points previously surveyed; b) Perspective of the surface obtained with points surveyed by IRIS.

A key point in that project is the development of IRIS - a measuring device for high accuracy surveys of both the submerged and emerged parts of those structures. The surveys obtained with the pre-prototype of IRIS, which is only able to survey the submerged part of the armour layer showed that a good scan of this part of the structure can be obtained.

Research Areas: Real Time Architectures, Inertial Navigation, laser and acoutic mapping.
Laboratories: DSOR, VISLAB
External Partners: Laboratório Nacional de Engenharia Civil, Lisbon, Portugal. Administração do Porto de Sines, Sines Portugal. Autoridade do Porto de Avilez, Avilez, Espanha
Initiated: March 1, 2003
Expected conclusion: June 30, 2007
Classification: AdI (Agência de Inovação)
Documents produced in 2006:

3.1.2. COOPERATIVE ROBOTICS

Project name: SocRob – SOCIETY OF ROBOTS OR SOCCER ROBOTS

Project leader within ISR: Prof. Pedro Lima (IST/ISR)

Project description: This project fosters general research on cooperative robotic systems, aiming at introducing methodologies for collaborative teamwork (including topics such as role assignment, cooperative plan representation, cooperative learning, cooperative perception), driven by results from Multi-agent and Discrete Event Systems theory. Its current case study is on Soccer Robots, with regular participations in RoboCup.

The major contribution on this period concerned the development of Version 1.0 of the MeRMaID (Multiple-Robot Middleware for Intelligent Decision-making), which has been under development at ISR/IST since mid 2005, building on the team previous experience (since 1999) with a C-based multiple-thread software development environment, implemented to program and operate ISR soccer robot team ISocRob. MeRMaID' goal is to provide simplified and systematic high-level behavior programming for multi-robot teams. It constrains, on purpose, some of the programmer's options, but it is designed to enable both arbitration and fusion behavior coordination mechanisms, as well as to accept plans described by state machines, Petri nets and other types of decision-making algorithms, including fuzzy-logic decision-making and rule-based systems. Its current version enables concurrent multi-platform programming, modularity (for flexible module replacement and easy module edition/modification), and independence from robot hardware (since it includes an Hardware Abstraction Layer). The supporting software is based on the *active object* design pattern. In Object-Oriented Programming, active objects are objects that decouple method execution from method invocation, in order to simplify synchronized access to an object that resides in its own thread of control. These objects retain their own execution context and execution flow. MeRMaID is developed in C++ and currently runs under the Linux OS. A Webots-based simulator has also been developed, enabling testing the actual code of the robots in their simulated counterparts. This is a powerful tool to speedup the design and test of individual and relational behaviors, before running them on the real robots. MeRMaID has been tested with 3 simulated robots, each running its code in a different computer, and all playing on the Webots machine.

Significant research progresses were made on multi-sensor fusion for object location, using methods that fuse *a priori* probability density functions of general shape, representing the belief of the different robots on the object location. For this purpose, we had studied Gaussian models before. In that case, sensor fusion, including tests for disagreement among sensors, was significantly simpler than in the general (possibly multimodal) case. The latter can be handled using entropy both as a measure of (dis)agreement and of improvement when two or more sensor measurements are fused.

Further work was done on applying Kalman filtering and Monte Carlo Localization methods to the self-localization of soccer robots in a RoboCup MSL field, using vision and odometry, as well as on using fuzzy decision making methods to coordinate the behaviors of a robotic goalkeeper for the RoboCup MSL team. Formation control and coordinated passes have been also implemented in the SONY AIBO ERS-7 robots of the ISocRob 4LL team.

Research Areas: Sensor Fusion, Cooperative Perception, Multi-Agent Systems, Teamwork, Discrete Event Systems.

Laboratories: Intelligent Systems Lab

Initiated: January 1997

Expected conclusion:

Classification:

Documents produced in 2006:

Project name: Euron Research Atelier on Networked Robot Systems

Project leaders within ISR: Prof. João Sequeira and Prof. José Santos-Victor (IST/ISR)

Project description: This Research Atelier aimed at assessing the state of the art in Networked Robot Systems and producing a Roadmap report for the funding entity, the Euron Consortium. The UPC coordinated the project.

Research Areas: Cooperative Robotics
Laboratories: Mobile Robotics Lab, Vision Lab
External Partners: IST, UPC, UniZar, SSSA, UniSurrey, CNRS/LAAS, ETHZ, AICIA
Initiated:
Conclusion: December 2006
Funding agency: EU – EURON - RA-507728

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Project name: URUS**-** Ubiquitous Networking Robotics in Urban Settings

Project leaders within ISR: Prof. João Sequeira and José Santos-Victor (IST/ISR)

Project description: This project aims at developing and testing robotics networked systems for assistance and surveillance in urban areas.
Currently available technologies and infrastructures enable that a team of heterogeneous robots can coordinate among themselves, using the information both from multiple fixed sensors and from sensors onboard the robots.
The URUS project focuses on the development of a network of robotic agents able to interact with people in urban environment in guiding, assistance, transportation and surveillance tasks. Besides the robots, this network includes image (cameras) and acoustic (sonar) sensors, and smart devices for human-robot interaction such as PDA's and mobile phones.
Demonstration experiments will take place in an urban area in the city of Barcelona.

Research Areas: Cooperative Robotics, Human-Robot Interaction, Navigation
Project partners: Instituto Superior Técnico (IST), Universitat Politecnica de Catalunya (UPC), Universidad de Zaragoza (UniZar), Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna (SSSA), The University of Surrey (UniSurrey), Centre National dela Recherche Scientifique (CNRS/LAAS), Eidgenoessische Technische Hochshule Zurich (ETHZ), Robotech SRL, Telefonica Investigacion y

Desarrollo SA Unipersonal, Agencia d'Ecologia Urbana de Barcelona, Associacion de la Investigacion y Cooperation Industrial de Andalucia (AICIA)
Laboratories: Mobile Robotics, Vision Lab, Intelligent Systems Lab
Initiated: Sept.2006
Expected conclusion: Sept.2009
Classification: FP6-2005-IST-6-045062

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Project name: Swarm Intelligence for Cooperative Control of Multiple Robots

Project leader within ISR: Prof. João Sequeira (IST/ISR)

Project Description: This project aims at developing techniques for the coordination of multiple robots in indoors surveillance missions. The basic control primitives are inspired in animal and insect populations. Figure 8 shows an aspect of the environment where the works are currently being undertaken. The infrastructure is shared with the SACOR project described next.
Project results are to be presented at the 13th IEEE IFAC International Conference on Methods and Models in Automation and Robotics, MMAR 2007, 27-30 August, Szczecin, Poland, 2007.

Figure 8: The indoor environment to test swarm techniques in surveillance missions

Research areas: Cooperative Robotics
Laboratories: Mobile Robotics Lab
External Partners: Cranfield University, UK.
Initiated: January 2006
Conclusion: Abril 2007
Classification: Windsor Treaty Programme / Anglo-Portuguese Action B-11/06

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Project name: SACOR - Semi-Autonomous Cooperative Robots

Project leader within ISR: Prof. João Sequeira (IST/ISR)

Project Description: This project aimed at studying the fundamental concepts in control architectures for semi-autonomous robots. The proposed architecture uses concept from viability theory and hybrid systems.

Along the project, an experimental setup has been developed in the Mobile Robotics Lab to test the theoretical ideas developed. This setup, including both the hardware and software techniques, was also made available to other projects, such as the Action B-11/06 project mentioned above.
Figure 8 shows a view of the Mobile Robotics Lab with a set of cameras mounted on the ceiling. These are used to provide target detection and robot localisation which are used by the set of robots to, cooperatively, execute tasks such as blocking an intruder. Figure 10 shows a robot approaching a target (marked with in bright red to simplify detection). Figure 11 shows trajectories obtained with, real, Nomad Scout robots in this environment.

Figure 10: Scout robot approaching a bright red target

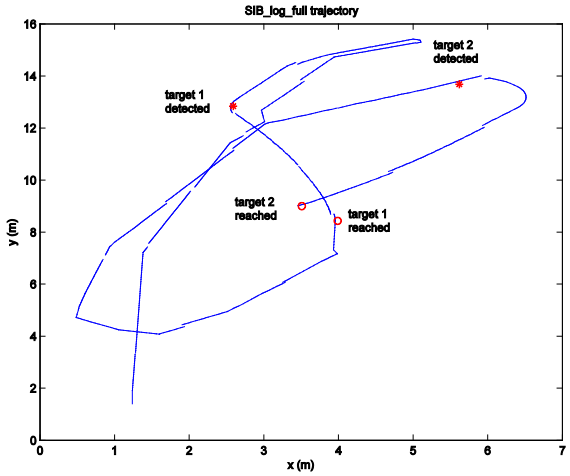


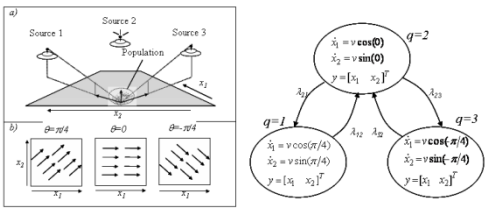
Figure 11: Typical trajectories obtained during a mission with multiple targets

Research areas: Cooperative Robotics
Laboratories: Mobile Robotics Lab
External Partners: None
Initiated: 2002
Conclusion: December 2006
Classification: FCT - POSI/SRI/40999/2001

3.1.3. ROBOTICS APPLICATIONS

Project name: EURON – EUROPEAN ROBOTICS NETWORK

Project leaders within ISR: Prof. Pedro Lima (member of the Dissemination Key Area Committee Member), Prof. M. Isabel Ribeiro (member of Education Key Area Committee Member)



Project description: The objective of EURON is to implement and maintain a network of excellence that allowed coordination of research, teaching and education, academic-industry collaboration, and publications and conference in the area of robotics, and facilitated addressing of issues of interest to institutions and companies throughout Europe. The aim is to provide a fruitful basis that allows Europe to remain at the forefront of Robotics both in terms of research and industrial products.

In 2006, ISR/IST was distinguished by EURON in two fronts (see Awards section):

- Dejan Milutinovic's PhD Thesis "Stochastic Model of Micro-Agent Populations" was the runner-up of the EURON's George Giralt PhD Award for the best European PhD thesis in Europe in 2005, leading to an invitation to write a book, co-authored by Pedro Lima, for the STAR Series of Springer Verlag to be published in 2007;
- The RAPOSA robot was selected as one of the four finalists of the EURON Technology Transfer Award 2006.

Research Areas: Robotics (all contributing fields).
Laboratories: Intelligent Systems Lab, Mobile Robotics Lab, Computer Vision Lab
Initiated: December 2003
Expected conclusion: December 2008
Classification: EC Contract No. Contract nº 507728
Documents produced in 2006:

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Project name: RIOL - Robotic Inspection over Power Lines

Project leader within ISR: Prof. João Sequeira (IST/ISR)

Project description: This project aims at developing a prototype robot able to move on electric power lines for inspection tasks, wildlife monitoring and forest fire detection.

Preliminary studies were based on the simple 2-link structure of Figure 3. Though the dynamic behaviour is acceptable, e.g., with good robustness to typical disturbances, this structure tends to demand high torques from the actuators and hence it is of no practical use.

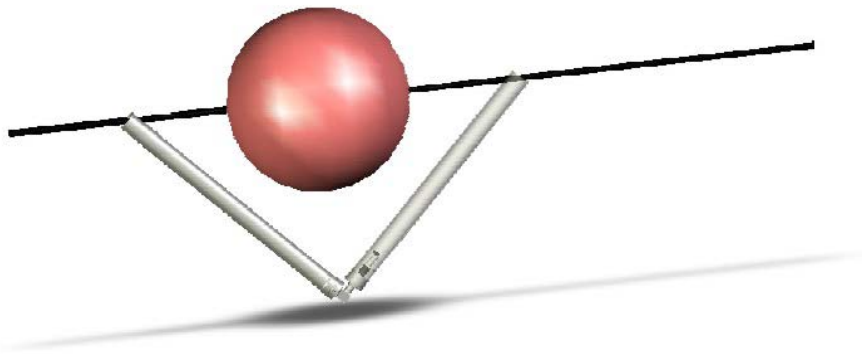


Figure 3: The basic 2-link robot

The robot currently under construction is composed by a main body and three arms. The robot moves with a variation of the brachiation movement, with always two arms grabbing the line at each time.
Currently, power line inspection is done by human experts, flying onboard helicopters, using direct visual inspection and thermal imaging systems. This is a dangerous and financially costly activity and hence the development of a robotic system is both an economic and socially relevant application and a scientific challenging problem.
The prototype, shown in Figure 4, is being constructed first using a CAD system. A variation of this structure, with the central linear arm replaced by an arm with rotation joints, is shown in Figure 5.

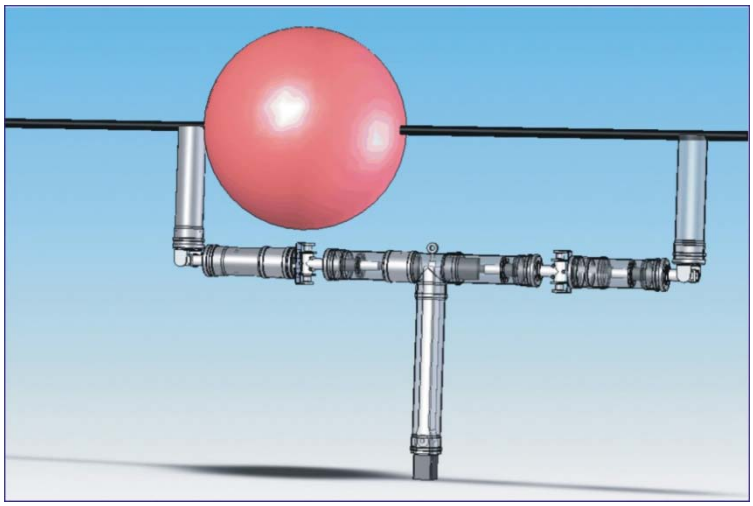


Figure 4: The RIOL robot under development

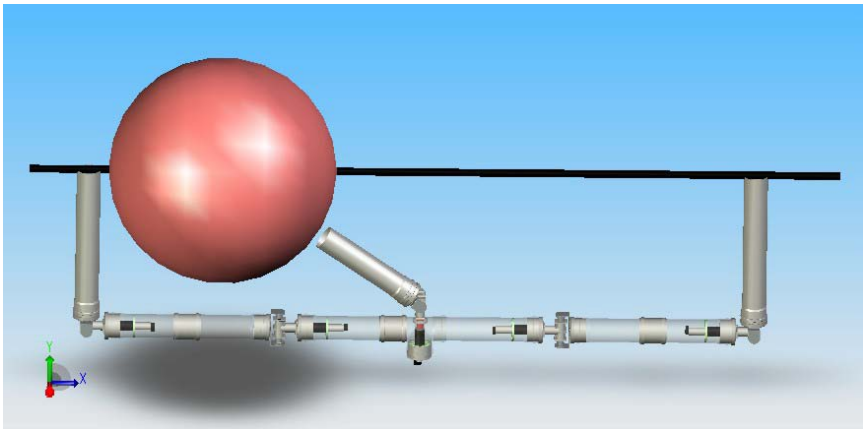
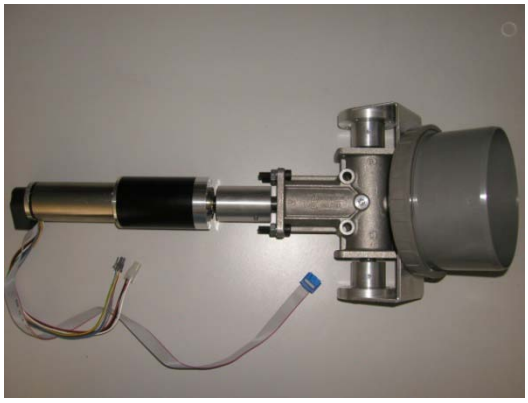


Figure 5: A variation of the previous structure

Figure 6 shows the coupling between one of the actuators and the gearing system of one of the joints.

a) Gearing system for a revolution joint



b) DC motor coupled to the gearing system

Figure 6: Details of the mechanical components under construction

The evaluation of the robot follows two lines. A Matlab/Simulink model (Figure 7) is used to assess relevant aspects of the dynamic behaviour. Practical implementation aspects are tested using the components being developed. Figure 8 shows the setup being assembled for the flexibility test of a 2 link arm. Figure 9 shows a full size mockup of the robot.

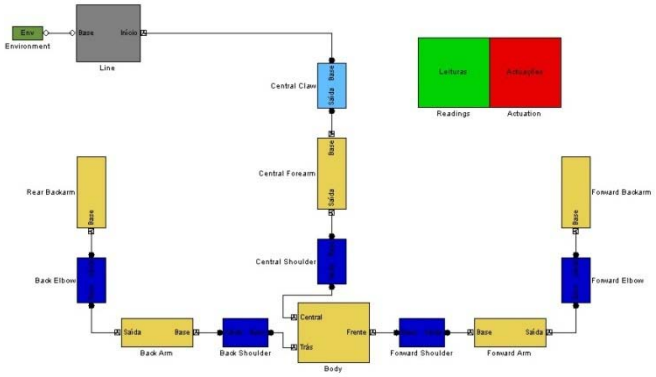


Figure 7: Matlab/Simulink model of the RIOL robot

Figure 8: Setup for testing the flexibility of a 2-link arm

Figure 9: A full size mockup of the RIOL robot

Research areas: Modeling and Control of Robots, Hybrid Systems
Laboratory: Mobile Robotics Lab
External partners: None
Initiated: 2005
Expected conclusion: 2008
Classification: FCT - POSC/EEA-SRI/60775/2004

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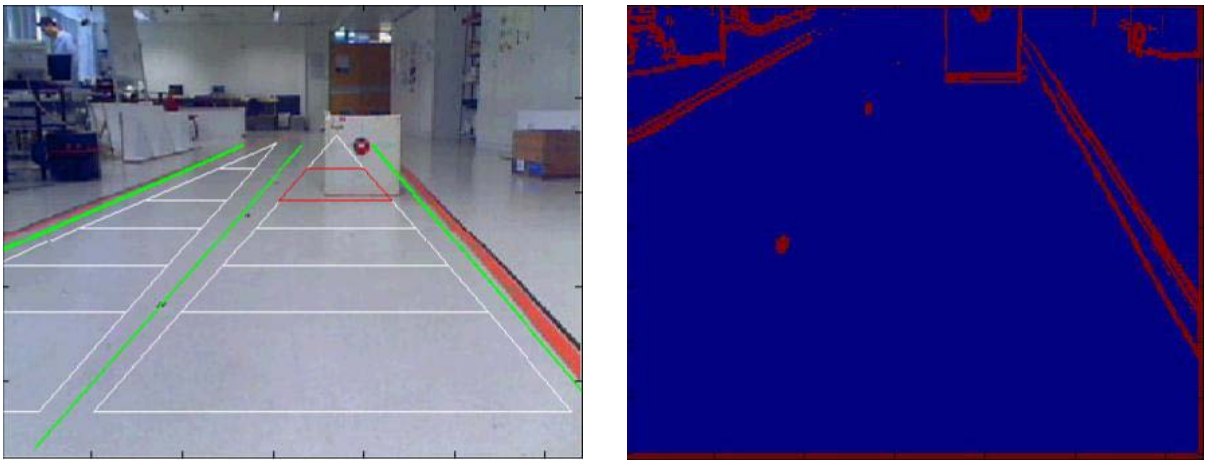
Project name: HANS – Highway Autonomous Navigation System

Project leader within ISR: Prof. João Sequeira (IST/ISR)

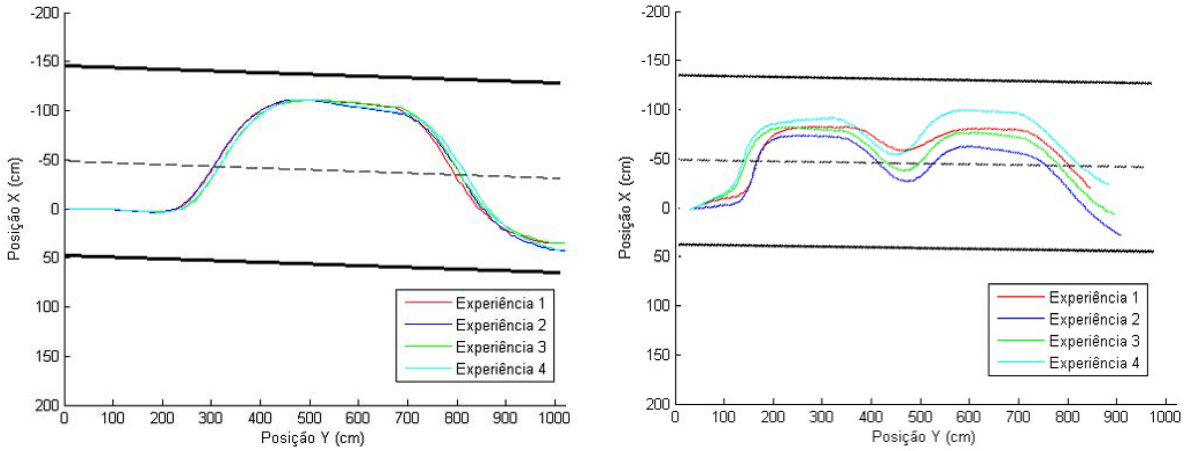
Collaborators: André Godinho and André Gonçalves
Project Description: This project aimed at developing a system for autonomous driving of automobiles in highways. As a project option, the system was constrained to use a single low cost webcam and standard off-the-shelf ultrasound sensors.
The image acquired by the webcam is processed for edge detection (Figure 12). A nonlinear control law is used to obtain smooth overtaking trajectories. The overall system was tested using an ATRV robot and a decision automaton able to mimic the decision system of a typical human driver (Figure 14). Real trajectories obtained with the ATRV vehicle are shown in Figure 13. Furthermore, the vision system was tested in a real highway. A snapshot of the results can be seen in Figure 15.
The results of this project were presented at the 4th International Conference on Informatics in Control, Automation and Robotics, ICINCO 2007, Angers, May 9-12, France, 2007.



a) Road lane detection and identification

b) Edge detection

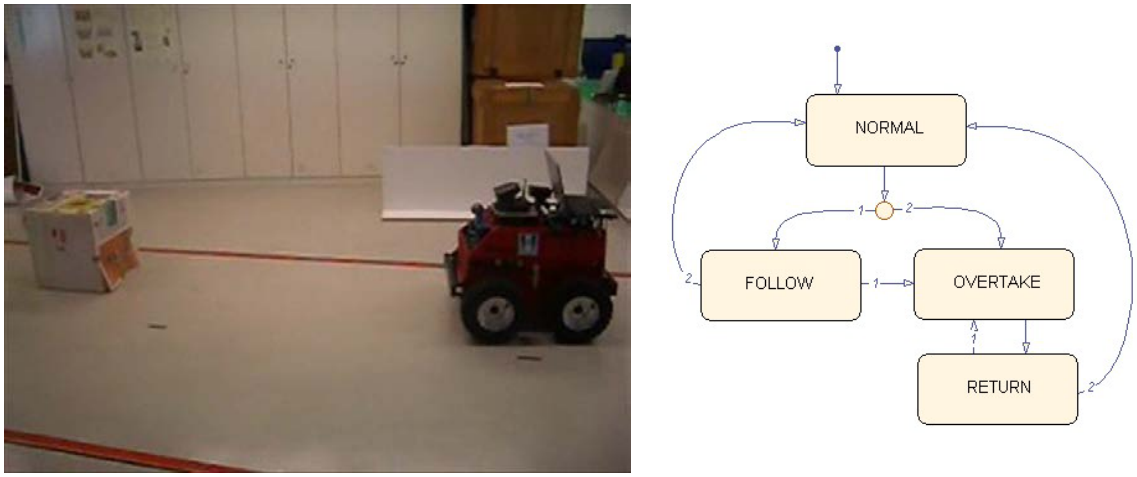
Figure 12: Image processing to extract road lane information



a) Single overtaking maneuver

b) Double overtaking maneuver

Figure 13: Real trajectories during overtaking maneuvers



a) The ATRV robot

b) Decision automaton

Figure 14: The test vehicle and decision system

Figure 15: A snapshot of the vision system operating in a real highway scenario

Classification: internal, undergraduate research project
Status: Finished

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Project name: Domestic personal assistant hybrid robot

Project leader within ISR: Prof. João Sequeira (IST/ISR)

Collaborator: Luís Tavares

Description: This project aimed at developing a prototype robot able to move on typical domestic indoor scenarios. Possible applications of such robot include personal assistance and monitoring. Figure 16 shows a CAD conceptual view of a possible structure for this kind of robot. The distinctive characteristic is the hybrid locomotion, composed by crawlers and legged wheels.

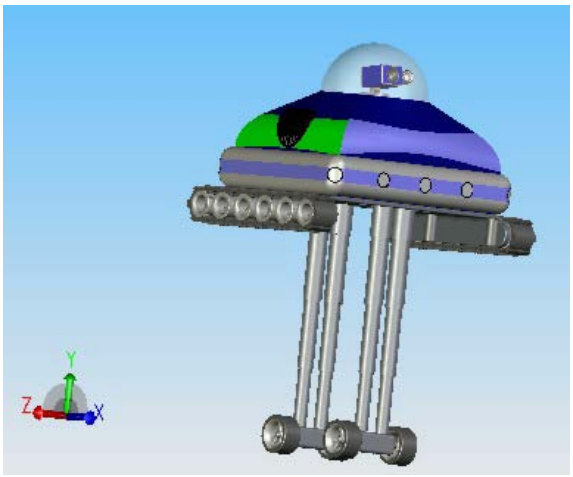

Figure 16:A CAD conceptual view of the personal assistance hybrid robot

A prototype was built using the Lego system (Figure 17). The underlying concept (the hybrid locomotion for domestic indoor environments) was successfully tested. Figure 18 shows a sequence of snapshots taken when the robot was climbing regular stair steps.

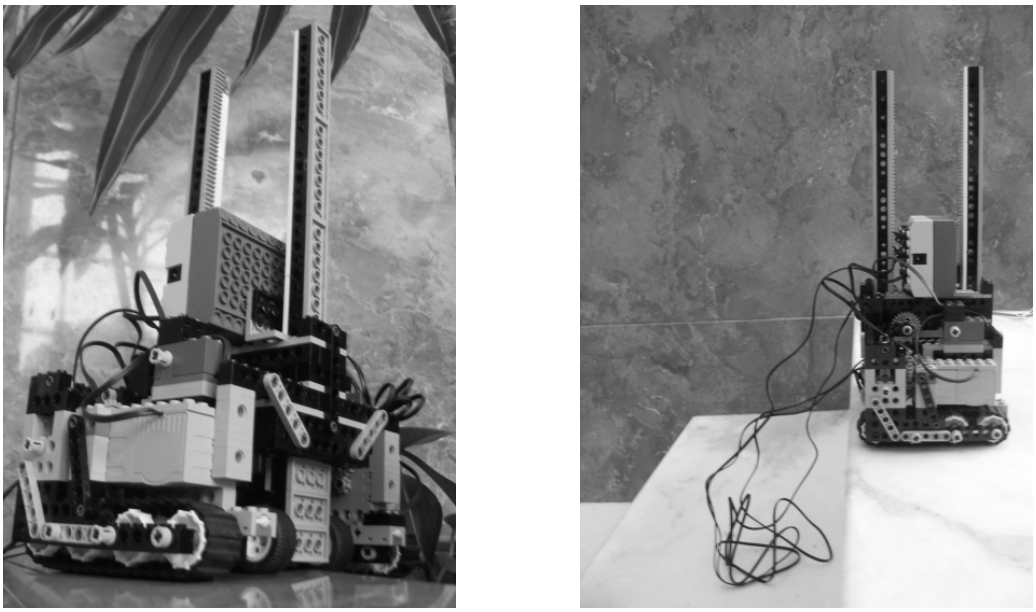

Figure 17: Two views of the preliminary versions of the THOR prototype robot

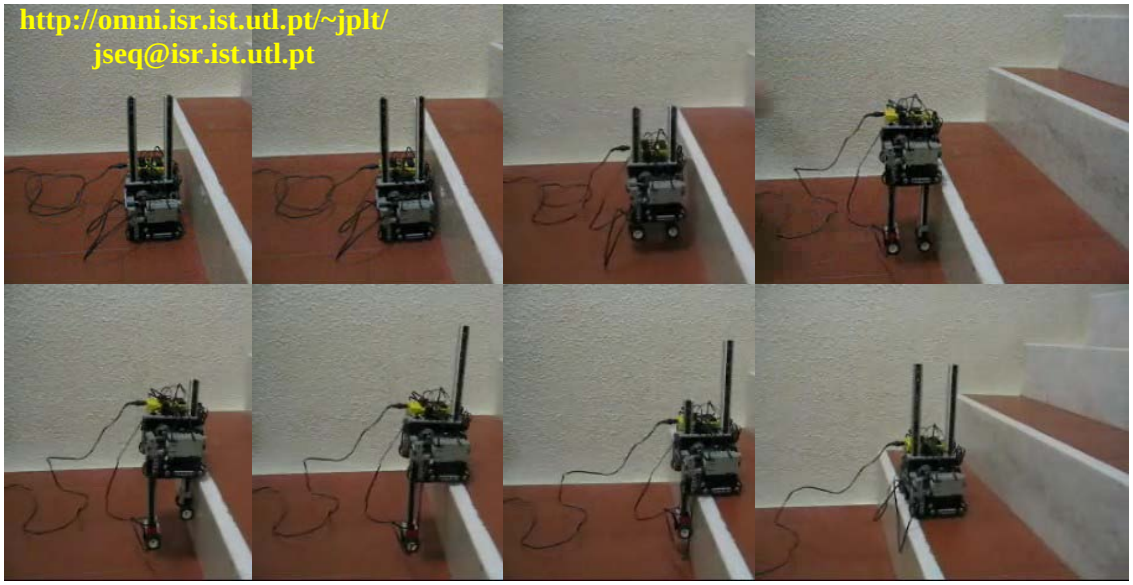

Figure 18:The THOR robot climbing regular step stairs

Classification: internal, undergraduate research project
Status: Finished

3.1.4. UNDERWATER ACOUSTICS

Project name: UAB – UNDERWATER ACOUSTIC BARRIERS FOR HARBOUR PROTECTION

Project leaders within ISR: Prof. Sérgio Jesus

Project description: The present project proposal aims at studying, develop and test in the field an underwater acoustic barrier UAB). The objective of an UAB is to detect underwater intrusions in a given area of the ocean, like for instance, a bay, a port or a river. One of the most promising concepts in this area today is to form a virtual plane between two vertical acoustic transmitting/receiving line arrays of transducers/receivers, the sea surface and the bottom, using the acoustic time-reversal mirror (TRM) principle. The two vertical line arrays (VLA) are connected either by cable or by a wireless lan. Forming a focused TRM on each of the receivers of the VLA will allow, in principle, the detection of any acoustic reflecting object perturbing the acoustic field when crossing the barrier. There are two type of problems to be treated in this project: theoretical problems dealing with the optimal frequency and number and distribution of sensors of the VLA's allowing a adequate resolution of the targets and technological problems dealing with the assembling of the system formed by the two synchronized VLA's being able to work on real time and in shallow waters (20/30 m).

Research Areas: Underwater acoustics
Laboratories: SIPG - Signal and Image Processing Group
External Partners: Instituto Hidrográfico
Initiated: January 2006,
Expected Conclusion: December 2007
Classification: FCT POCI/MAR/59008/2004
Documents produced in 2006:

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Project name: RADAR – ENVIRONMENTAL ASSESSMENT WITH A RANDOM ARRAY OF ACOUSTIC RECEIVERS

Project leaders within ISR: Prof. Sérgio Jesus

Project description: This research project aims at the development and validation of acoustic remote sensing systems and inversion methods for the reliable, rapid environmental assessment (REA) of shallow water areas. One of the most promising REA concepts is to use a field of sonobuoys, deployed either from the air or from surface ship, to receive signals from a controlled sound source or sources of opportunity. The acoustic data, radio telemetered to the aircraft or ship, are processed to determine the range-dependent, water-column and bottom acoustic properties over the area spanned by the drifting buoys. The resulting environmental parameters integrated with concurrent oceanographic measurements are then used to initialize and calibrate oceanographic prediction models for nowcast and forecast environmental hazards in potential areas. The proposed research work directly stems from previous efforts carried at University the Bruxelles and at SACLANT Undersea Research Center for geoacoustic inversion techniques with random fields of sonobouys and at University of Algarve, in the context of experimental testing of ocean acoustic tomography with sources of opportunity. In particular, proved concepts under static conditions, such as the use of a broadband coded signal propagated between a single sound source and a single hydrophone or a fixed array of hydrophones, will be extended to the dynamic configuration of freely drifting sonobuoys.

Research Areas: Underwater acoustics
Laboratories: SIPG - Signal and Image Processing Group
External Partners: Instituto Hidrográfico
Initiated: October 2004
Expected Conclusion: September 2007
Classification: FCT POCTI/CTA/47719/2002
Documents produced in 2006:

Project name: NUACE – NON-COOPERANT UNDERWATER ACOUSTIC CHANNEL ESTIMATION

Project leaders within ISR: Prof. Sérgio Jesus

Project description: Channel estimation is a common problem to many fields of research and, in particular, in underwater acoustics where the received signal is prone to severe time-space variability, strong multipath, dispersion and reverberation. Classical deconvolution methods attempt to estimate the parametric filter that best matches the medium response to a test input signal. These approaches mainly suffer from two well known drawbacks: one is the need for a known input signal, thus reducing its practical feasibility and efficiency and, two, is that the estimation process is started from scratch at each single environmental or geometric change between source and receiver(s), what makes it extremely slow. This project intends to develop and test the experimental feasibility of environmental model-based methods to estimate the channel impulse response. Environmental model-based techniques are drawn from physical representations of the medium of propagation through the solution of the wave equation and boundary conditions. Searching for the environmental parameters that provide the best fit between the model-based replicas and the actual received signal can be viewed from three advantageous aspects: one is that there is no need for a known (deterministic) excitation of the medium, so the identification can be performed in a blind fashion, two, is that the search is reduced to the space covered by the solutions of the wave equation thus, in principle closer to the true solution and three, each identified parameter has a physical meaning thus providing simultaneously, a possibility for including a priori information of its evolution in time and space, and an estimate of the physical medium itself with all its implications. A key aspect to be brought up in this project is that there is good evidence that signal and noise do propagate through the same channel, therefore noise acquires some modal structure and the signal gets a stochastic aspect. That explains the fact that, in a recent analysis of single hydrophone experimental data, it was found that the signal was confined to a subspace with a much smaller dimension than the expected dimension given by the model. Thus, taking advantage of this experimental fact, putting together the information at each hydrophone throughout the array would be one of the goals of this project. In order to fullfil the project objectives, developing model-based techniques requires access to experimental facilities and actual at sea data. Therefore this project includes the at sea deployment of existing equipment, such as a 16-hydrophone vertical line array and an acoustic sound source, at fixed locations along the Portuguese coast, for listening both to controlled and uncontrolled sound sources (such as ships of opportunity) in various geometric configurations, along variable range-dependent and range-independent propagation transects and frequency bands.

Research Areas: Underwater acoustics
Laboratories: SIPG - Signal and Image Processing Group
External Partners: Instituto Hidrográfico
Initiated: January 2004
Expected Conclusion: December 2006
Classification: FCT POSI/CPS/47824/2002
Documents produced in 2006:

3.1.5. COMPUTER VISION

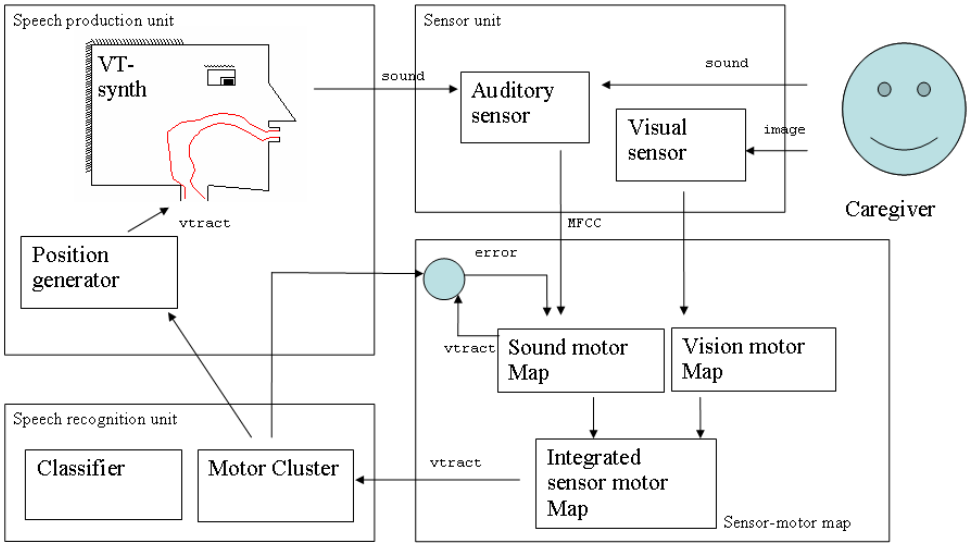
Project name: CONTACT - Learning and Development of Contextual Action

Project leaders within ISR: Professor José Santos–Victor and Professor Alexandre Bernardino (IST/ISR)

Project description: As infants, each one of us developed the ability to move our muscles to manipulate objects and also to communicate with gestures and speech. Did we learn to perceive and produce gestures for manipulation and speech independently, or are these two learning processes linked? The CONTACT project is an ambitious attempt to investigate the parallel development of manipulative and speech-related motor acts from a multi-disciplinary perspective. The project is designed to test the hypothesis that fundamentally similar mechanisms are involved in the development of perception and production for both speech and manipulation. This hypothesis is stimulated by recent evidence suggesting that the human brain interprets motor acts (movements) of other people in essentially the same way, regardless of wether the act generates speech or a manipulative gesture.

The work developed at IST during the first year of the project consisted on sound source localization for the iCub head. For that purpose, the robot head was equipped with two microphones. The binaural sound difference (intensity or phase) is used for localization on the horizontal plane. For the vertical plane, the proposed method was based on the design of ear shapes (*pinnae*) similar to some extent to the human ears so that notches at different sound frequencies can be used as cues for the (vertical) localization of the sound.

In the second year of the project, we developed an architecture that allows an artificial system to acquire language. Initially the system explores its own vocal track and builds audiomotor maps. Then, through the interaction with a caretaker the system learns basic sounds (e.g. phonemes) that can later on be used for communication.



Research Areas: Computer Vision
Laboratories: Vislab - Computer Vision Lab
External Partners: IST, DIST, U.Genova (I), Dpt Psychology U. Uppsala (SE); Dept Human Physiology, U. Ferrara (I); Dpt Linguistics, U. Stockholm (SE); Initiated: September 2005
Expected conclusion: August 2009
Classification: NEST-5010
Documents produced in 2006: Error! Reference source not found.

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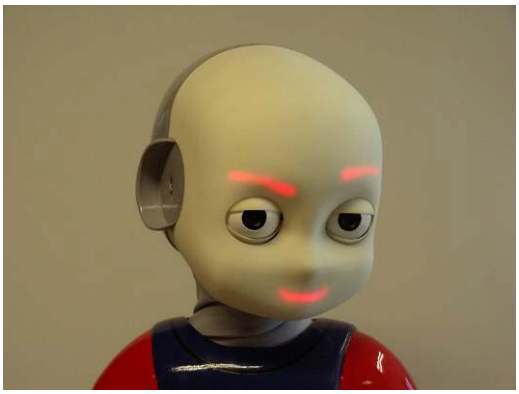
Project name: ROBOT-CUB - ROBotic Open-architecture Technology for Cognition, Understanding, and Behaviour.

Project leaders within ISR: Professor José Santos–Victor and
Professor Alexandre Bernardino (IST/ISR)

Project description: RobotCub is an Integrated Project funded by European Commission through the E5 Unit (Cognition) of Information Society Technologies priority of the Sixth Framework Programme. The consortium is initially composed of 11 European research centers plus two research centers in the USA and three in Japan specialized in robotics, neuroscience, and developmental psychology. The main goals of RobotCub are two: (1) to create an open robotic platform for embodied research that can be taken up and used by the research community at large to further their particular approach to the development of humanoid-based cognitive systems, and (2) to advance our understanding of several key issues in cognition by exploiting this platform in the investigation of cognitive capabilities. The scientific objective of RobotCub is, therefore, to jointly design the mindware and the hardware of a humanoid

platform to be used to investigate human cognition and human-machine interaction. We call this platform CUB or Cognitive Universal Body. It is worth remarking that the results of RobotCub will be fully open and consequently licensed following a General Public (GP) license to the scientific community.

The team at IST is responsible for the design of the head of the iCub. The design specifications were based on the characteristics of the oculomotor system of children. This is the most complete robotic head for the given size. It consists of a three degrees of freedom (dof) eye sub-system and a three dof neck. The eyes can verge independently and tilt around a common axis. The neck can perform the pan-tilt-swing movements. The overall weight of the head is about 1.2Kg, motors included. All motors are equipped with encoders and the head possesses an inertial unit (the vestibular system). IST also worked on the design of the robot's face. The fact that the robot should act in a social environment to elicit communication with other robots and/or people was taken into account. The work on the face design was done in collaboration with the design company *Alma Design*. The picture below shows the designed head.



Research Areas: Computer Vision
Laboratories: Vislab - Computer Vision Lab
External Partners: IST, DIST, U.Genova (I), Arts Lab SSS. Anna (I), AI Lab U. Zurich (CH); Dpt Psychology U. Uppsala (SE); Dept Human Physiology, U. Ferrara (I); U.Hertfordshire (UK); U. Salford (UK); EPFL (CH); Telerobot S.r.l. (I); European Brain Research Institute (I) Initiated: September 2004
Expected conclusion: August 2009
Classification: IST-2004-004370
Documents Produced in 2006:

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Project name: GESTINTERACT: Gesture Interpretation for the Analysis of Interactions *Humans/Robots/Humans*

Project leader: Prof. José Santos-Victor (IST/ISR)

Project description: When engaged in collaborative activities, people express their opinions, intents and wishes by speaking to each other using intonation, facial expressions and gestures. They move in physical space and manipulate objects. These actions are inherently linked to the individual's cognitive perception. They have a meaning and a purpose. They are adapted to both the environmental and social setting. In this project methods and techniques for the interpretation of human gestures will be developed using computer vision so that the analysis of the interaction and communication between humans and man-machine can be performed. The interaction will take place indoors. The space where the interaction occurs will be covered by a network of cameras. The techniques to be developed shall allow for the machine/robot to interpret human gestures from those with whom it interacts but also the interpretation of the interaction among humans using gestures and body posture.

Research Areas: Computer Vision
Laboratories: VisLab – Computer Vision Lab
External Partners: ISR – Coimbra Pole
Initiated: Sept. 2005
Expected conclusion: August 2008
Classification: FCT - POSI/EEA-SRI/61911/2004
Documents Produced in 2006:

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Project name: VEMUCARV– Spatial validation of complex urban grids in virtual immersive environments

Project leader within ISR: Prof. Alexandre Bernardino (IST/ISR)

Project description: The main goals of this project are related to the semi-automatic acquisition and maintenance of 3D virtual reality models of urban areas. It is intended to use registered aerial images and low altitude laser range scans to acquire 3D data of city structure. This data will be processed in order to segment relevant structures for urban planning (buildings, roads, green areas, etc). Range information provides a very rich description of 3D structure but lack photometric information. Aerial photos provide this information, allowing to pre-segment regions based on color and texture. The main scientific innovation of this project is the combined use of 2D (aerial images) and 3D (range scans) to simplify and improve the building extraction process. Most current approaches use one or the other types of data exclusively. The final result provides a computer model which stands for a mix geometry-image database that can interface to GIS software available (at CML), as well as the generation of real-time walkthrough with thematic information. The results of this project are to be integrated on Lisbon City Hall public computational facilities.

Research Areas: Computer Vision, Virtual Reality, Computer Aided Design, Geographical Information Systems.
Laboratories: VisLab – Computer Vision Lab
External Partners: IDMEC-IST, CML
Initiated: May. 2005
Expected conclusion: June 2008
Classification:
Documents Produced in 2006:

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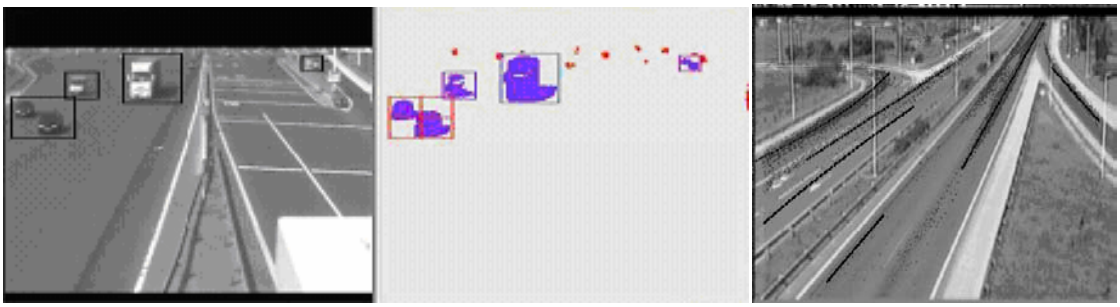
Project name: INTELTRAF – Monitorização Automática do Fluxo de Trânsito Automóvel e Detecção de Acidentes e Avarias em Auto-Estradas.

Project leader within ISR: Prof. José Santos –Victor (IST/ISR)

Project description:
This project aims at developing an Automated Traffic Surveillance system with Computer Vision techniques. In a scientific and technological point of view we pretend to develop real-time algorithms for video sequence analysis of traffic scenes and explore innovative extended field of view camera systems (panoramic), with the final goal of price reduction and performance gain with respect to currently existing systems. In particular we address the applications of measuring traffic flow and detecting abnormal events on highways and critical urban areas. Traffic flow monitoring records statistical data on traffic distribution along time (number of vehicles, average velocity, average wait time on queues, etc.). We propose to develop a system that monitors a traffic region, acquires statistical data on traffic density and makes this data available on the Internet. Automatic event detection can help in speeding-up reaction to abnormal events, like accidents and serious transgressions to traffic rules. We propose to develop a system that

detects abnormal events on critical traffic points, records the event history and send alarm signals to control stations.

Most of the work developed at IST consisted of estimating the highway lanes from the observation of traffic during a period of time. The method is based on a detection module and a tracker. The observed trajectories are input to a cluster algorithm defined in the trajectory space.



Research Areas: Intelligent Transportation Systems, Computer Vision
Laboratories: Vislab - Computer Vision Lab
External Partners:
Observit, Tecnologias de Visão por Computador, Lda;
Brisa, Auto-estradas de Portugal, SA;
AITEK, SRL (Italy)
Initiated: September 2003
Expected conclusion: June 2007
Classification: POSI, Medida 1.3
Documents Produced in 2006:

3.1.6. UNMANNED AIR VEHICLES

Project Name: **ObservFly**

Project Coordinator: Prof. Carlos Silvestre (ISR/IST)

Project description: The primary objective of the ObservFly Project is to equip a large (3.5 m wing span) radio-controlled model airplane, developed by and property of CavadasAeromodelismo, with avionic systems that will be able to autonomously steer the airplane through a series of predefined smooth trajectories with the goal of recording image data from a wireless camera installed on board. The avionics is vibration isolated from the fuselage using a soft suspension mechanism, which acts as a mechanical low pass filter to provide further attenuation of the aircraft vibration on the electronics. The avionics hardware is built using the low power high performance floating point Texas Digital Signal Processor (DSP) TMS320C33, which is connected to the data acquisition hardware through a dual port RAM expansion board. The onboard distributed architecture is being built around the CAN (Controller Area Network) Industrial Real Time Network. Communication with the ground station is done resorting to a Serial Link Internet Protocol over a wireless modem that allows for transmission of the aircraft status (attitude, linear and angular position, airspeed, etc.) and reception of uplink commands from the ground station in real-time. A simulation model of the Aircraft Dynamics named SimAirDyn, is also being developed and tuned for the ObservFly platform. SimAirDyn is an accurate mathematical model suitable for effective control system design and flight envelope expansion. The Airplane is modeled as a six degrees of freedom rigid body, actuated by forces and moments that are generated at the propeller, fuselage, and wings. The remaining components, namely the landing gear and the antennas, which have a smaller impact on the overall behavior of the aircraft dynamic model, are not included in the simulator and will be treated as disturbance by the control system. The Inertial Navigation System onboard the platform will use the algorithms developed within the scope of the ASAINS project The navigation information together with the airspeed are transmitted through the downlink at a transmission rate of 1 Hz. From the Guidance and Control System point of view the Aircraft operation modes relevant for the project are autonomous takeoff, accurate stationary flight, and landing. The first two flight conditions involve controlling the platform using the information provided by the navigation system. The last and critical flight condition is

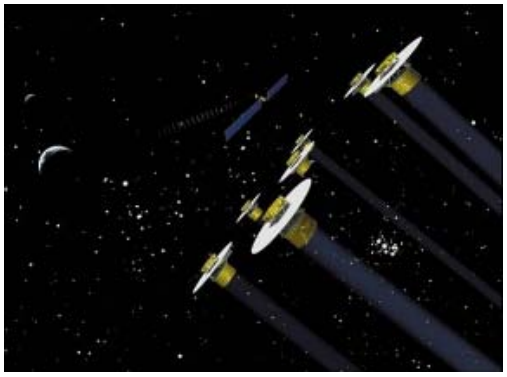
the automatic landing. The controller for automatic landing will be developed using a sensor based approach. To improve the airborne data acquisition quality, special emphasis will be placed on developing 3-D guidance and control systems for accurate path following and trajectory tracking.

Aircraft Characteristics: The Aircraft is capable of lifting a 11Kgf payload for two hours on a tank of gas, The Wingspan is 3.5m and the length is 1.8m and has a takeoff distance half load of 50m. It uses a one cylinder two stroke- 60cc engine, producing about 8 horsepower.

Research Areas: Nonlinear dynamic modeling, Guidance and Control, Inertial Navigation, Laser and Vision Mapping.
Laboratories: DSOR
Initiated: September 1, 2005
Conclusion: December 31, 2008
Classification: Internal Project
Documents produced in 2006:

3.1.7. SPACE APPLICATIONS

Project name: FORMATION ESTIMATION METHODOLOGIES FOR DISTRIBUTED SPACECRAFT



Project leader within ISR: Prof. Pedro Lima (IST/ISR)

Project description: The goal of the FEMDS project was to extend the traditional Guidance, Control and Navigation (GNC) loop for a single spacecraft to a set of spacecraft flying in formation. For that purpose, we started by an extensive literature review on multi-agent systems and approaches to GNC of formation flying spacecraft, as well as GNC of formations of robots moving on planar surfaces, where the number of degrees of freedom (DoF) is reduced from 6 to 3, thus leading to a large number of available solutions. Following that study, carried out by ISR/IST, a functional architecture for the whole multi-spacecraft system was proposed, and candidate algorithms were selected for the GNC system. This ended Phase I of the project. Phase II started by a feasibility study, carried out by DEIMOS, concerning a GTO demonstration mission, composed of 3 formation flying spacecraft. The study provided the required modes for the mission, corresponding to the behaviors of the functional architecture defined during Phase I of the project, as well as initial and final conditions for each mode formation state. Those were used in the functional design and implementation in Matlab/Simulink, by ISR/IST, of the candidate GNC algorithms identified in Phase I, which were then tested mainly for the formation acquisition mode (FAC). The algorithms were implemented and tested in DEIMOS' FF-FES simulator, which was extended from previous versions to meet some of this project requirements, such as its adaptation to the functional architecture and full 6 DoF simulation.

The work carried out in previous years demonstrated:

- The feasibility of keeping a 3-spacecraft formation highly stable on a Geostationary Transfer Orbit (GTO) for up to ~4h around apogee with low-thrust laws;
- The ability of the proposed closed loop Guidance and Control (GC) algorithm to bring the 3 spacecraft from an initial location, inside a sphere of diameter 8 km down to the specified triangle with distances in the order of 200 m between spacecraft, with collision avoidance, and under the effect of several unmodeled perturbations;
- The ability of the proposed full order decentralized navigation algorithm to track the formation state, starting from an initial value different from the true state value, and under the effect of several unmodeled perturbations.

Preliminary successful results concerning the full closed-loop Guidance, Navigation and Control (GNC) algorithm, i.e., including the estimator in the loop, were also presented.
The work performed in 2006 mainly concerned extending the state to 6 DoF (relative position, linear velocity, attitude and angular velocity) and consolidating the results on estimation of translational components of the formation state.
The implemented Navigation algorithm is based on:

- *For the translational components*: a combination of an Extended Kalman Filter (EKF) and a Covariance Intersection algorithm at each spacecraft, and on inter-spacecraft measurements obtained from an Radio Frequency (RF) system. Each spacecraft communicates its most recent state estimate to its successor spacecraft in the communication network. The filtering part of the state estimation process is performed, at alternate sampling times, by an EKF, when local measurements are used, and a Covariance Intersection algorithm, when observations (i.e., the state estimates) come from other spacecraft. The prediction part of the state estimation process is performed by the EKF;
- *For the rotational components*: a so-called Extended Kalman Filter Fusion at each spacecraft, and on absolute attitude measurements obtained from a Star Tracker sensor. Each spacecraft communicates its most recent state estimate to its successor spacecraft in the communication network. The filtering part of the state estimation process is performed, at alternate sampling times, by an EKF using local measurements, and another EKF, when observations (i.e., the state estimates) come from other spacecraft. The prediction part of the state estimation process is performed by an EKF.

The Navigation algorithm was tested for FAC and another simulated mode of the GTO, to estimate the state of the closed loop system when the GC algorithm is used with the true state as input, so as to reduce the inter-s/c distances.
The results of 2006 work show:

- A significant improvement over previous results (by one order of magnitude) of the accuracy achieved by the relative position and relative linear velocity estimator, as the result of eliminating biases and systematic tuning of noise covariance matrices, based on consistency tests. The estimation error covariance matrix of the translational components was reduced to values very close to the lower bounds for the uncertainty;
- A successful extension of the navigation filter to 6 DoF, providing an integrated estimation of relative translational and rotational state components, which meets the GNC specifications for the accuracy.

Research Areas: Satellite Formations, Formation Control, Multi-vehicle state estimation, Multi-Agent Coordination Architectures
Laboratories: Intelligent Systems Lab
External Partners: DEIMOS Engenharia (PO)
Initiated: July 2003
Conclusion: December 2006
Classification: ESA (European Space Agency) 17529/03/NL/LvH/bj
Documents produced in 2006:

3.2 POST-DOCS ACTIVITIES REPORTS

3.2.1. Activity report of JACINTO NASCIMENTO

Period: September 2005 December 2006
Fellowship: HAR - *Reconhecimento de Actividades Humanas*. Vigilância (PTDC/EEA-ACR/69007/2006). (Projecto em fase de avaliação). Projecto a desenvolver em parceria com o Departamento de Eng. De Informática e de Computadores - INESC ID/INESC/IST/UTL (com a referência DID/AML-mavc-84/06).

My post-doctoral research is taking place at ISR, funded by FCT (with the scholarship SFRH/BPD/9409/2002). During this year my work is related with the above research projects. Next I will summarize the contents of the two projects.

Research topic:

HUMAN ACTIVITY RECOGNITION AND MODELLING

Objective (HAR project):

HAR, *Human Activity Recognition - Surveillance (PTDC/EEA-ACR/69007/2006)*

Human activity analysis has become one of the most active research areas in the image processing and computer vision communities. In fact there exist many promising applications among which we can highlight the human-computer interaction, human performance analysis, visual surveillance, video content analysis for indexing and virtual reality.

In this project we address the surveillance systems, in particular, the analysis of human activities which unroll in shopping centers, subway stations, airports or indoor environments.

Most of the proposed systems which recognize human activities address the following common tasks: region detection and tracking, activity learning and classification. As the detection and tracking systems have progressed significantly, the activity learning and recognition become the key goal to be accomplished.

The need of such systems is undoubtedly increasing, with a large number (hundreds) of cameras covering the public spaces. The observation room is usually equipped with a large set of monitors, used by human operators to watch over multiple areas. The traditional job of the security operator, monitoring several video streams for extended periods of time becomes impossible, as the number of cameras grow. Therefore, we need systems which are able to detect and recognize human activities and select events which call for the attention of the operators.

In this project we address activities concerning single person and activities involving the interaction between two or more persons. *What are the behaviors expected when two or more person meet?* This is the main question that we intend to answer.

Another important issue in this project is to explore the modeling of the spatial context and to increase the temporal horizon to improve the robustness of the activities recognition.

Project Fellowship: ANOVIS - *Active and networked omnidirectional vision*. (Projecto em fase de avaliação).

Objectives/Goals

The goals of this project are two-fold: (i) the development of a novel generation of vision cameras characterized with omnidirectional fields of view and new imaging geometries and (ii) design and implementation of the corresponding computer vision algorithms tailored for the specific camera geometries for calibration and applications such as surveillance and inspection.

Approach

In this project we will focus on the design of omnidirectional catadioptric cameras that combine a standard camera and a convex mirror. The shape of the mirror and the camera-mirror assembly will determine the overall geometric properties of the camera. By designing the camera, one can obtain better geometrical properties as e.g. constant resolution for scene structures non-parallel to the image plane, enhanced resolution at regions of interest, enlarged field of view of a single camera (or of a camera network), reduced sensor sizes, etc. In the project we follow two principal directions:
i) Enhance the capabilities of individual omnidirectional cameras, by designing the mirror to meet some desired criteria and by using an active camera able to pan, tilt and zoom (contrasting with fixed assemblies that are currently used). Also, the problem of image quality and optic aberrations will be addressed, possibly leading to the design of new lenses allowing the miniaturization of catadioptric cameras.
ii) Combine several (heterogeneous) cameras in a network in order to have stereo imaging or to cover larger scene areas (as public infrastructures). This will call for new methods for calibration, background estimation and event detection, with particular relevance in video surveillance applications.
The development of these new camera geometries will require novel data processing methodologies for sensor modeling/calibration, reconstruction, camera-localization, motion estimation, structure from motion, etc, as the multi-view geometric constraints are significantly different from those arising in single view point cameras (as in perspective cameras).

Major Results

The results of my research work can be summarized in the following publications:

Published papers:

International Conferences

[G] **J. Nascimento, J. M. Sanches, J. S. Marques**, "A Method for the Dynamic Analysis of the Heart Using a Lyapounov Based Denoising Algorithm", *Proc. of the EMBS2006 - 28th IEEE Engineering in Medicine and Biology Society,* pp. 4828-4831, New York, USA, August 2006.

International Journals

[H] **J. Nascimento, J. S. Marques**, "Performance evaluation of object detection algorithms for video surveillance", *IEEE Transactions on Multimedia*, vol. 8, no. 4, pp. 761-774, August 2006.

Submitted papers:

International Conferences

[C] **J. Nascimento, M. A. T. Figueiredo, J. S. Marques**, "Semi-supervised Learning of Switched Dynamical Models for Classification of Human Activities in Surveillance Applications", *International Conference on Image Processing.*

[D] **J. Nascimento, J. M. Sanches, J. S. Marques**, "Tracking the Left Ventricle in Ultrasound Images based on Total Variation denoising", *IbPRIA* 2007 - *3rd Iberian Conference on Pattern Recognition and Image Analysis.*

[E] **J. Nascimento, M. A. T. Figueiredo, J. S. Marques**, "On-line Classification of Human Activities", *IbPRIA2007 - 3rd Iberian Conference on Pattern Recognition and Image Analysis.*

International Journals

[F] **J. Nascimento, M. A. T. Figueiredo, J. S. Marques**, "Independent increment processes for human motion recognition", *Computer Vision and Image Understanding.*

Ongoing papers:

[A] **J. Nascimento, M. A. T. Figueiredo, J. S. Marques**, "Learning the Statistics of People in Video for Visual Surveillance".

[B] **M. Tajana, J. Gaspar, J. Nascimento, A. Bernardino, P. Lima**, "3D Tracking by Catadioptric Vision based and Particle Filters".

3.2.2. Activity report of VÍTOR VIEIRA LOPES

Period: January 2006 - December 2006
Fellowship: FCT Post-Doctorate grant
Advisor: Prof. Agostinho Rosa

Description of activities:

The post-doc main work theme is the development of biological system simulations using complex systems approaches. This research aims the development of algorithms that can make use of modern graphical processing units (GPU) inherent parallelism. The effort addresses two major sub-tasks: a) development of novel monitoring techniques for biological sample characterization, and b) simulation and model validation based on biological experiments.

During this period, the research focused on:

- Cellular automata based algorithms to simulate complex physical phenomena – freezing;
- Nonlinear signal processing techniques for the analysis of spectrometric signals and other biological signals;
- Infra-red image based augmented reality image processing techniques to that can be used for a better food product quality characterization;
- Experimental conditions optimization for filming cellular *saccharomyces cerevisiae* growth and interactions under a microscope in order to capture the behaviour of cellular communities;
- Data-analysis techniques (chemometric techniques) for panel sensory data, i.e. the food quality perceptual evaluation.

Other activities:

Fund razing is a less noble but important activity. During this period, it was possible to contribute and be involved in four research project proposals. These project proposals are part of LaSEEB collaborative research effort with different national research institutions. The submitted project proposals are: PTDC/BIO/69310/2006, PTDC/EEA-ELC/70664/2006, PTDC/SAU-BEB/65631/2006, PTDC/EIA/71069/2006.
Contributing to this post-doc work, there is also an ongoing collaboration research work with Minho University for gather part of the necessary data to the development of the complex system framework to model biological systems (pure biotechnological, food processing industry, etc).

Published papers:

[A] **V. V. Lopes, R. C. Martins, and A. C. Rosa**, "Sensory panel data analysis: An information theory oriented approach", *Proc. CAC2006 - 10th International Conference on Chemometrics in Analytical Chemistry*, Águas de Lindóia, Brasil, September 2006.

[B] **R. C. Martins, V. V. Lopes, and A. A. Vicente**, "Margarine products quality monitoring using UV-VIS-SWNIR spectroscopy", *Proc. CAC2006 - 10th International Conference on Chemometrics in Analytical Chemistry*, Águas de Lindóia, Brasil, September 2006.

Submitted papers:

R. C. Martins, V. V. Lopes, and A. A. Vicente, "Margarine quality monitoring based on reflectance spectroscopy", *Proc. 8º Encontro de Química dos Alimentos*, 4-7 March 2007, Beja, Portugal.

R. C. Martins, V. V. Lopes, A. A. Vicente, "Modelling the effect of morphology and processing conditions on the supercooling of strawberries", Journal of Food Engineering, Dec. 2006

R. C. Martins, V. V. Lopes, A. A. Vicente, "Sistemas computacionais para a previsão da qualidade e seguranca alimentar: evolução e sistemas complexos", Revista Ingenium, Nov. 2006

3.3 THESES

In this section the Doctoral and Master theses concluded, or in progress, during 2006 at ISR-Lisbon are identified.

3.3.1. THESES CONCLUDED DURING 2006

DOCTORAL THESES (4)

Sajjad Fekriasl, "Robust Adaptative MIMO Control Using Multiple-Model Hypothesis Testing and Mixed-u Synthesis", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, January 2006.

Abstract:

The thesis addresses the problem of robust adaptive control for linear multivariable systems subject to unmodeled dynamics and uncertain real parameters, either constant or slowly time-varying. The design methodology integrates state-of-the-art non-adaptive robust feedback synthesis techniques, using the mixed-mu design method (using the so-called D,G-K iteration), with a stochastic system identification method that exploits multiple-models and dynamic hypothesis-testing concepts.
The proposed design methodology, Robust Multiple-Model Adaptive Control, referred to as RMMAC, leads to an efficient procedure for the design of "robust'' adaptive multivariable feedback control systems for plants
that include both unmodeled dynamics and possibly large parametric uncertainty in the plant state description.
In the course of the design process, the minimum number of required models, their parameter uncertainty range, and also local compensators are automatically obtained by using the proposed step-by-step adaptive
methodology. The RMMAC methodology is applicable to multivariable feedback control system designs with full accounting of model parameter, dynamic errors, and explicit performance requirements. The performance of the RMMAC methodology is evaluated using non-trivial simulation examples, with one or two unknown parameters in both SISO and MIMO systems, and is compared with those obtained with the best global non-adaptive robust control (GNARC). The RMMAC can be an attractive engineering design tool for disturbance-rejection and command-tracking and a viable alternative for control applications where the performance that can be achieved with the GNARC is unsatisfactory.

Cristian Munteanu, "Increasing Adaptability in Evolutionary Algorithms for Solving Complex Optimization Problems", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, March 2006.

Abstract:

The thesis proposes and analysis several models of Evolutionary Algorithms with improved adaptation. Research is focused on increasing the adaptation of Evolutionary Computation (EC) methods such as to achieve better problem-solving efficiency and robustness. Three main directions are sought: dynamic adaptation to generic landscapes, adaptation to the problem's knowledge domain and the combination of the former two types of adaptation. The first direction has been researched by proposing and analysing two novel algorithms with improved dynamic adaptation to generic search landscapes. The algorithms were named Adaptive Reservoir Genetic Algorithm (ARGA) and Adaptive Reservoir Evolutionary Algorithm (AREA), respectively. Next, for the second direction of improved adaptation we introduce and study two new genetic operators called Principal Component Analysis Mutation (PCA-mutation) and Gaussian Uniform Crossover (GUX), that we integrate in well-tailored architectures to solve real-world optimisation problems (digital filter design, gray-scale and colour image enhancement). The third direction

of research is tackled by solving a difficult Brain-Computer-Interface pattern classification problem with a variant of ARGA additionally tailored to the specific task it has to solve.

Keywords:

Evolutionary Algorithms, Adaptation, Optimisation, Image Enhancement, Infinite Impulse Response Filter Design, Brain Computer Interface.

Members of the Thesis Committee:

Prof. João Miranda Lemos, IST (P)
Prof. Luís Correia, FCUL (P)
Prof. Agostinho Rosa, IST (P)
Prof. José Santos Victor, IST (P)
Prof. Carlos Mira da Fonseca, UALG (P)
Prof. José Bioucas Dias, IST (P)
Prof. João Freitas Xavier, IST (P)

Manuel Cabido Lopes, "A developmental Roadmap for Learning by Imitation in Robots", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, May 2006.

Abstract:

There is a growing research effort for designing "robot companions" able to interact with people in a friendly way, over extended periods of time. This is a challenging endeavor for two main reasons: (i) the need to work in highly unpredictable and uncertain environments, designed for people instead of robots and (ii) the variety of the tasks to execute and the interaction with (non-technical) people over long periods of time. These problems are addressed in this thesis using the paradigms of imitation and artificiaç development.
With the metaphor of imitation, one could "program" a humanoid-type robot to solve a certain task simply by demonstration and have the robot imitating the task later on, avoiding the user having to write sophisticade computer programs.
Although imitation is a learning mechanism massively used by human infants, it is not an easy problem. Inspired after developmental psychology, we present a developmental pathway for the robot to progressively acquire the skills necessary to imitate observed actions: (i) explore its own sensory-motor capabilities, (ii) understand its surrounding environment, (iii) become aware of people acting in the environment.
The first developmental level is devoted to sensory-motor coordination, during which the robot learns how to control its own body. Sensory-motor maps allow the robot to predict the sensory consequences of a certain action (forward model) as well as to determine the motor action necessary to produce a given effect in the world (inverse model). We present a variety of sensory-motor maps are learned during periods of auto-observation.
In the second developmental level, the robot is attracted toward objects. It learns how to grasp them and explore their properties, based on the sensory-motor maps learned previously. In addition, the robot learns how to recognize grasp actions performed by others, an approach based on the recent findings of the mirror neurons in the pre-motor cortex of macaque monkeys. In the last stage of development, the robot engages (to some extent) in social interaction. Its attention is drawn toward people and the robot learns how to imitate the tasks performed by a demonstrator. For that purpose, it solves the view-point transformation problem to account for the different coordinate frames of the demonstrator and its own body, chooses among different metrics giving different imitation behaviors and solves the body correspondence problem.
Experiments have been conducted with Baltazar, an anthropomorphic robot combining a binocular head and na articulated arm and hand.

Keywords:

Imitation learning, Artificial Development, Humanoid Robotics, Human-robot Interaction, Vision, Machine Learning.

Members of the Thesis Committee:

Alexandre Castro Caldas, Prof. Catedrático, Universidade Católica, (P).
José Santos Victor, Prof. Associado, IST, supervisor, (P).
Yiannis Demiris, Imperial College, (UK).
Estela Guerreiro da Silva Bicho Erlhagen, Universidade Minho, (P)
Mário Alexandre Teles de Figueiredo, Prof. Associado, IST, (P)
Alexandre José Malheiro Bernardino, Prof. Auxiliar, IST (P)

Robert Edward Loke, "Progressive visualization of incomplete sonar-data sets", Ph.D. Thesis, Technical University of Delft, Delft, The Netherlands, November 2006.

MASTER THESES (4)

Bruno Duarte Damas, "Arquitectura de Aprendizagem e Decisão de um Agente Inspirado em Emoções", M. Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, February 2006.

Abstract:

In this thesis an autonomous agent architecture of learning and decision inspired on emotions and Damásio's concept of somatic marker is proposed. Recent neurophysiologic findings claim a major role of emotions in human decision processes, even if at an automatic and unconscious level. This thesis compares the influence of human emotions in decision processes to learning based on local weighted regression estimation. When an agent interacts in a world some other concepts naturally arise, like exploration, resources management, state equilibrium, rush and relevance: this thesis discusses all theses issues, associating them, whenever possible, with emotional mechanisms. To conclude several distinct problems are presented to the proposed agent architecture.

Keywords:

Agents, Learning, Decision, Emotions, Local Weighted Regression, Artificial Intelligence.

Members of the Thesis Committee:

Prof, Jorge Salvador Marques, IST (P)
Prof. Luís Miguel Botelho, ISCTE (P)
Prof. Luís Manuel Marques Custódio, IST (P)

Ricardo Ferreira, "Stereo Reconstruction of a Submerged Model Breakwater and Interface Estimation", M. Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, March 2006.

Abstract:

The present work is dedicated to the study of refraction effects between two media in stereo reconstructions of a three-dimensional scene. Refraction induces nonlinear effects on the observed image resulting in a highly complex stereo matching process. The proposal is to use a linear, first order Taylor approximation, which maps this problem into a new problem with a conventional solution, feasible around a particular image point. Images are transformed (corrected) before entering any of the known stereo matching algorithms. The final step of converting disparity to world coordinates must also be properly adapted.
An interface estimation algorithm that estimates its shape from stereo image pairs is also presented. It assumes the submerged scenery is known so it works best when a highly textured plane is used. The algorithm consists of a cost function for the interface to pass through a particular point in space. Minimization of this cost function in the presence of smoothness constraints (for example using dynamic programming like algorithms) results in the global optimum surface.
For the two algorithms, results are presented taken both from synthetic images generated by a raytracer and results from real life scenes observing an actual model breakwater.

Keywords:

Interface, Reconstruction, Stereo, Calibration, Estimation.

Members of the Thesis Committee:

Prof. João Paulo Costeira, IST (P)
Prof. Helder Araújo, FCTUC (P)
Prof. Carlos Sivestre, IST (P)
Prof. Pedro Quintas Aguiar, IST (P)

Miguel Arroz, "Plataforma de Desenvolvimento de Agentes de Busca e Salvamento", M. Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, May 2006.

Abstract:

This thesis is a description of the framework, proposed by the author, with the purpose of simplifying the development of autonomous agents suited for the participation on the RoboCup Rescue competitions. Also, the framework presents solutions to some existing problems on the currently available tools. The Common LISP Rescue Framework was built using the LISP programming language, and includes some innovative characteristics. Some of them are support for processing of more than one task simultaneously, sharing data between the tasks, and support for multiple world representations, each one of different granularity.

Keywords:

Autonomous Agents, Software Architecture, Artificial Intelligence, Rescue Agents, RoboCup, Common LISP.

Members of the Thesis Committee:

Prof. Luís Manuel Marques Custódio, IST (P)
Prof. Luís Seabra Lopes, UA (P)
Prof. Ana Almeida e Paiva, IST (P)

João Alves, "Real Time Architectures for Autonomous Vehicles", M. Sc. Thesis, Instituto Superior Técnico, Lisbon, Portugal, May 2006.

Abstract:

This thesis addresses some of the problems related with the conception and implementation of real-time distributed systems. The hardware architecture on which the real-time system was developed is presented and the different hardware modules and solutions for communication support are described. An overview of the CAN bus is presented and a higher layer protocol to work over the CAN bus limitations imposed by the packet size is proposed, aiming to expand the protocol's ability to handle long messages. An addressing scheme over CAN is implemented in order to tackle the problem of routing with other heterogeneous network interfaces. In addition, some solutions to incorporate different network topologies with CAN are presented. The reliable communication problem in distributed systems with reduced computational resources is addressed and a UDP based solution is the proposed and implemented. After the presentation of the different communication solutions, a flexible and modular network architecture for distributed systems integration is presented. The need for a global time base in distributed systems is introduced and the problem of clock synchronization on distributed architectures is studied. A software architecture for modular support in distributed real-time systems is proposed and it's logical and timing correctness analyzed. Finally as an example of application of the proposed architecture to the control of the autonomous underwater vehicle Infante, developed at Instituto Superior Técnico, is presented.

Keywords:

Real-time Systems, CAN bus, Distributed Systems, Network Architectures, Protocols, Autonomous Vehicles.

3.3.2. THESES IN PROGRESS DURING 2006

In this subsection the Doctoral and Master theses in progress during 2006, at ISR/IST (ECE) and ISR/Algarve (ECE), are identified and ordered by the scientific research area.

DOCTORAL THESES

Research Area: Decentralized State Estimation for Satellite Formations
Title:
Doctoral Student: Sónia Marques
Advisor: Pedro Lima
Initiated: September 2001
Expected conclusion: 2007
Current Status: On-going, finished PhD coursework
Documents produced in 2006:

Research Area: Inverse Reinforcement Learning
Title:
Doctoral Student: Valdinei Silva
Advisor: Pedro Lima (IST), Anna R. Costa (U. São Paulo, Brasil) – double degree
Initiated: February 2003
Expected conclusion: 2007
Current Status: On-going, finished PhD coursework
Grant: GRICES/CAPES
Documents produced in 2006:

Research Area: Petri Net Based Modelling and Coordinated Execution of Robotic Tasks
Title:
Doctoral Student: Hugo Costelha
Advisor: Pedro Lima
Initiated: October 2003
Expected conclusion: 2008
Current Status: On-going, finished PhD coursework
Grant: FCT
Documents produced in 2006

Research Area: Multi-Agent Reinforcement Learning for Stochastic Games
Title:
Doctoral Student: Gonçalo Neto
Advisor: Pedro Lima
Initiated: October 2003
Expected conclusion: 2008
Current Status: On-going, finished PhD coursework
Grant: FCT
Documents produced in 2006:

Research Area: Discrete-Event Based Opponent Modelling
Title:
Doctoral Student: Abdolkarim Pahliani
Advisor: Pedro Lima
Initiated: February 2005
Expected conclusion: 2009
Current Status: On-going, finished PhD coursework
Grant: FCT
Documents produced in 2006:

Research Area: Artificial Intelligence
Title: Emotion-based Agents
Doctoral Student: Rodrigo Ventura
Advisor: Carlos Pinto-Ferreira
Initiated: 2001
Expected conclusion: 2007
Current Status: Dissertation delivered, awaiting thesis defence.
Documents produced in 2006:

Research Area: Computer Vision
Title: Recognition using Biological inspired filters.
Doctoral Student: Plinio Moreno Lopez
Advisor: José Santos-Victor
Initiated: 2002
Expected conclusion: 2008
Current Status: Submitted
Grant: FCT
Documents produced in 2006:

Research Area: Computer Vision
Title: Recognition of Human Activities from video
Doctoral Student: Pedro Canotilho Ribeiro
Advisor: José Santos-Victor
Initiated: 2003

Expected conclusion: 2008
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Computer Vision
Title: Image matching
Doctoral Student: Ricardo Oliveira
Advisor: João Paulo Costeira
Initiated: 2001
Expected conclusion: 2008
Current Status: Submitted
Grant: FCT
Documents produced in 2006:

Research Area: Computer Vision
Title: Image matching
Doctoral Student: Ricardo Ferreira
Advisor: João Paulo Costeira
Initiated: 2005
Expected conclusion: 2008
Current Status: submitted
Grant: FCT
Documents produced in 2006:

Research Area: Computer Vision
Title: Biological inspired audio-visual learning.
Doctoral Student: Karl Jonas Hornstein
Advisor: José Santos-Victor
Initiated: 2005
Expected conclusion: 2008
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Cooperative Robotics/Topological Navigation/Learning
Title: Learning Cooperative Navigation in the Absence of Communication
Doctoral Student: Francisco António Chaves Saraiva de Melo
Advisor: Isabel Ribeiro
Initiated: 2003
Expected conclusion: 2007
Current Status: On-going
Grant: FCT - PhD grant SFRH/BD/3074/2000
Documents produced in 2006:

Research Area: Hybrid Systems to control multiple robots in active surveillance missions.
Title: Yet to be defined
Doctoral Student: Nelson Gonçalves
Advisor: João Silva Sequeira
Initiated: 2005
Expected conclusion: 2008
Current Status: Ongoing
Grant: FCT SFRH/BD/23804/2005
Documents produced in 2006:

Research Area: Guidance and Control of Dynamical Systems
Title: Sensor-Based Guidance and Control of Robotic Vehicles
Doctoral Student: Rita Cunha
Advisor: Carlos Silvestre
Initiated: 2001
Expected Conclusion: 2007
Current Status: On-going
Grant: FCT Graduate Scholarship
Documents produced in 2006:

Research Area: Control and Navigation of Autonomous Vehicles
Title: Integrated Design of Navigation and Control Systems for Autonomous Vehicles
Doctoral Student: José Vasconcelos
Advisor: Carlos Silvestre and Paulo Oliveira
Initiated: 2004
Expected Conclusion: 2008
Current Status: On-going
Grant: FCT Graduate Scholarship
Documents produced in 2006:

Research Area: Control Theory
Title: Coordinated Path Following Control of Multiple Autonomous Vehicles
Doctoral Student: Reza Ghabcheloo
Advisor: António Pascoal / Carlos Silvestre
Initiated: 2002
Expected Conclusion: 2007
Current Status: On-going
Grant: FCT Graduate Scholarship
Documents produced in 2006:

Research Area: Navigation
Title: Landmark-Based Navigation of Autonomous Underwater Vehicles (AUVs) using Bathymetric and Geomagnetic Information.
Doctoral Student: Francisco Curado Teixeira
Advisor: António Pascoal (IST) / Hipólito Monteiro (Geological Survey of Portugal – IGM)
Initiated: 2001
Expected Conclusion: 2007
Current Status: On-going
Grant: FCT Graduate Scholarship
Documents produced in 2006:

Research Area: Navigation and Positioning Systems
Title: Navigation and Positioning Systems for Underwater Robots using Nonlinear Estimation Techniques
Doctoral Student: Alex Alcocer Peñas
Advisor: Paulo Oliveira / António Pascoal
Initiated: 2004
Expected Conclusion: 2008
Current Status: On-going
Grant: FCT Graduate Scholarship
Documents produced in 2006:

Research Area: Guidance and Control of Dynamic Systems
Title: Terrain Avoidance Control for Robotic Helicopters

Doctoral Student: Bruno Guerreiro
Advisor: Carlos Silvestre
Initiated: 2005
Expected Conclusion: 2009
Current Status: research in progress
Documents produced in 2006:

Research Area: Wireless Communications
Title: Frequency-domain detection techniques for DS-CDMA and MC-CDMA signals
Doctoral Student: Paulo Silva
Advisor: Rui Dinis
Initiated: 2004
Expected conclusion: 2008
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Wireless Communications
Title: Nonlinear distortion effects on multicarrier signals
Doctoral Student Teresa Araújo
Advisor: Rui Dinis
Initiated: 2006
Expected conclusion: 2010
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Image Processing
Title: Motion Tracking on Manifolds
Doctoral Student: Jorge Gomes da Silva
Advisor: Jorge Salvador Marques and Arnaldo Abrantes
Initiated:
Expected conclusion: 2007
Current Status: concluded, waiting for discussion
Grant:
Documents produced in 2006:

Research Area: Image Processing
Title: Tracking Groups of Pedestrians with Bayesian Networks
Doctoral Student: Pedro Mendes Jorge
Advisor: Jorge Salvador Marques and João M. Lemos
Initiated:
Expected conclusion: 2007
Current Status: concluded, waiting for discussion
Grant:
Documents produced in 2006:

Research Area: Signal processing for communications
Title: MIMO communication in strongly frequency- and time-dispersive media
Doctoral Student: Cesaltina Nabais Escarigo Ricardo
Advisor: João Gomes
Initiated: 2006
Expected conclusion: 2011

Current Status: On-going
Grant:
Documents produced in 2006:

Research Area: Wireless Communications
Title: Codebooks for non-coherent communication in multiple-antenna systems
Doctoral Student: Marko Beko
Advisors: João Xavier, Victor Barroso
Initiated: 2003
Expected conclusion: 2007
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Computational Learning
Title: Classificação de documentos usando aprendizagem baseada em núcleos
Doctoral Student: André T. Martins
Advisors: Mário A. T. Figueiredo, Pedro M. Q. Aguiar
Initiated: 2005
Expected conclusion: 2008
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Signal Processing
Title: Matched-Field Tomography using simplified Acoustic Systems
Doctoral Student: Cristiano Soares
Advisor: Sérgio Jesus
Initiated: 2002
Expected conclusion: 2007
Current Status: Thesis report has been delivered.
Grant: FCT
Documents produced in 2006:

Research Area: Signal Processing
Title: From environmental to acoustic asssessment
Doctoral Student: Nelson Martins
Advisor: Sérgio Jesus
Initiated: 2002
Expected conclusion: 2007
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Signal Processing
Title: Model based underwater communications.
Doctoral Student: António J. Silva
Advisor: Sérgio Jesus, João P. Gomes
Initiated: 2002
Expected conclusion: 2007
Current Status: On-going
Grant: PRODEP
Documents produced in 2006:

Research Area: Signal Processing
Title: Acoutic tomography with high frequency signals and vector sensor arrays.
Doctoral Student: Paulo Santos
Advisor: Sérgio Jesus, Paulo Felisberto
Initiated: 2006
Expected conclusion: 2009
Current Status: On-going
Grant: none
Documents produced in 2006:

Research Area: Computer Sciences – Human Vision/Computer Vision/Visual Psychophysics
Title: Multi-scale integrated cortical architecture with applications in computer vision
Doctoral Student: João Rodrigues
Advisor: Hans du Buf
Initiated: 1998
Expected Conclusion: December 2006
Current Status: on going
Grant: PRODEP III Medida 5 - Acção 5.3 from April 2004 - September 2006
Documents produced in 2006:

Research Area: Computer Sciences – Computer Graphics
Title: 3D object Reconstruction and Triangulation
Doctoral Student: Roberto Lam
Advisor: Hans du Buf
Initiated: 2001
Expected conclusion: 2008
Current Status: on going
Grant:
Documents produced in 2006:

Research Area: Computer Sciences – Human Vision/Computer Graphics
Title: Not yet available
Doctoral Student: Pedro Guerreiro
Advisor: Hans du Buf
Initiated: 2005
Expected conclusion: 2010
Current Status: on going
Grant:
Documents produced in 2006:

Research Area: Computer Sciences – Human Vision/Computer Graphics
Title: Robust face recognition by 3D cortical representations
Doctoral Student: Samuel Nunes
Advisor: Hans du Buf
Initiated: 2005
Expected Conclusion: 2010
Current Status: on going
Grant: UE - EXOCET/D
Documents produced in 2006:

Research Area: Computer Sciences – Human Vision/Computer Vision
Title: Eye tracking, focus of attention and shading in 3D face recognition
Doctoral Student: Daniel Almeida
Advisor: Hans du Buf
Initiated: 2005
Expected conclusion: 2010

Current Status: on going
Grant: UE – EXOCET/D
Documents produced in 2006:

Research Area: NeuroSciences
Title: Physilogical Modeling and characterization of olfactive discrimination in rats
Doctoral Student: Ernesto Soares
Advisor: Agostinho Rosa
Initiated: July 1999
Expected Conclusion: 2007
Current Status: Defense March 2007
Grant: Calouste Gulbenkian Foundation
Documents produced in 2006:

Research Area: Artificial Life – Social Systems
Title: Agentes autónomos com capacidade de cooperação: Desenvolvimento e aplicações
Doctoral Student: Osvaldo Brasão
Advisor: Agostinho Rosa
Initiated: July 1999
Expected Conclusion: 2007
Current Status: Defense March 2007
Grant: FCT
Documents produced in 2006:

Research Area: Biomedical Engineering
Title: Análise da Microestrutura do EEG do Sono por ondeletas e Sintonia do detector por Computação Evolutiva
Doctoral Student: Rogério Largo
Advisor: Agostinho Rosa
Initiated: 2005
Expected conclusion: 2007
Current Status: on-going
Grant: EST-IPS
Documents produced in 2006:

Research Area: Artificial Life – Evolutionary Systems
Title: Metodologias Evolucionistas na protecção e gestão de colheitas
Doctoral Student: Gong Hongfei
Advisor: Agostinho Rosa
Initiated: October 1999
Expected Conclusion: 2007
Current Status: on-going
Grant: FCT
Documents produced in 2006:

Research Area: Biomedical Engineering
Title: A Bio-computational model of the human vision
Doctoral Student: Raquel César
Advisor: Agostinho Rosa
Initiated: June 2005
Expected Conclusion: 2007
Current Status: on-going
Grant: FCT

Documents produced in 2006:

Research Area: Evolutionary Algorithms
Title: Antropologic Evolutionary Algorithms
Doctoral Student: Carlos Fernandes
Advisor: Agostinho Rosa
Initiated: December 2004
Expected Conclusion: 2008
Current Status: on-going
Grant: FCT
Documents produced in 2006:

Research Area: Evolutionary Systems - BioChemistry
Title: Algoritmo para Evolução de Matrizes de pesos por Alinhamento Múltiplo Inverso de Sequências Proteicas
Doctoral Student: Nelson Pereira
Advisor: Agostinho Rosa
Initiated: 2005
Expected Conclusion: 2009
Current Status: on-going
Grant: FCT
Documents produced in 2006:

Research Area: Evolutionary Algorithms
Title: Parallel Evolutionary Algorithms
Doctoral Student: João Paulo Caldeira
Advisor: Agostinho Rosa
Initiated: December 2005
Expected Conclusion: 2009
Current Status: on-going
Grant: EST-IPS
Documents produced in 2006:

Research Area: Evolutionary Algorithms
Title: Linguistic modelling by Evolutionary Algorithms
Doctoral Student: Rui Tavares
Advisor: Agostinho Rosa
Initiated: Oct 2005
Expected Conclusion: 2009
Current Status: on-going
Grant: UE
Documents produced in 2006:

Research Area: Biomedical Engineering
Title: Processamento e Classificação de Eventos Fásicos no Sono
Doctoral Student: Daria Migotina
Advisor: Agostinho Rosa
Initiated: 2006
Expected Conclusion: 2010
Current Status: on-going
Grant: FCT
Documents produced in 2006:

MASTER THESES

Research Area: Machine Learning
Title: Aprendizagem por Reforço de Sistemas com Múltiplos Objectivos: o Problema da Selecção de Acções.
Master Student: Constança d'Andrade de Oliveira e Sousa
Advisor: Luís Custódio
Initiated: 2004
Expected conclusion: February 2007
Current Status: Dissertation delivered, awaiting thesis defence.
Documents produced in 2006:

Research Area: Formation Control of Aerial and Land Vehicles
Title:
Master Student: Pedro Fazenda
Advisor: Pedro Lima
Initiated: 2004
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Middleware for Multi-Robot Systems
Title: Multi-Robot Behavior-Based Architectures using Coordination by Arbitration
Master Student: Nelson Ramos
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Middleware for Multi-Robot Systems
Title: Multi-Robot Behavior-Based Architectures using Coordination by Fusion
Master Student: Marco Barbosa
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Multi-Robot Systems
Title:
Master Student: Hugo Pereira
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Multi-Robot Systems
Title:
Master Student: Matteo Tajana
Advisor: Alexandre Bernardino, Pedro Lima
Initiated: 2006

Expected conclusion: 2007
Current Status: On-going
Documents produced in 2006:

Research Area: Multi-Robot Systems
Title: Análise de Incerteza para Comportamentos Relacionais em Futebol Robótico.
Master Student: João Torres
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Multi-Robot Systems
Title: Análise Lógica de Comportamentos Relacionais em Futebol Robótico.
Master Student: Tiago Antunes
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Guidance, Navigation and Control of Aerial Vehicles
Title: Condução, Navegação e Controlo de PASSAROLA – Dirigivel Autónomo para Operações de Salvamento
Master Student: Ricardo Alcácer
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Supervision of Discrete Event Systems
Title: Controlo de Sistemas de Eventos Discretos Baseado em Lógica Temporal Linear
Master Student: Bruno Lacerda
Advisor: Pedro Lima
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Human-Robot Interaction
Title: Coordenação de Comportamentos para Robot Recepcionista do ISR
Master Student: Manuel Malhado
Advisor: Rodrigo Ventura
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Human-Robot Interaction
Title: Navegação Baseada em Visão e Sonares de Robot Recepcionista do ISR

Master Student: Ana Aleixo
Advisor: Rodrigo Ventura
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Search and Rescue Robots
Title: RAPOSA - Robot *Autónomo* Para Operações de Salvamento
Master Student: Fausto Ferreira
Advisor: Rodrigo Ventura
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, still doing some coursework
Documents produced in 2006:

Research Area: Inventory Control
Title: Smooth Priorities
Master Student: Francisco José Pais de Almeida de Varennes e Mendonça
Advisor: Carlos Bispo
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Control Theory
Title: Flow and level regulation on a network of water channels
Master Student: Tiago José Fernandes Justo
Advisor: Carlos Bispo
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going
Documents produced in 2006:

Research Area: Queuing Networks
Title: The scheduling problem for variance reduction
Master Student: Zita Daniela Batista Fernandes
Advisor: Carlos Bispo
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Queuing Networks
Title: Experimental study on local scheduling for multi-class networks
Master Student: Marta Fraústo Basso Rebello
Advisor: Carlos Bispo
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Train schedule management
Title: The meet and pass problem
Master Student: José Pedro da Luz Bernardo de Figueiredo
Advisor: Carlos Bispo
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going, finished coursework
Documents produced in 2006:

Research Area: Computer Vision
Title: Model Based 3D Tracking with Particle Filters
Master Student: Matteo Tajana
Advisor: Alexandre Bernardino
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going
Grant: FCT
Documents produced in 2006:

Research Area: Cognitive Robotics
Title: Development of Speech Production
Master Student: Cláudia Soares
Advisor: Alexandre Bernardino
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going
Grant: Contact Project
Documents produced in 2006:

Research Area: Robotics
Title: Mechanical Design of Robot Heads
Doctoral Student: Ricardo Beira
Advisor: José Santos-Victor
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going
Grant: RobotCub Project
Documents produced in 2006: Error! Reference source not found.

Research Area: Computer Vision
Title: Predictive Tracking
Doctoral Student: Paulo Carreiras
Advisor: Alexandre Bernardino
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going
Grant: None
Documents produced in 2006:

Research Area: Computer Vision
Title: Binocular Head Tracking
Doctoral Student: Samuel Ferreira
Advisor: Alexandre Bernardino
Initiated: 2006
Expected conclusion: 2007
Current Status: On-going

Grant: None
Documents produced in 2006:

Research Area: Cooperative Robotics
Title: Cooperative Navigation of Mobile Robots
Masters Student: João Casaleiro
Advisor: Isabel Ribeiro
Initiated: 2004
Expected conclusion: 2007
Current Status: Ongoing
Grant: none
Documents produced in 2006:

Research Area: Robot kinematics and dynamics
Title: Dynamic Evaluation of the RIOL Robot
Masters Student: Luís Tavares
Advisor: João Sequeira
Initiated:
Expected conclusion: September 2007
Current Status: Ongoing
Grant: RIOL project grant
Documents produced in 2006:

Research Area: Robot sensing and control
Title: Autonomous highway driving using vision and laser range finder sensors
Masters Student: André Godinho
Advisor: João Sequeira
Initiated: September 2006
Expected conclusion: September 2007
Current Status: Ongoing
Grant:
Documents produced in 2006:

Research Area: Robot sensing and control
Title: Autonomous highway driving using multiple low cost cameras
Masters Student: André Gonçalves
Advisor: João Sequeira
Initiated: September 2006
Expected conclusion: September 2007
Current Status: Ongoing
Grant:
Documents produced in 2006:

Research Area: Robot navigation and control
Title: Detection of dangerous objects through cooperation among robots
Masters Student: Michael Salgueiro
Advisor: João Sequeira
Initiated: September 2006
Expected conclusion: September 2007
Current Status: Ongoing
Grant:
Documents produced in 2006:

Research Area: Robot navigation and control
Title: Indoor surveillance robots
Masters Student: Miguel Lombo
Advisor: João Sequeira
Initiated: September 2006
Expected conclusion: September 2007
Current Status: Ongoing
Grant:
Documents produced in 2006:

Research Area: Robot kinematics and dynamics
Title: (Not yet defined)
Masters Student: Pedro Godinho
Advisor: João Sequeira
Initiated: September 2006
Expected conclusion: September 2007
Current Status: Ongoing
Grant:
Documents produced in 2006:

Research Area: Signal processing for communications
Title: Modem baseado em DSP para comunicação sem fios
Master Student: Rui Miguel Cocco Martins Gusmão
Advisor: João Gomes
Initiated: 2005
Expected conclusion: 2007
Current Status: On-going
Grant:
Documents produced in 2006:

Research Area: Biomedical Engineering
Title: Processamento de imagens em microscopio confocal
Master Student: Alexandre Calapez
Advisor: Agostinho Rosa
Initiated: 2002
Expected Conclusion: 2007
Current Status: Thesis writing
Grant:
Documents produced in 2006:

Research Area: Evolutionary Computation
Title: Simulator of Artificial Immune System
Master Student: Nuno Fachada
Advisor: Agostinho Rosa
Initiated: 2006
Expected Conclusion: 2007
Current Status: Thesis writing
Grant:
Documents produced in 2006:

3.4. ADVANCED TRAINING

3.4.1. COURSES

Brief Introduction to Bioinformatics and Computational Biology - Short Course organized by the FLAD Computational Biology Collaboratorium, hosted by the Instituto Gulbenkian da Ciência, Oeiras, Portugal, and the Institute for Systems and Robotics, pole of the Instituto Superior Técnico (ISR-Lisbon), June 2006.

S. Jesus, O. Rodriguez, C. Soares, N. Martins, A. Silva, P. Felisberto – Curso de Acústica Submarina, Universidade do Algarve, Portugal, May 2006.

José Santos-Victor – Statistical and Computational Models of Vision, Ph.D. Course, IST, Lisbon, Portugal.

3.4.2. SEMINARS

- **During 2006 the following seminars were given outside ISR:**

Agostinho Rosa – "Inteligência Artificial e Lógica Computacional", Pró-Reitoria de Pesquisa e de Pós-Graduação, UEPG - Universidade Estadual de Ponta Grossa, Paraná, Brasil, February 2006.

Agostinho Rosa – "Inteligência Artificial e Lógica e Computacional", INSPAM - Instituto de Pesquisas Avançadas em Medicina, Paraná, Brasil, February 2006.

Agostinho Rosa – "CAP: Nova Forma de Avaliação dos Distúrbios do sono", Instituto do Coração, HCFMUSP - Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, Brasil, February 2006.

Pedro Lima – "RAPOSA – Robot Autónomo Para Operações de Salvamento", XIII Semana Informática do IST, 7 March 2006, and Jornadas de Engenharia Electrotécnica e de Computadores do IST, 30 March 2007.

Pedro Lima – "Robótica", High School José Gomes Ferreira, March 2006.

Pedro Lima - "Mobile Robots and RoboCup", for the Summer Course 2006, Robots - What can they do with(out) us?, sponsored by BEST Almada, Faculdade de Ciências e Tecnologias da Universidade Nova de Lisboa, Almada, September 2006.

Carlos Bispo – "Gestão de Operações", for the Summer Course 2006, Robots - What can they do with(out) us?, sponsored by BEST Almada, Faculdade de Ciências e Tecnologias da Universidade Nova de Lisboa, Almada, September 2006.

Pedro Lima – "Robótica e Ensino Experimental de Ciência e Tecnologia - 10 anos de Actividades", 1st Algarve Soccer Robotics National Meeting, Paderne, October 2006.

Alexandre Bernardino - "Research Projects @ VisLab", invited talk**,** Universidad Jaume I, Castellon de la Plana, Espanha, November 2006.

Agostinho Rosa – "Novas perspectivas neurofisiológicas para Neurologia e Psiquiatria", UFRJ – Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil, December 2006.

- **Monthly seminars with Mathematic Department:**

In a monthly basis and co-organized by João Xavier, the following seminars were held:

"Minimum-Energy and H-infinity State Estimation",
Pedro Aguiar (ISR-IST)
May 2006

"O processo de Moran Contínuo",
Fabio Chalub (FCT/UNL)
May 2006

"Gamma-convergence"
Pedro Santos (DM/IST)
June 2006

"String kernels and similarity measures for information retrieval"
André Martins (Priberam and IST)
June 2006

"Two-Step Iterative Shrinkage/Thresholding Algorithms for Total Variation and Wavelet-Based Image Restoration"
José Bioucas (IT/IST)
July 2006

"Recent Techniques for Solutions to Nonlinear Dispersive Equations"
Mahendra Panthee (CAMGSD)
July 2006

"Synchronization of pendulum clocks - the Huygens phenomena"
Henrique Oliveira (IST-DM/CAMGSD)
October 2006

"Time-series models on manifolds: the AR case"
João Xavier (ISR)
October 2006

"Probabilistic Data Association Techniques for Target/Contour Tracking in Clutter"
Jacinto Nascimento (ISR/IST)
November 2006

"An example of 2D-1D discrete-continuum reduction argument by Gamma-convergence"
Margarida Baía (CAMGSD/IST)
November 2006

"Biologically Inspired Visual Geometries"
Alexandre Bernardino and José Gaspar, Profs. IST

- **ISR Regular seminars:**

In a regular basis, and organized by Paulo Oliveira, the following seminars were held:

"Stability of switched seesaw systems with application to the stabilization of underactuated vehicles"
António Pedro Aguiar, Researcher, ISR/IST
January 2006

"Infranet Project – Taking Accurate Measurements of High Voltage Installations with Laser Range Scanners and GPS"
Alberto Vale, PhD Student ISR/IST
January 2006

"Fast and Exact Algorithms for Energy Minimization"
Jerome Darbon, ENST Engineering School
January 2006

"Understanding Bio-Complexity with Signal Processing"
Gail Rosen, Ph.D. Student at Georgia Tech, USA
February 2006

"Estacionamentos mecânicos ou sistemas que permitem multiplicar o espaço disponível"
Miguel Louro, Consultant of Suporte Parksystems
February 2006

"Pervasive Networks of Robots for Research and Teaching"
Daniela Rus, CSAIL-MIT
March 2006

"Inverse Reinforcement Learning with Evaluation"
Valdinei Silva, University of São Paulo, Brasil
March 2006

"Hessian of the Riemannian distance function on connected locally symmetric spaces: centroid computation with a Newton method"
Ricardo Ferreira, Ph.D. Student ISR/IST
March 2006

"Entropy penalization methods for Hamilton-Jacobi equations"
Enrico Valdinoci,
March 2006

"Efficient planning under uncertainty in the POMDP framework"
Matthijs Spaan, Ph.D. student at the University of Amsterdam, The Netherlands
March 2006

"A Two-Hour Tutorial Presentation of Sajjad Fekris's Ph.D. Research on Robust Multiple-Model Adaptive Control (RMMAC)"
Michael Athans, Invited Research Professor, ISR/IST
April 2006

"Development of a Landing Controller for an Automated Helicopter"
Sarabjit Bhooee, Student in the Imperial College of London
May 2006

"Biologically inspired mechanisms for human action understanding towards Social Robots"
Yiannis Demiris, BioART, Intelligent Systems and Networks Group, Department of Electrical and Electronic Engineering, Imperial College London
May 2006

"Robôs Móveis: Aplicações indoor e outdoor"
Marcelo Becker, Prof. in PUC – Minas, Brazil
June 2006

"Fuzzy Control – An Introduction"
Gerd Schulz, visit under ERASMUS programme
June 2006

"Manifold Learning: Representing High-Dimensional Data in Low-Dimensional Spaces"
Marko Stösic, Researcher ISR/IST
July 2006

"Ranklets: a complete set of orientation selective rank feature"
Fabrizio Smeraldi, lecturer in Queen Mary university of London
September 2006

"An Introduction to Uncertainty Based Methods"
Luis Crespo, National Institute of Aerospace
September 2006

"Optimization under Uncertainty"
Luis Crespo, National Institute of Aerospace
September 2006

"Lagrangean duals and problem decomposition"
Raquel César, Ph.D. Student, ISR/IST
October 2006

"The Changing Role of Computer Vision Applications"
Petia Radeva, Computer Science Department & Computer Vision Center, Universitat Autònoma de Barcelona.
October 2006

"Rational Trigonometry Applied to Robotics"
João Pequito Almeida, Student IST/ISR
November 2006

"Marginal-SLAM: A convergent Particle Method for Simultaneous Robot Localization and Mapping"
Ruben Martinez-Cantin, Universidad of Zaragoza
November 2006

"The Theory of Fast and Robust Adaptation"
Naira Hovakimyan, Department of Aerospace and Ocean Engineering, Virginia Polytechnic Institute and State University, USA
December 2006

3.4.3. READING GROUPS

A new group on *Sequential Decision Making* was set up by Matthijs Spaan and Francisco Melo to start January 2007.

VisLab Weekly seminar meeting.

3.4.4. VISITS ABROAD

Sérgio Jesus – Earth and Ocean Science Lab, Prof. N. Ross Chapman, Univ. of Victoria, Victoria BC, Canada, April - May 2006.

José Gaspar - visited Prof. Peter Sturm, at INRIA-Alpes, June 2006.

Sérgio Jesus – NATO Underwater Research Center (NURC), La Spezia (Italy), Rapid Environmental Picture Workshop, December 2006.

Agostinho Rosa – UNESP, Universidade Estadual Paulista, Botucatu, São Paulo, Brasil.

Agostinho Rosa – UFRJ, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.

Agostinho Rosa – HC–USP, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brasil.

3.4.5. SUPERVISION OF STUDENTS ENROLLED IN FOREIGN UNIVERSITIES

Pedro Lima - Supervisor of Valdinei Silva, Ph.D. Student from Universidade Politécnica de São Paulo, Brasil – twelve month period at ISR/IST, March 2005 to February 2006.

Alexandre Bernardino, **Pedro Lima –** co-supervisors of Matteo Tajana, MSc Student from Politecnico di Milano, fifteen month period at ISR/IST, May 2006- July 2007.

José Santos-Victor - co-supervisor of Roger Freitas, PhD student, Federal University of Espírito Santo, Vitória, Brasil.

José Santos-Victor - co-supervisor of Sandra Nope, PhD student, University of Cali, Colombia.

José A. Gaspar - co-supervisor of Miguel Andrés Realpe Robalino, Escuela Superior Politecnica del Litoral - ESPOL , Guayaquil, Ecuador.

Alexandre Bernardino – Supervisor of Jorge Grande, Universidade de Castelló, Espanha, (Jan-Sept. 2006), M.Sc, ERASMUS.

Alexandre Bernardino – Supervisor of Matteo Tajana, Politecnico di Milano, Italy, (June 2006-June 2007), M.Sc, ERASMUS.

3.5. CONGRESSES, MEETINGS and PRESENTATIONS

This section includes invited talks, conferences attended and conferences where papers were presented, during 2006, by ISR-Lisbon researchers.

3.5.1. INVITED TALKS

Isabel Ribeiro, "Uma Viagem ao Mundo dos Robots," Invited Talk, High School Emídio Navarro, Viseu, Portugal, January 2006.

Isabel Ribeiro, "Social and Ethic Problems in Search and Rescue Robots: questions for discussion," Invited Talk, *Euron Atelier on Robotethics*, Genoa, Italy, 27 Feb-2 March 2006.

Isabel Ribeiro, "Autonomous Robotics: Challenges and Opportunities," Invited Talk, *Symposium on the Research Activities of the Technical University of Lisbon*, Lisbon, Portugal, 2-3 Feb 2006.

António Pascoal - "Control of Single and Multiple Autonomous Robots for Ocean Exploration". Invited Talk, Fellows Lecture Series. *United Technology Corporation / Pratt and Whitney*, Hartford, Connecticut, USA, August 22, 2006.

António Pascoal - "A Engenharia e os Oceanos, "Forum Novas Fronteiras da Ciência e do Conhecimento, April 1, 2006.

Pedro Lima – "Discrete-Event-Based Modeling, Analysis and Design of Multi-Robot Systems" – Multi-Robot Systems: Perception, Behaviors, Learning, and Action, Dagstuhl Seminar 06251, H. Burkhard, M. Riedmiller, U. Schwiegelshohn, M. Veloso (Eds.), June 2006.
http://drops.dagstuhl.de/portals/index.php?semnr=06251

João Sequeira, "A New Perspective in Human-Robot Interaction", Macau University, Macau, P. R. of China, June 2006.

João Sanches – "An Alignment-by-Reconstruction Algorithm Reconstruction from Fluorescence Confocal Microscopy Images", 7th IEEE EMBS International Summer School on Biomedical Imaging, Berder, France, June, 2006.

José Santos-Victor - "Short-Term Human action recognition - insights from and to biology," Invited Speaker, AERFAI Summer School on Action and Object Classification Techniques in Digital Images, Granada, June, 2006.

José Santos-Victor, "Short-Term Human activity recognition - learning from biology," Invited Speaker, IV Conference on Articulated Motion and Deformable Objects, Andratx, Mallorca, Spain, 11-14 July 2006.

José Santos-Victor - "Computer and robot Vision: Learning from Biology", Invited Speaker, Controlo 2006 - 7th Portuguese Conference on Automatic Control, Lisbon, Portugal, September 2006.

Agostinho Rosa – "Avanços em Polissonografia", V Simpósio Internacional de Sono, Associação Paulista de Medicina, São Paulo, Brasil, November 2006.

Agostinho Rosa – "Neurofisiologia do Sono", V Simpósio Internacional de Sono, Associação Paulista de Medicina, São Paulo, Brasil, November 2006.

Agostinho Rosa – "Polissonografia e Distúrbios do Sono", V Simpósio Internacional de Sono, Associação Paulista de Medicina, São Paulo, Brasil, November 2006.

3.5.2. PARTICIPATIONS

- 9th ESA Workshop on Advanced Space Technologies for Robotics and Automation, ESTEC, Noordwijk, The Netherlands, November 2006.
- EUSIPCO2006 - 14th European Signal Processing Conference, Florence, Italy, September 2006.
- MTS/IEEE Oceans2006 Conference, Boston, USA, September 2006.
- ICIP2006 - IEEE International Conference on Image Processing, Atlanta, GA, USA, October 2006.
- ICIAR2006 - International Conference on Image Analysis and Recognition, Póvoa de Varzim, Portugal, September 2006.
- ICRA - IEEE International Conference on Robotics and Automation, Orlando, Florida, USA, May 2006.
- BMVC - British Machine Vision Conference, Oxford Brookes University, UK, September 2006.

3.5.3. ORGANIZATIONS

8th European Conference on Underwater Acoustics, Carvoeiro, Portugal, June 2006.

3.6. SERVICE ACTIVITIES

3.6.1. EDITORIAL BOARDS

Agostinho Rosa – Member of the Editorial Board of the ACM Symposium on Applied Computing – Artificial Intelligence & Computer Logic Track.

Agostinho Rosa – Member of the Editorial Board of the International Journal of Information & Communication Technology in Education.

Agostinho Rosa – Member of the Editorial Board of the International Journal of Web-based learning and Teaching Technologies.

Jorge S. Marques – Associate Editor of Statistics and Computing Journal, Springer.

José Santos-Victor – Associate Editor, IEEE Transactions on Robotics.

Pedro Lima – Member of the Editorial Advisory Board of the Journal of Advanced Robotic Systems, published by Vienna University of Technology.

Pedro Lima – Member of the Editorial Board of the Portuguese Magazine Robótica.

3.6.2. ADVISORY BOARDS

Agostinho Rosa – Member of the Conselho das Comunidades Maceenses of APIM, Macau, RE-RP China.

Agostinho Rosa – Member of the Academy of Finland – Research Council for Natural Sciences and Engineering, Research Project evaluation.

Agostinho Rosa – Member of the CONICIYT – Comision Nacional de Investigación Científica e Tecnológica, FONDECYT - Research Project evaluation**.**

João Sanches – Member of the Technical Comittee for the evaluation of projects submitted to the SEF (Serviço de Estrangeiros e Fronteiras) for the development of a kiosk and a portable system for biometric data acquisition.

José Santos-Victor - Member of the Aurora Board of Participants of the European Space Agency (ESA).

Pedro Lima – Member of the Board of Trustees of the RoboCup Federation.

Pedro Lima – Portuguese representative to the Mirror Group of the European Technological Platform on Robotics, EUROP.

Pedro Lima – Member of the Dissemination Key Area Board of EURON-II.

Pedro Lima – Founding member of the Technical-Scientific Committee of the Portuguese Robotics Open.

3.6.3 PROGRAMME AND TECHNICAL COMMITTEES

Agostinho Rosa – Member of the Programme Committee of ESM2006 – 20th Annual European Simulation and Modelling Conference, Toulouse, France, February 2006.

Agostinho Rosa – Member of the Programme Committee of the BioMed2006 – 4th IASTED International Conference on Biomedical Engineering, Innsbruck, Austria, February 2006.

Pedro Lima – Member of the International Program Committee of the IAS2006 - Intelligent Autonomous Systems Conference, University of Tokyo at Kashiwa, Japan, March 2006.

Agostinho Rosa – Member of the Programme Committee of the ACM SAC2006 – ACM Symposium on Applied Computing, Dijon, France, April 2006.

Agostinho Rosa – Member of the Programme Committe of the ICEIS2006 – 8th International Conference on Enterprise Information Systems, Paphos, Cyprus, May 2006.

Pedro Lima – Member of the International Program Committee of the RoboCup2006 Symposium, Bremen, Germany, June 2006.

Pedro Lima – Member of the International Program Committee of the CONTROLO2006 - 7th Portuguese Conference on Automatic Control, Lisboa, Portugal, September 2006.

Pedro Lima - Chair of the International Program Committee of MVS2006 - 1st IFAC Workshop on MultiVehicle Systems, Salvador, Bahia, Brasil, October 2006.

Pedro Lima – Member of the International Program Committee of the CCA2006 - IEEE International Conference on Control Applications, Technical University of Munich, Germany, October 2006.

Pedro Lima – Member of the International Program Committee of the IROS2006 - IEEE/RSJ International Conference on Intelligent Robots and Systems, Beijing, China, October 2006.

Pedro Lima – Member of IFAC Technical Committee on Discrete Event and Hybrid Systems.

Agostinho Rosa - IFAC member of Technical Committee on Optimal Control.

Agostinho Rosa – IASTED member of Technical Committee on Biomedical Engineering.

Isabel Ribeiro - Member of the Program Committee of Scientific Meeting of the Robótica2006 - 6th Portuguese Robotics Festival, Guimarães, Portugal, April 2006.

Jorge Marques – Member of the Program Committee of PRIS2006 – 7th International Workshop on Pattern Recognition in Information Systems, Cyprus, May 2006.

Jorge Marques – Member of the Program Committee of ECCV'06 - European Conference on Computer Vision, Graz, Austria, May 2006.

Isabel Ribeiro - Member of the International Program Committee of the Posters Sessions of the ICRA2006 - IEEE *International Conference on Robotics and Automation,* Orlando, EUA, May 2006.

João Gomes - Member of the Organizing Committee of ECUA2006 - 8th European Conference on Underwater Acoustics, Carvoeiro, Portugal, June 2006.

Isabel Ribeiro - Member of the International Program Committee of the DARS2006 - *8th International Symposium on Distributed Autonomous Robotic Systems*, Minneapolis, Minnesota, USA, July 2006.

Jorge Marques – Member of the Program Committee of SPR2006 – 6th International Workshop on Statistical Pattern Recognition, part of IAPR2006, Hong Kong, China, August 2006.

Isabel Ribeiro - Member of the International Program Committee of the ICINCO2006 - *3rd International Conference on Informatics in Control, Automation and Robotics*, Setubal, Portugal, August 2006.

João Sequeira, Member of the Program Committee of the ICINCO 2006 - 3rd International Conference on Informatics in Control, Automation and Robotics, Setubal, Portugal, August 2006.

Francisco Garcia – Organizing Committee of the MCMC2006 – 7th IFAC Conference on Manoeuvring and Control of Marine Craft, Lisbon, Portugal, September 2006.

João Gomes - Member of the Technical Committee of WUWNet2006 - 1st ACM International Workshop on Underwater Networks, Los Angeles, USA, September 2006.

Isabel Ribeiro - Member of the International Program Committee of the MCMC2006 - *7th IFAC Conference on Manoeuvring and Control of Marine Craft*, Lisbon, Portugal, September 2006.

Pedro M. Q. Aguiar – Member of the Technical Committee of ICIAR2006 - International Conference on Image Analysis and Recognition, Póvoa deVarzim, Portugal, September 2006.

Alexandre Bernardino - Programme Committee Member, 6th International Workshop on Epigenetic Robotics, EPIROB'06, Paris, France, September 2006.

Alexandre Bernardino - Programme Committee Member, ICIAR 2006, International Conference on Image Analysis and Recognition, Póvoa do Varzim, Portugal, September 2006.

Pedro M. Q. Aguiar – Member of the Technical Committee of ICIP2006 - IEEE International Conference on Image Processing, Atlanta, USA, October 2006.

Isabel Ribeiro - Member of the International Program Committee of the 1st IFAC Workshop in Multi-Vehicle Systems, Salvador, Brasil, October 2006.

Isabel Ribeiro - Member of the International Program Committee of the 2006 *IEEE International Conference on Intelligent Robots and Systems*, IROS2006, Pequim, China, October 2006.

Jorge Marques – Member of the Program Committee of CIARP2006 - 11th Iberoamerican Congress on Pattern Recognition, Cancun, November 2006.

João Gomes – Member of the Technology Committee on Marine Communications of the Oceanic Engineering Society.

José Santos-Victor - Programme Committee Member, IEEE International Conference on Robotics and Automation, ICRA.

José Santos-Victor - Programme Committee Member, IEEE Computer Society Conference on Computer Vision and Pattern Recognition, CVPR.

José Santos-Victor - Programme Committee Member, IEEE International Conference on Intelligent Robots and Systems, IROS.

Luis Montesano - Robotics: Science and Systems.

3.6.4. CHAIRPERSON

Agostinho Rosa - ACM SAC 06 – Dijon – França.

Isabel Ribeiro, *Chair* of the Plenary Session by Prof. Klauss Schilling, CONTROLO 2006 - 7th Portuguese Conference on Automatic Control, Lisbon, Portugal.

João Sequeira, Chair of Parallel Session, ICINCO 2006 - 3rd International Conference on Informatics in Control, Automation and Robotics, Setúbal, Portugal.

3.6.5. REVIEWERS

Agostinho Rosa - IEEE Transactions on Biomedical Engineering - Trans BME.

Agostinho Rosa - IEEE Transactions on Evolutionary Computation.

Agostinho Rosa – BSPC, Biomedical Signal Processing & Control

Agostinho Rosa - Eurasip International Journal of Biomedical Engineering.

Agostinho Rosa - Pattern Recognition Letters.

Agostinho Rosa – IRMJ, Information Resources Management Journal.

Agostinho Rosa - Clinical Neurophysiology.

Agostinho Rosa – Sleep.

Alexandre Bernardino – Autonomous Robots, 2006, Springer Netherlands.

Alexandre Bernardino – International Journal on Humanoid Robot, 2006, World Scientific.

Alexandre Bernardino – IEEE Transactions on Image Processing.

Alexandre Bernardino - IEEE Transaction on Robotics.

Alexandre Bernardino – CONTROLO'2006 - The 7th Portuguese Conference on Automatic Control.

Alexandre Bernardino – ECCV'06 - 9th European Conference on Computer Vision.

Alexandre Bernardino – EPIROB'06 - The 6th International Workshop on Epigenetic Robotics.

Alexandre Bernardino – ICIAR'06 – International Conference on Image Analysis and Recognition.

Alexandre Bernardino – ICRA'06 - IEEE International Conference on Robotics and Automation.

Alexandre Bernardino – ITSC'06 - The 9th International IEEE Conference on Intelligent Transportation Systems.

Francisco Garcia – IEEE Transactions on Circuits and Systems.

Francisco Melo, CDC 2006 – 45th IEEE Conference on Decision and Control.

Francisco Melo, ACC 2006 – 2006 American Control Conference.

Isabel Lourtie - IEEE Transactions on Circuits and Systems.

Isabel Ribeiro – Review of the book "Controlo Digital: exercícios resolvidos" submitted for publication to the University of Coimbra press, August 2006.

Isabel Ribeiro - IEEE Transactions on Intelligent Transportation Systems.

Isabel Ribeiro - IEEE Transactions on Robotics.

Isabel Ribeiro - Robotics and Autonomous Systems.

Isabel Ribeiro – CONTROLO 2006 - 7th Portuguese Conference on Automatic Control.

Isabel Ribeiro - IECON2006 - The 32nd Annual Conference of the IEEE Industrial Electronics Society.

Isabel Ribeiro, MCMC2006 – 7th IFAC Conference on Manoeuvring and Control of Marine Craft.

Isabel Ribeiro, DARS2006 – 8th International Symposium on Distributed Autonomous Robotic Systems.

Isabel Ribeiro, ICRA2006 - IEEE International Conference on Robotics and Automation (artigos apresentados especialmente a sessões de posters).

Isabel Ribeiro - ROBÓTICA – Scientific Meeting of the Festival Nacional de Robótica.

Isabel Ribeiro, IROS2006 – IEEE/RSJ International Conference on Intelligent Robots and Systems.

João Gomes - IEEE Journal of Oceanic Engineering.

João Gomes - IEE Electronics Letters, Journal of the Acoustical Society of America.

João Gomes – CDC2006 – 45th IEEE Conference on Decision and Control.

João Sanches - IEEE Transactions on Medical Imaging.

João Sanches - IEEE Transactions on Image Processing.

João Sanches – ICIAR2006 - International Conference on Image Analysis and Recognition.

João Sanches – CIARP2006 - Iberoamerican Congress on Pattern Recognition.

João Sequeira - Elsevier Journal of Sound and Vibration**.**

João Sequeira – ICINCO 2006 - 3rd International Conference on Informatics in Control, Automation and Robotics.

João Sequeira - CONTROLO2006 - 7th Portuguese Conference on Automatic Control.

João Sequeira – Robótica 2006 - Scientific Meeting of the 6th Festival Nacional de Robótica.

João Sequeira - SYROCO 2006, - 8th International IFAC Symposium on Robot Control, Bolonha.

João Sequeira – IROS2006 – IEEE/RSJ International Conference on Intelligent Robots and Systems.

Jorge Marques - IEEE Transactions on Image Processing.

Jorge Marques - Pattern Recognition Letters.

José A. Gaspar - ECCV'06, European Conference on Computer Vision.

José A. Gaspar - ICRA'06, IEEE International Conference on Robotics and Automation.

José A. Gaspar - IROS'06, IEEE/RSJ International Conference on Intelligent Robots and Systems.

José A. Gaspar - RSS'06, Robotics: Science and Systems Conference.

José A. Gaspar - T-CSVT'06, IEEE Transactions on Circuits and Systems for Video Technology.

José A. Gaspar - T-RA'06, IEEE Transactions on Robotics and Automation.

José Santos-Victor – IEEE Transactions on Pattern analysis and Machine Intelligence.

José Santos-Victor – IEEE Transactions on Robotics and Automation.

José Santos-Victor – IEEE Transactions on Biomedical Engineering.

José Santos-Victor – IEEE Transactions on Robotics.

José Santos-Victor – IEEE Transactions on System Man and Cybernetics.

José Santos-Victor – Journal of Robotics and Autonomous Systems.

José Santos-Victor – BMVC - British Machine Vision Conference.

José Santos-Victor – IBPRIA - 2nd Iberian Conference on Pattern Recognition and Image Analysis.

José Santos-Victor – ICRA - IEEE International Conference on Robotics and Automation.

José Santos-Victor – IROS - IEEE/RSJ International Conference on Intelligent Robots and Systems.

Luis Montesano – ICRA 2006 - IEEE International Conference on Robotics and Automation.

Luis Montesano – IROS 2006 - IEEE International Conference on Intelligent Robots and Systems.

Luis Montesano - IEEE Transactions on Robotics.

Luis Montesano - Robotics: Science and Systems.

Luis Montesano – IJCAI 2006 - International Joint Conference on Artificial Intelligence.

Pedro Lima - IEEE Transactions on Fuzzy Systems.

Pedro Lima - IEEE Robotics and Automation Magazine.

Pedro Lima - IEEE Transactions on Robotics.

Pedro Lima - IEEE Transactions on Systes, Man and Cybernetics – Part B.

Pedro Lima - IEE Proceedings on Control Theory and Applications.

Pedro Lima - ARS International Journal of Advanced Robotic Systems.

Pedro Lima - Springer-Verlag Journal of Intelligent and Robotic Systems.

Pedro Lima - Elsevier Journal of Robots and Autonomous Systems.

Pedro Lima – ICRA2007 - IEEE International Conference on Robotics and Automation.

Pedro Lima – IEEE Vehicular Technology Conference Fall 2006.

Pedro M. Q. Aguiar - IEEE Transactions on Image Processing.

Pedro M. Q. Aguiar - IEEE Transactions on Medical Imaging.

Pedro M. Q. Aguiar – IEEE Transactions on Robotics.

Pedro M. Q. Aguiar - Journal of Microscopy Research and Technique.

Pedro M. Q. Aguiar - Journal of Mathematical Imaging and Vision.

Pedro M. Q. Aguiar – ETRI Journal of Information, Telecommunications & Electronics.

Pedro M. Q. Aguiar – ICIP2006 – IEEE International Conference on Image Processing.

Pedro M. Q. Aguiar - ICIAR2006 - International Conference on Image Analysis and Recognition.

Pedro M. Q. Aguiar – IROS2006 - IEEE/RSJ International Conference on Intelligent Robots and Systems.

Sérgio Jesus – Journal of the Acoustical Society of América.

Sérgio Jesus – IEEE Journal of Ocean Engineering.

Sérgio Jesus – Acta acústica.

3.6.6. OTHER ACTIVITIES

Pedro Lima – Founding President of the IEEE Portugal Robotics and Automation Society Chapter.

Pedro Lima – Coordinator of the Systems, Decision and Control Scientific Area, Department of Electrical and Computers Engineering, IST.

Pedro Lima – Ph.D. Advisor of Porfírio Silva, candidate at the Philosophy Department of Faculdade de Letras of University of Lisbon. Thesis title: "Robótica Institucionalista: as Ciências do Artificial como Ciências do Humano".

Pedro Lima – reviewer of projects submitted to the Agency for the Innovation.

Pedro Lima – Reviewer of projects submitted to *Ciência Viva* – National Agency for Scientific and Technological Culture.

Pedro Lima - External reviewer of the PhD Thesis of Alberto Jardón Huete, "Metodologia de Diseño de Robots Asistenciales. Aplicación al Robot Portátil ASIBOT", Universidad Carlos III de Madrid, Spain, Advisors: Prof. António Giménez, Prof. Carlos Balaguér.

Pedro Lima – Reviewer of project submitted to the Dutch Technology Foundation STW.

João Sequeira - served as Coordinator for the Specialization Area of Systems, Decision and Control in the Graduation in Electrical and Computer Engineering until October 2006. Currently is in the Executive Board of the Department of Electrical and Computer Engineering.

Isabel Ribeiro – served as Director of the Institute for Systems and Robotics.

Isabel Ribeiro – Member of the jury of the Georges Giralt PhD Award in the frame of EURON-European Robotics Research Network.

Isabel Ribeiro – Member of the evaluation panel of the PhD and Post-Doc grants financed by Fundação para a Ciência e a Tecnologia (FCT), May 2006.

Isabel Ribeiro – Member of the evaluation panel for the proposals submitted for of Centers of Excellence in the frame of the call for projects launched by AdI – Agência de Inovação, January-July 2006.

Isabel Ribeiro – Member of the jury of Prof. Luís Vidigal award, in the frame of the Department of Electrical and Computer Engineering (DEEC) of IST.

Isabel Ribeiro – Member of the evaluation panel for the final reports of R&D projects funded by Fundação para a Ciência e a Tecnologia (FCT), since January 2006.

Francisco Melo – Visiting researcher at Carnegie Mellon University, School of Computer Science, with the CORAL research group leaded by Prof. Manuela Veloso, from January, 6th to April, 1st 2006.

Victor Barroso – Coordinator of the KEY AREA Critical Infrastructures and Risk Assessment of the CMU-Portugal consortium.

Victor Barroso – Vice-President of the IST's Scientific Council.

Victor Barroso – Coordinator of the Telecommunications Scientific Area of the ECE Department of IST.

Francisco Garcia – member of the coordination board of the IST Masters in Electrical and Computer Engineering.

Isabel Lourtie - Vice President of the IST's Department of Electrical and Computer Engineering.

Jorge Marques – Coordinator of the Ph.D. Program in Electrical and Computer Engineering of IST, 2006.

João Gomes - Systems manager of ISR signal processing laboratory.

João Sanches - Systems manager of the laboratories of the Scientific Area of Control and Decision Systems of the IST's ECE DEp.

3.7. ACADEMIC ACTIVITIES

Here we list the participation during 2006, of ISR-Lisbon researcher in committees for Doctoral and Master Thesis, and other academic related activities.

Sérgio Jesus – Member of the M.Sc. Thesis Committee of Carlos Alberto Martin Benito Teixeira de Sousa, "Simulação computacional de sonar ultrasónico de abertura sintética", Instituto Superior Técnico, Universidade Técnica de Lisboa, January 2006.

Pedro Lima – Member of the Ph.D. Thesis Committee of João Miguel Guerreiro Dias Alves Lourenço, "Controlo Adaptativo Baseado em Modelos Múltiplos", Instituto Superior Técnico, Universidade Técnica de Lisboa, 2006.

Luis Custódio - Member of the M.Sc. Thesis Committee of Bruno Duarte Damas, "Arquitectura de Aprendizagem e Decisão de um Agente Inspirado em Emoções", Instituto Superior Técnico, Universidade Técnica de Lisboa, February 2006.

Luís Custódio - President of the M.Sc. Thesis Jury of Miguel Barreto da Silva Arroz, "Plataforma de Desenvolvimento de Agentes de Busca e Salvamento", Instituto Superior Técnico, Universidade Técnica de Lisboa, March 2006.

Agostinho Rosa – Member of the Ph.D. Thesis Committee of Cristian Munteanu, "Increasing Adaptability in Evolutionary Algorithms for Solving Complex Optimization Problems", March 2006.

Victor Barroso – Member of the Committee of promotion to Associate Professor of the ECE Department of IST, Scientific Area of Telecommunications.

Victor Barroso – Member of the Committee of promotion to Associate Professor of the ECE Department of IST, Scientific Area of Control and Decision Systems.

Victor Barroso – Member of the Committee of promotion to Full Professor of the ECE Department of IST, Scientific Area of Telecommunications.

Jorge Marques – Member of the Ph.D. Thesis Committee of João Alves Lourenço, "Controlo Adaptativo Baseado em Múltiplos Modelos", Instituto Superior Técnico, Universidade Técnica de Lisboa, 2006.

Jorge Marques – Member of the Ph.D. Thesis Committee of Fernando Pina Soares, "Extracção de Objectos de Representação Cartográfica a Partir de Imagens Aéreas de Elevada Rsolução Espacial", Instituto Superior Técnico, Universidade Técnica de Lisboa, October 2006.

Jorge Marques – Member of the M.Sc. Thesis Committee of Maria Luísa Sousa e Castro, "Classificação de Imagens de Satélite por Aglomeração Hierárquica Usando o MatLab", Faculdade de Ciências da Universidade do Porto, October 2006.

Jorge Marques – Member of the M.Sc. Thesis Committee of Bruno Damas, "Arquitectura de Aprendizagem e Decisão de um Agente Inspirado em Emoções", Instituto Superior Técnico, Universidade Técnica de Lisboa, February, 2006.

Jorge Marques – Member of the M.Sc. Thesis Committee of João Silva Martins, "Computational Retina Models for Bioelectronic Vision", Instituto Superior Técnico, Universidade Técnica de Lisboa, December 2006.

João Gomes - Co-advisor and member of the Ph.D. Thesis Committee of António João Freitas G. da Silva, "Time-reversed underwater communications", Instituto Superior Técnico, Universidade Técnica de Lisboa, 2006.

Pedro M. Q. Aguiar – Member of the M.Sc. Thesis Committee of Ricardo Ferreira, "Stereo Reconstruction of a Submerged Model Breakwater and Interface Estimation", Instituto Superior Técnico, Universidade Técnica de Lisboa , March 2006.

Pedro M. Q. Aguiar - Member of the M.Sc. Thesis Committee of Gonçalo Valadão Matias, "Radar Interferometry: 2D Phase unwrapping via graph cuts", Instituto Superior Técnico, Universidade Técnica de Lisboa, Julho 2006.

Alexandre Bernardino – Member of the Ph.D Thesis Committee of Manuel Lopes, "A Developmental Roadmap for Learning by Imitation in Robots", Instituto Superior Técnico, 2006.

José Gaspar - Member of the PhD Thesis Committee of Radu Orghidan, "Catadioptric Stereo Based on Structured Ligth Projection", University of Girona, Spain, July 2006.

José Gaspar - elaborated report for the "European PhD" mention in the PhD thesis of Luis Montesano, "Detection and tracking of moving objects from a mobile platform - Application to navigation and multi-robot localization", University of Saragoza / Spain, March 2006.

José Santos-Victor – Member of the Ph.D. Thesis Committee of Nicolas Mansard, "Enchaînement de Tâches Robotiques", Université de Rennes, France, December 2006.

José Santos-Victor – Member of the Ph.D. Thesis Committee of Toon Goedemé, "Visual Navigation", Katholic University of Leuven, Belgium, December 2006.

José Santos-Victor – Member of the Ph.D. Thesis Committee of Luis Montesano, "Detection and tracking of moving objects from a mobile platform. Applcation to navigation and multi-robot localization", Department of Informática e Ingeniería de Sistemas, University of Zaragoza, April 2006.

José Santos-Victor – Member of the Ph.D. Thesis Committee of Cristian Munteanu, "Increasing Adaptability in Evolutionary Algorithms for Solving Complex Optimization Problems", Electrical and computer engineering, Instituto Superior Técnico, March 2006.

José Santos-Victor – Member of the Ph.D. Thesis Committee of Rui Rodrigues, "Robust and hardware accelerated 3D point and line reconstruction from images", Universidade do Minho, June 2006.

José Santos-Victor – Member of the Ph.D Thesis Committee of Manuel Lopes, "A Developmental Roadmap for Learning by Imitation in Robots", Instituto Superior Técnico, 2006.

João Sequeira – Member of the PhD Thesis Jury of Li Yugang, "Kinematics, Dynamics and Intelligent Control for Nonholonomic Mobile Modular Manipulators", University of Macau, Macau, P. R. China, June 2006.

João Sequeira – Member of the PhD Thesis Jury of Manuel Pereira Carvalheira, "Controlo de um Veículo Aéreo Semi-Autónomo", University of Minho, Guimarães, Portugal, February 2006.

Isabel Ribeiro - Member of the Jury of the Aggregation Exam of Helena Maria dos Santos Geirinhas Ramos, with the lesson "Instrumentação Suportada em Computadores Pessoais", Instituto Superior Técnico, 4-5 de Maio de 2006.

Isabel Ribeiro - Member of the PhD Thesis Jury of Rui Paulo Pinto da Rocha, "Building Volumetric Maps with Cooperative Mobile Robots and Useful Information Sharing," School of Engineering of University of Oporto, May 2006.

Isabel Ribeiro – Referee of the European PhD Thesis of Jesus Morales Rodríguez, "Control of a Multi-Articulated Tracked Mobile Robot and Integration in a Multirobot System," Departamento de Ingeniería de Sistemas e Automática, Universidad de Málaga, Spain, November 2006.

Isabel Ribeiro – Member of the jury for the position of Associate Professor at the Department of Electrical and Computer Engineering of IST in the scientific area of Systems, Decision and Control, March 2006.

3.8. VISITS TO ISR

3.8.1. Distinguished Visitors

- **Patrick Quidel**, adjoint for the scientific and innovation cooperation of the French Ministry for Foreign Affairs and **Alain Derivier** , scientific adviser of the French Embassy in Portugal, March 2006.
- **Prof. Marcelo Becker**, Visiting Professor at École Polytechnique Fédéral de Lausanne, June 2006.
- **Mrs. Wu Quidi**, Vice-Minister of Education of the People's Republic of China, heading a delegation of 10 members, September 2006.
- **Prof. Michel Verhaegen**, Technical University of Delft, September 2006.
- **Prof. Klaus Schilling**, Julius Maximilians Universitat, Germany, September 2006.
- **Dr. Luís G. Crespo**, Research Scientist of the National Institute of Aerospace, USA, September 2006.
- **Prof. Peter Dowd,** Executive Dean, Faculty of Engineering, Computer and Mathematical Sciences, The University of Adelaide, Australia, October 2006.
- **Prof. Cristopher Cook**, Dean, Faculty of Engineering, University of Wollongong, Australia, October 2006.
- **Prof. Brendon Parker**, Dean, Faculty of Engineering, The University of South-Wales,Australia, October 2006.
- **Mr. Christian Estrosi**, The French Ministry of Environment, Territory and Regional Development, October 2006.
- **Mr. Zheng Xiaoguang**, First Secretary for Science & Technology of Embassy of the People's Republic of China, November 2006.
- **Prof. Yiannis Demiris,** Imperial College, UK.
- **Prof**. **Aude Billard,** Ecole Polytechnique Fédérale de Lausanne, Switzerland.
- **Prof**. **Auke Ijspeert,** Ecole Polytechnique Fédérale de Lausanne, Switzerland
- **Prof. Claes von Hofsten**, University of Uppsala, Sweden.
- **Prof. Kerstin Dautenhaun,** University of Hertfordshire, UK.

3.8.2. Other Visits

Visit of students from IST, in the scope of an ECE workshop "JEEC", February 2006.

Visit of students from High School **"**Colégio de Quiaios, Figueira da Foz", March 2006.

Visit of students from High School "Instituto D. João V", March 2006.

Visit of students from High School "Escola Secundária Gil Eanes, Lagos", April 2006.

In the scope of the Science and Technology Week, in November 2006, ISR promoted an open day that included visits to the Ocean Robotics Lab, Mobile Robotics Lab, and Vision Lab

3.9. SPECIAL EVENTS

3.9.1. OPENING TALK OF IEEE RAS PORTUGAL CHAPTER

Pervasive Networks of Robots for Research and Teaching
By Daniela Rus
CSAIL-MIT Professor
Instituto Superior Técnico, Lisboa, Portugal
29 March 2006

Coordinator: Pedro Lima.
Laboratories: Intelligent Systems Laboratory.
Support: IEEE Robotics and Automation Society, and IEEE Portuguese Section.
Description: Autonomous Mobile Networks are distributed ad-hoc networks that can sense, actuate, compute and communicate with each other using point-to-point multi-hop communication. The nodes in such networks include static sensors, mobile sensors, robots, and humans. Such systems combine the most advanced concepts in perception, communication and control to create computational systems capable of large-scale interaction with the environmnet, extending the individual capabilities of each network component to encompass a much wider area and range of data. In this talk we discuss communication, control and information processing in networked robots for research and teaching. Due to the absence of any networking infrastructure the nodes must cooperate to accomplish communication, global control and distributed information aggregation. We present distributed algorithms for routing messages that use mobility to guarantee message delivery, distributed algorithms for aggregating maps and using the maps to guide navigation, and some recent results on information diffusion. Finally, we discuss how these research topics can be used to establish a curriculum for teaching an undergraduate robotics curriculum integrated across ME, EE, and CS departments.
URL: http://robota.dem.uc.pt/ieee_ras_pt/

3.9.2. INTRODUCTION TO ROBOTICS

Programme Ciência Viva
Scientific Occupation of Youth during Holidays 2006
Instituto Superior Técnico, Lisboa, Portugal
June 2006

Coordinator: João Sequeira
Laboratories: Mobile Robotics Laboratory
Support: *Ciência Viva* – National Agency for Scientific and Technological Culture.
Description: João Sequeira was in charge of the summer course "Introdução à Robótica (Introduction to Robotics)" organised within the national programme Ciência Viva (Scientific Occupation of Youth During Holidays 2006), June 2006.
During this summer course a total of 11 students (high school level) built robots using the Lego Mindstorms system. The course program contained very basic notions of robot programming that, at the end, allowed them to complete a task of medium complexity, namely following a dark lane along a pre-specified circuit and taking into account possible lane breakdowns. Figures

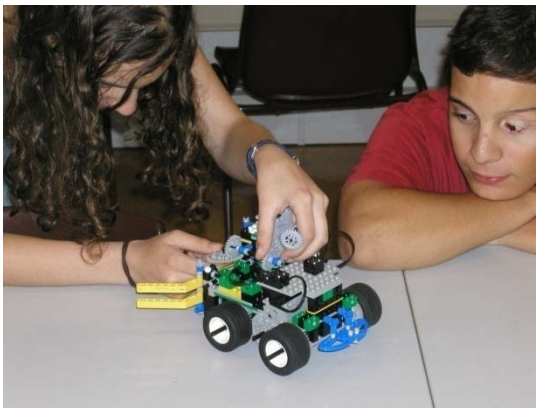
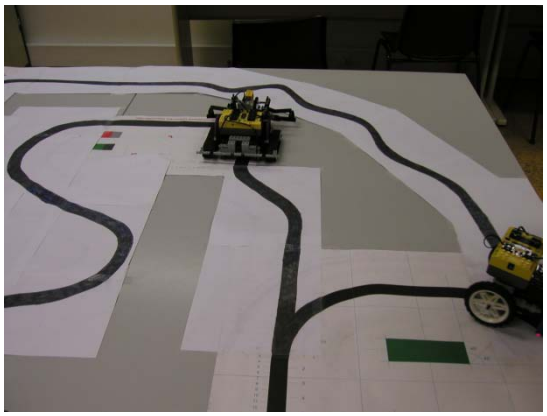


Figure 19:Students using the Lego Mindstorms



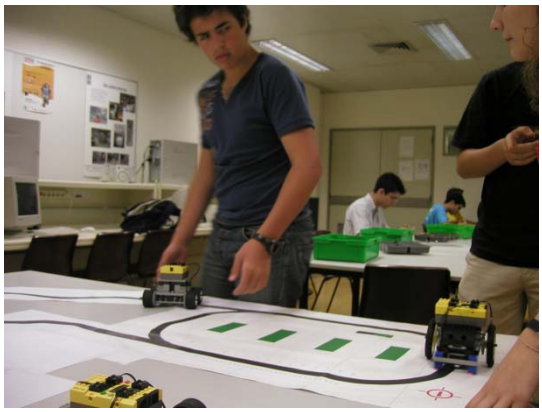


Figure 20: Lego robots in action

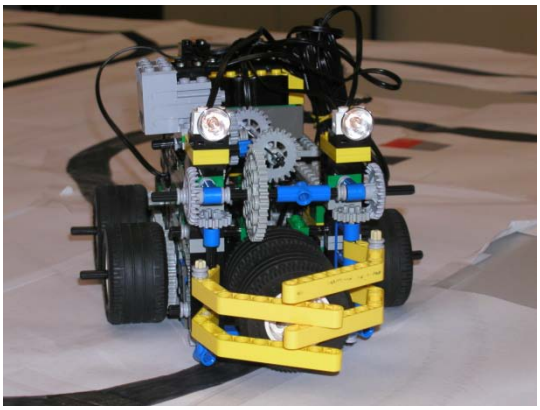


Figure 21:An example of a robot built by the students

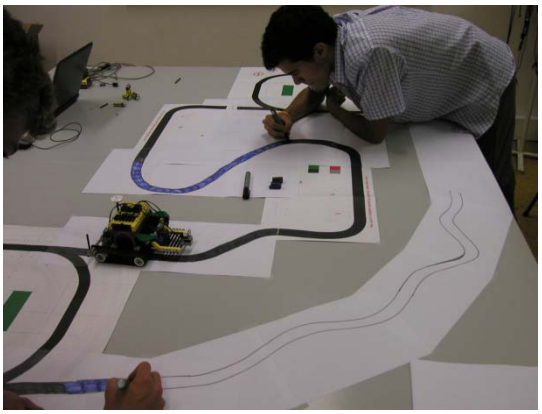


Figure 22:Students painting the dark lane that forms the test circuit

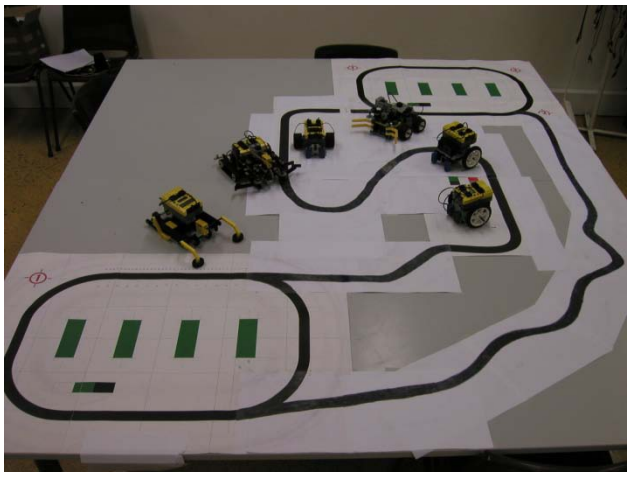


Figure 23: An overall view of the complete test circuit and of some of the robot developed by the students

3.9.3. CONSTRUIR UMA EQUIPA DE FUTEBOL ROBÓTICO JÚNIOR PARA O ROBÓTICA2007

Programme Ciência Viva
Scientific Occupation of Youth during Holidays 2006
Instituto Superior Técnico, Lisboa, Portugal
July 10-14, 2006

Coordinator: Pedro Lima.
Laboratories: Intelligent Systems Laboratory.
Support: *Ciência Viva* – National Agency for Scientific and Technological Culture.
Description: This was a workshop for High School students aiming at motivating them for the learning of Science and Technology, namely Robotics. The students had to build from an initial kit a team of two robots capable of playing football according to the rules of RoboCup Junior. In the process, they learned from several disciplines such as math, electronics, programming and mechanics, among others. In the end, the available teams played in a round-robin tournament. The workshop had the participation of 21 students from 13 schools, selected out of 34 candidates.
URL: http://lci.isr.ist.utl.pt/projects/educational/cvnasferias/index2006.html

3.9.4. Organization, 7th IFAC Conference on Manoeuvring and Control of Marine Craft (MCMC2006)

Lisbon, Portugal,
September 2006.

General Chair: António Pascoal

Organizing Committee: Carlos Silvestre, Pere Ridao, Paulo Oliveira, António Aguiar, Franciso Garcia.

Description: The MCMC'2006 will provide an excellent opportunity for the presentation and discussion of research and development work in the general area of automatic control with applications to the maritime field. Specific topics will include guidance and control, monitoring and surveillance, optimization and operations planning, modelling and identification, and operational safety. Motivated by recent, fast paced developments in the area, special attention will also be given to the discussion of a number of topics that

include navigation, guidance, and control of robotic marine platforms and systems, including autonomous surface and underwater vehicles. Researchers and practitioners from these fields will be brought together to discuss common theoretical and practical problems, describe scientific and commercial applications, and explore avenues for future research.

This Conference is the seventh of a series of IFAC-sponsored meetings in the field of Manoeuvring and Control of Marine Craft, held on a triennial basis. The last two editions took place in Spain (MCMC'2003) and Denmark (MCMC'2000).

The MCMC'2006 is organized by the Instituto Superior Técnico (IST) in cooperation with the Institute for Systems and Robotics (ISR) and the Portuguese Association of Automatic Control (APCA), a national member organization of the International Federation of Automatic Control (IFAC).

URL:http://mcmc2006.isr.ist.utl.pt/

3.9.5. CONTROLO2006 – 7th Portuguese Conference on Automatic Control

Instituto Superior Técnico, Lisbon, Portugal
September 11-13, 2006.

Members of the Organizing Committee: Isabel Ribeiro, José Santos-Victor.

URL: http://controlo2006.ist.utl.pt/

3.9.6. MVS 2006 - FIRST IFAC WORKSHOP ON MULTIVEHICLE SYSTEMS

Centro de Convenções da Bahia, Salvador, Bahia, Brasil
October 2-3, 2006

General Chair Anna Reali Costa, EPUSP, São Paulo, Brasil.
International Programa Committee Chair: Pedro Lima.
Laboratories: Intelligent Systems Laboratory.
Support: IFAC, SBA, CAPES.
Description: MVS 2006, the First IFAC Workshop on Multivehicle Systems, was held in Salvador, Bahia, Brasil, on October 2-3, 2006. It gathered researchers from around the world to present their work, promoting a discussion forum for key issues in systems regarding multiple land, air, and marine vehicles. Current research interests in this field focus on cooperative navigation, multivehicle planning and learning, architectures for cooperation, cooperative perception, interaction and communication, among others.
MVS 2006 was organized by Escola Politécnica from the University of Sao Paulo (EPUSP), Instituto Tecnológico de Aeronáutica (ITA), Universidade Federal da Bahia (UFBA), and Centro Universitário da FEI (FEI), in Brasil, and Institute for Systems and Robotics / Instituto Superior Técnico (ISR / IST), from Portugal. It was sponsored by the International Federation of Automatic Control (IFAC), the Sociedade Brasileira de Automática (SBA), and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).
The MVS 2006 International Program Committee (IPC) members represented 10 countries. 28 full paper submissions were received. The IPC conducted a thorough review process where all papers were examined by 3 autonomous reviewers, whose reports gave grounds for the IPC to select the 19 papers included in the technical program for oral presentation.
The technical program of MVS 2006 also included two plenary invited lecturers, Lynne Parker and George Pappas, outstanding experts in this area, who focused on issues like integration, heterogeneity, algebraic graph models, and hybrid system models for formation control and multi-robot tasks.
URL: http://www.lti.pcs.usp.br/mvs2006/

3.9.7. IEEE CDC 2006 Workshop - New Developments in Point-Stabilization, Trajectory-Tracking, Path-Following, and Formation Control of Autonomous Vehicles

San Diego, CA, USA
December 12th, 2006

Organizing Committee: António Aguiar, António Pascoal, João Hespanha
Laboratories: Dynamical Systems and Ocean Robotics Lab
Description: The ever increasing sophistication of autonomous vehicles is steadily paving the way for the execution of complex missions without direct supervision of human operators. A key enabling element for the execution of such missions is the availability of advanced systems for motion control of single and multiple autonomous vehicles. The workshop is motivated by new developments in this area, especially those in the realm of point-stabilization, trajectory-tracking, path-following, and formation control.

The latter problem is motivated by the fact that the multiple vehicle approach offers several advantages - when compared with the traditional single vehicle paradigm - such as increased efficiency, performance, reconfigurability, and robustness and new capabilities. Some of the potential applications include tasks that involve searching and surveying as well as exploration and mapping in harsh environments. At a theoretical level, the coordination of autonomous vehicles involves the design of distributed control laws with limited and disrupted communication, uncertainty, and imperfect or partial measurements.

The workshop will bring together leading researchers that will give tutorial talks on emerging problems and new results. The program will consist of presentations divided in two parts, encompassing theoretical and new developments in the area of motion control of autonomous vehicles. The topics addressed are organized around the following themes:

i) Point-stabilization, trajectory-tracking and path-following of autonomous vehicles;
ii) Coordinated/Cooperative control of a group of autonomous vehicles.

URL: http://users.isr.ist.utl.pt/~pedro/cdc06workshop/

3.10. AWARDS

• EURON's George Giralt PhD Award for the best European PhD thesis in Europe in 2005 – **runner up: Dejan Milutinovic**'s PhD Thesis "Stochastic Model of Micro-Agent Populations", supervised by Pedro Lima.

• EURON Technology Transfer Award 2006 – **finalist**: RAPOSA robot developed in a consortium with SME IdMind. Coordinators at ISR/IST: **M. Isabel Ribeiro and Pedro Lima**.

Best Young Researcher – American Association of Sleep Medicine – APSS 2006, Cecilia Lopes, Agostinho Rosa**.**

IST Prize for the best graduation project on EECS - João Henrique Dias Leonardo, "Limiar de Desempenho para Estimação Bayesiana de Parâmetros em Variedades Riemenianas". Advisor: João Xavier.

IST Prize for the best graduation project on EECS - Bernardo António Esteves Pires, "Imagens Panorâmicas". Advisor: Prof. Pedro Aguiar.

3.11. PUBLICATIONS

A) M.Sc. Theses (4)

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[2] **João Alves**, "Arquitecturas Distribuídas para Controlo de Veículos Autónomos", Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2006.

[3] **Ricardo Ferreira**, "Stereo Reconstruction of a Submerged Model Breakwater and Interface Estimation", Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2006.

[4] **Miguel Arroz**, "Plataforma de Desenvolvimento de Agentes de Busca e Salvamento", Master Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2006.

B) Ph.D. Theses (4)

[5] **Cristian Munteanu**, "Increasing Adaptability in Evolutionary Algorithms for Solving Complex Optimization Problems", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2006.

[6] **Manuel Lopes**, "A Developmental Roadmap for Learning by Imitation in Robots", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2006.

[7] **Sajjad Fekri Asl**, "Robust Adaptative MIMO Control Using Multiple-Model Hypothesis Testing and Mixed-u Synthesis", Ph.D. Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2006.

[8] **Robert Loke**, "Progressive visualization of incomplete sonar-data", Technical University of Delft, Delft, The Netherlands, 2006.

C) Books (Editor) (1)

[9] **A. Caiti, R. Chapman, J. P. Hermand, Sérgio Jesus**, (Eds), Acoustic Sensing Techniques for the Shallow Water Environment - Inversion Methods and Experiments, Springer, 2006.

D) Chapters In Books (7)

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[16] **C. Sousa, L. Custódio**, "Dealing with Errors in a Cooperative Multi-agent Learning System", *Revised Selected Papers*, Karl Tuyls, Pieter Jan't Hoen, Katja Verbeeck, Sandip Sen (Eds.), Lecture Notes in Computer Science, Vol. 3898, pp. 139-154, Springer, 2006.

E) International Journals (25)

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[19] **D. Milutinovic, P. Lima**, "Modeling and Optimal Centralized Control of a Large-Size Robotic Population", *IEEE Transactions on Robotics*, Vol. 22, Issue: 6, pp.1280-1285, 2006.

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[21] **S. Fekri Asl, M. Athans, A. Pascoal**, "Issues, Progress and New Results in Robust Adaptive Control", *International Journal of Adaptive Control and Signal Processing*, Vol. 20, pp. 519-579, 2006.

[22] **L. Lapierre, D. Soetanto, A. Pascoal**, "Non-Singular Path-Following Control of a Unicycle in the Presence of Parametric Modeling Uncertainties", *International Journal of Robust and Nonlinear Control*, Vol. 16, Issue 10, pp. 485-503, 2006.

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F) International Conferences (95)

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[52] **M. M. Morgado, P. Oliveira, C. Silvestre, J. Vasconcelos**, "USBL/INS Integration Technique for Underwater Vehicles", *Proc. MCMC2006 - 7th IFAC Conference on Manoeuvring and Control of Marine Craft*, Lisbon, Portugal, 2006.

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[58] **P. Batista, C. Silvestre, P. Oliveira**, "A Sensor Based Homing Strategy for Autonomous Underwater Vehicles", *Proc. MED2006 - 14th Mediterranean Conference on Control and Automation*, Ancona, Italy, 2006.

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4. LABORATORY FACILITIES AND SERVICES

4.1. COMMON FACILITIES

ISR/IST has a computer network infra-structure based on 4 PC servers, providing basic services such as mail and web servers, shell accounts, firewall, among others (databases, mailing lists, etc.). The firewall provides IP connectivity (IPv4 and native IPv6) to the IST campus network. More than 150 users have accounts on the isr.ist.utl.pt domain mail and/or shell), and more than 300 machines, including PCs, SUN workstations, Macintoshes and others, are currently linked to the network, using switching technology (Ethernet 10/100, plus a gigabit core switch). Moreover, all ISR facilities are covered by the campus WiFi 802.11b/g) network, thus providing wireless access to the Internet.

4.2. LABORATORY FACILITIES

INTELLIGENT SYSTEMS LAB (IS)

The ISLab offers the main following facilities:

- 1 all-terrain remotely-operated (by wireless or cable LAN) robot (RAPOSA), endowed with several sensors for detection of dangerous gases, humidity, and temperature, a thermal camera, several web cams (some of them with controllable pan);
- 5 omni-directional (3 wheels) robots endowed with an on-board laptop with wireless communications, rate-gyro, 16 sonars, omni-directional catadioptric system, optical mouse for odometry, electromechanical kicker and rolling drum systems for robotic soccer applications;
- 1 RWI ATRV-Jr mobile robot, 4-wheel drive, equipped with 16 sonars, GPS, inertial navigation module and a compass, pan and tilt vision system and one SICK Laser scanner (shared with the Mobile Robotics and Computer and Robot Vision Labs);
- 1 Blimp aerial robot, with pan and tilt vision system, 3 servomotors, RF link for remote control and remote video-link for video transmission (shared with the Mobile Robotics and Computer and Robot Vision Labs);
- 4 Nomadic Super-Scout II mobile robots, equipped with 16 sonars and 2 cameras each, one of them part of an omni-directional catadioptric system;
- 14 Philips 740K USB Web Cams, used in the Super-Scout II robots;
- 1 Mobile Platform, built at ISR, with tricycle-like kinematics, 60W and 90W motors, open control and guidance architecture based on 2 Pentium motherboards, and 2 on-board cameras;
- 1 Real-Time RF video link;
- Matlab and Simulink software for different simulation projects;
- Several cameras, used for visual servoing and vision-based navigation applied to manipulators and mobile robots;
- 1 Space Mouse device, for teleoperation of mobile robots and manipulators;
- 1 PUMA 560 manipulator, whose Mark III controller was partially replaced by Trident Robotics TRC 004/6 boards, which allow manipulator control by an external PC;

• 35 Pentium Personal Computers (PIII or PIV, including 10 laptops, 4 of them for the omni-directional robots) – under Linux and Windows 2000/XP OS;

MOBILE ROBOTICS LAB (LRM)

The LRM offers the main following facilities:

- 2 Scout mobile platforms with on-board computer, vision camera and wireless Ethernet;
- 1 ATRV Jr Rover with ultrasound sensors, GPS and Inertial Measurement Unit. This mobile platform is shared with the Intelligent Systems and Computer Vision Laboratories;
- 4 Sony dogs Aibo, shared with the Intelligent Systems Lab;
- Robuter mobile platform, with a ring of 24 ultrasound sensors, and two on-boards processors: Motorola 68020@16MHz running the real-time operating system Albatros, and a Pentium@200Mhz running Windows NT. A laser scanner (Lasernet system) for localisation purposes with artificial landmarks is installed on the platform;
- A complete set of the LEGO Mindstorms system for Mobile Robotics;
- A Laser Range Finder from the Riegl supplier with range and luminance measurement;
- 3 Sick Laser Scanners;
- Three computer controlled Pan & Tilt Units from Direct Perception;
- Video cameras, including two Quick Cams and a Network Eye supporting direct display of real scenes on the Internet;
- 10 Pentium PCs + 5 portable Pentiums;
- Three laser printers, and one DeskJet colour printer;
- 5 kits Lego Mindstorms;
- 1 GT6A serial manipulator;
- 1 PC with VME bus;
- 8 webcams;
- 2 ethernet switches 100Mbps;
- 1 ethernet access point;
- 5 USB wireless adapters;
- 2 pairs of ethernet modems from OTC;
- 1 oscilloscope (digital) Tektronix.

A large open space appropriate for mobile robotics navigation experiments.

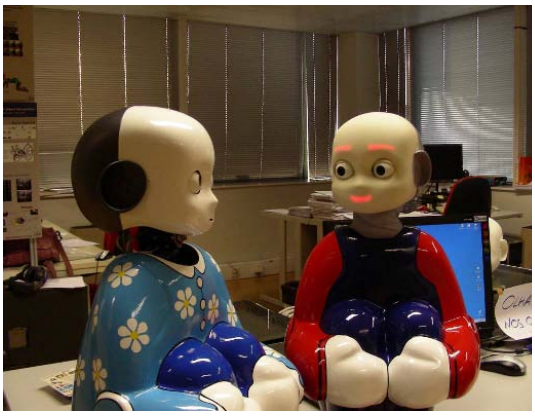
COMPUTER VISION LAB (VISLAB)

The VisLab is equipped with various PCs, various cameras (CCD, CMOS, Colour, Black & White, Digital or Analogue) and image frame grabbers, a pan-tilt unit and several pan-tilt cameras.

Special equipment consists of:

- 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 (see pictures below). It is the only humanoid-like upper torso platform available and built in Portugal for research in sensorimotor coordination, computer vision and learning.
- Two robotic heads designed for the iCub, each with 6 degrees of freedom, an inertial sensor, audio and ability to perform facial expressions (see pictures below).

- TRC LabMate mobile platform.
- One Pioneer mobile platform equipped with a manipulator.
- Two Nomad Superscout mobile platforms, equipped with vision and an on-board computer.

SIGNAL AND IMAGE PROCESSING GROUP (SIPG) – LISBON

The SP Lab offers capabilities to develop and test both software and hardware products for digital signal processing. Presently, the activities in course include the design, implementation and performance benchmarking of modems for underwater acoustic data communications, and testing of navigation and guidance techniques for autonomous robotics.

The SP Lab offers the main following facilities:

- 9 Intel-compatible personal computers;
- 1 Xerox Phaser 8550 Color printer;
- 100 Mbit/s thin Ethernet LAN interfacing the Signal Processing Laboratory to the ISR Network;
- 1 ORCA underwater acoustic communication system (surface modem with programmable acoustic receiver, underwater modem);
- 2 Texas Instruments TMS320C6711 hardware/software DSP development systems;
- 1 Motorola DSP96002 hardware/software DSP development system;
- 1 Motorola software development system for the DSP56000 digital signal processor (DSP);
- 2 Xilinx field programmable gate array (FPGA) hardware/software development systems;
- 2 Signalware high-speed multichannel analog I/O boards for the TMS320C6711 DSP starter kit;
- National Instruments multifunction data acquisition boards (1 MIO-16E-4 PCI board, 2 PC-Cards) and LabView virtual instrumentation software;
- 1 National Instruments digital I/O PCI board;
- 1 TEAC CS-391 multichannel data recorder;
- 1 Goldstar OS-9040D 40 MHz analog oscilloscope;
- 1 Hewlett-Packard HP8116A 50 Mhz function generator;
- 1 Escort EGC 3230 2 Mhz function generator with 100 Mhz frequency meter;
- 1 Sony F670ES power amplifier;
- 1 Kiotto KT-1990EX digital multimeter;
- 1 GW ST3030TD triple power supply;

- 1 Weller WTCP-S soldering station.

SIGNAL AND IMAGE PROCESSING GROUP (SIPG) – ALGARVE

- 1 room with 7 research desks + computer servers + electronics testing;
- Bench internal 100/1000 Mb computer network w/router, NFS, printers;
- Automatic backups, RAID5, etc.;
- 1 vertical line array (16 hyd) + radio buoy + acquisition system + wireless lan;
- 1 remote buoy with vertical line array and wireless lan.

DYNAMICAL SYSTEMS AND OCEAN ROBOTICS LAB (DSOR)

• **Mechanical / Electric shop** (8th Floor of ISR) - basic equipment and tools to machine mechanical pieces, assemble circuit boards, and test electrical / electronic circuitry.

Robotic Vehicles

• *DELFIM* **Autonomous Surface Vehicle (ASC)** - an autonomous surface craft (Catamaran-type) to carry out experimental research in the area of ocean robotics and to perform scientific missions at sea.

• ***DELFIM_X*** **Autonomous Surface Vehicle (ASC) -** an autonomous surface craft similar to the DELFIM, but with improved hydrodynamic characteristics.

• ***INFANTE*** **Autonomous Underwater Vehicle (AUV) –** an autonomous underwater vehicle to carry out experimental research in the area of ocean robotics and to perform scientific missions at sea.

• ***CARAVELA 2000*** **Autonomous Research Vessel –** 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)

• VARIO XTREM **R/C Helicopter** - a small helicopter (payload of 4 Kg) to carry out experimental research in the area of autonomous aerial robotics.

Small **Zodiac** to support operations at sea.

Mechanical/ Electrical Equipment

• **Pressure Chamber** - to test the marinization of equipment down to depths of 600 meters.
• **Crane** with the capacity to handle loads of up to 2500 Kg.
• **Industrial air compressor.**
• **Trailer for the transportation of marine vehicles.**

Actuators and Sensors for Robotic Ocean Vehicle Development and Operation (part of the equipment is dedicated to the operation of the INFANTE AUV and the DELFIM and CARAVELA ASVs).

• *Actuators* – 5 electrical thrusters.
• 3 rate gyros, 2 pendulums and 1 fluxgate (Watson's Attitude & Heading Reference Unit AHRS-C303);
• 3 rate gyros, 3 accelerometers and 1 magnetometer (SEATEX MRU-6)
• 3 rate gyros, 2 pendulums and 1 magnetometer (KVH attitude reference unit).
• 1 flowmeter TSA-06-C-A (EG & G Flow Technology);
• 2 depth cells DC 10R-C (Transinstruments);
• 2 echosounders ST200 (Tritech);

- 2 echosounders ST500 (Tritech);
- 1 Sidescan sonar (System Techonologies / Tritech);
- 1 Acoustic Modem for underwater communications (System Techonologies / Tritech);
- GIB (GPS Intelligent Buoys) – GPS based underwater positioning system, with target tracking capabilities.
- 1 Doppler Log TSM 5740 with 4 beams in a Janus configuration, operating at 300 KHz (Thomson-ASM);
- 1 Doppler Log, operating at 600 KHz, rated for 2000 m (RDI);
- 1 set of 3 rate gyros, 2 pendulums and 1 directional gyro from Humphreys.
- 1 *Long Baseline Positioning System* for underwater vehicle positioning - 1 transducer and 4 transponders.
- 1 *DGPS (Differential Global Positioning System)* for accurate surface vehicle navigation - 4 Motorola Encore unit and 3 FREEWAVE radios.

Hardware and Software Development Systems for Vehicle Simulation and Real-Time Vehicle Control

- *Hardware for real-time applications* - 3 Gespac 68030/68882 computers; a T805 transputer array; 4 MPL stand-alone 68020/60881 computers.
- *3 Single Board Computers RTD/USA*
- *Development System* - Microware FASTRAK development software running on a SUN-Workstation; professional OS9 for Gespac development systems.

Software Tools for Navigation, Guidance, and Control System Design

INTEGRA - Modeling and simulation tool for *the integrated analysis and design of navigation, guidance and control systems for autonomous vehicles.* The software was developed at IST/ISR and is built around the commercially available package MATLAB. The package is specially geared towards the development of dynamic models of robotic ocean vehicles. Furthermore, it provides the means to assess the combined performance of navigation, guidance and control systems prior to their implementation.

General Computer Facilities

11 Desktop PCs
7 Laptop PCs
2 Laser printers

EVOLUTIONARY SYSTEMS AND BIOMEDICAL ENGINEERING LAB (LASEEB)

The Laseeb offers the main following facilities on digital signal processing for biomedical engineering, digitalization and development for multimedia applications:

- 20 Personal Computers running Windows 98/NT4/2000 and Linux;
- 2 Laser printer;
- 2 color inkjet printers;
- 1 Video Capture Board MIRO VIDEO DC30;
- 3 Cd-RW Recorders;
- 1 Tape Backup 12 Gb;
- 1 Scanner;
- 1 Biological amplifier Medelec;
- 1 Biological amplifier Braintronics;
- 1 Biological amplifier CAPS;
- 2x30 ch. A/D Acquisition DT 2834 16 Hz;
- 2x16 ch. A/D Acquisition DT 2821 150 Hz;

- 1x16 ch. A/D Acquisition DT 2811 30 Khz;
- 1x8 ch A/D Acquisition PCMCIA 50Khz.

In the Laseeb Sleep Laboratory:

- Sonolab 632 from MEditron – Polysomnography Acquisition System;
- 1 Infrared Video Monitoring system from Meditron – sleep video;
- 1 LED bright light phototherapy from Meditron – Phase delay and advance therapy device;
- Med Supply A8000 from Meditron – CPAP machine;
- 1 Sonolab X1 from Meditron – Digital Pulse Oximetry;